EthnopharmacologicalImportance of*Gymnemasylvestre*

Abstract

*Gymnemasylvestre*is one of the valuable medicinally important herbs that belong to family Apocynaceae. *G. Sylvester* is a woody climbermostly found in India, Srilanka, China, Indonesia, Malaysia and Tropical Africa. Traditionally the leaf of theherb is used as antidiabetic, antihelmentic, antiobesity, anti-inflammatory, hypolipidaemic, antivenom and antimicrobial.The herb is used by some ethnic community in constipation, haemorrhoids, jaundice, leucoderma, asthma, bronchitis, cardiac problems and dyspepsia.Most important phytochemicals of the plant aregymnemic acid, deacyl gymnemic acid and gymnemagenol which help in the controlling of blood cholesterol, triglyceride levels, inflammation and body weight.The present reviewaims to document the traditional and modern pharmacological uses of the plant to provide better scope for further experiments and future application. The botanical description, cultivation practices, phytochemical constituents and safety issues of the plant has also been described in the chapter.

Keywords: *Gymnemasylvestre*, Medicinal Plant, Ethnopharmacology, Phytoconstituents,Traditional and Modern Uses

Introduction

"*GymnemaSylvestre*R. Br. is animportant herb belongs to the family Apocynaceaeor previously calledAsclepiadaceae.The herb is native to India, Australia and Tropical Africa commonly known as miracle plant in English, and Gurmar (slayer of sugar) in Hindi as chewing the leaves causes a loss of sweet taste for a short time" (Gloria et al., 2003; Keshavamurthy and Yoganarasimhan, 1990). Ethnomedicinally it is a popularplant mostly used in Homeopathic, Ayurvedic, Unani and Siddha systems of traditional medicineadvised tothe diabetic and toothache patients (Mitra et al., 1996)."Gymnemic acid is the most important constituent present in the leaves and roots of *G. sylvestre*used in the treatment of diabetes or lowering and balancing of blood sugar"(Duke et al., 1997)."Tribal people of India generallyuse the bark and roots of the herbas an emetic, expectorant, and analgesic for body ache and juice from the root has been acclaimed as a useful treatment for snakebite"(Sastry, 2005).In addition, the plant is traditionallyused as hepatoprotective (Rana and Avadhoot, 1992), anti-hypercholesterolemic, antimicrobial and anti- inflammatory properties (Potawale et al., 2008; Kumar et al., 2008), and prevention from dental caries (Hiji, 1990)."It is also used in the treatment of asthma, eye complaints, digestive problems, inflammations, snake bite" (Kini and Gowda, 1982)."There are a large number of phytochemical constituents have beenisolated from *G. sylvestre*, these are gymnemic acid, saponins, stigmasterol, quercitol and amino acid derivatives betaine, choline, and trimethylamine (Kapoor, 1990). Similarly the plant leaves contains albumin, resins, chlorophyll,carbohydrates, tartaric acid, formic acid, butyric acid, anthraquinone derivatives, inositol alkaloids, organic acid, paraben, calcium oxalate, lignin, and cellulose (Husen, 2023). The leaves also contain triterpene classes of oleanane saponins such as gymnemic acids, gymnemasaponins, and dammarane saponins such as gymnemasides and terpenoids as 6-octen 1-ol, 3,7-dimethyl, isophytol, squalene,

nerolidol, and β-amyrin" (Srinivasan andKumaravel, 2016).The present review on *G.sylvestre* is a research update with important medicinal traitsand significant ethnopharmacologicalimportance. It also searches the reality and prospects of its development into modern and efficient therapeutic trends of pharmacology and drug development. Moreover, the herb has significant role in most important health problems like diabetes, obesity, cardiovascular problems, osteoporosis, and asthma as wellas a popular medication for number of other health ailments.

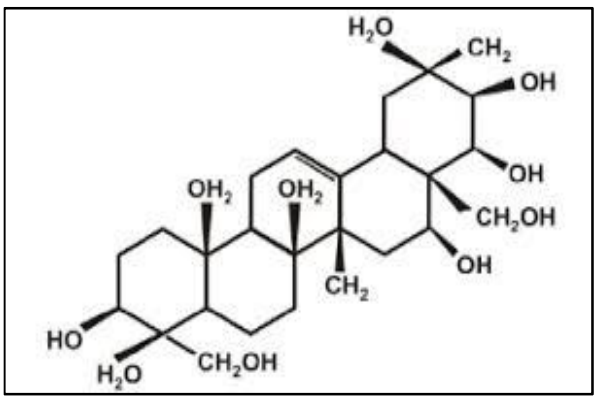
Geographical and Botanical Description

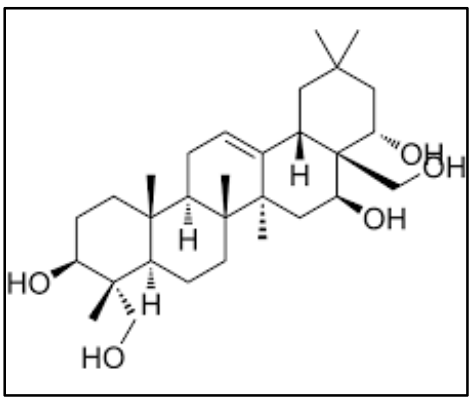
*G. sylvestre*flourish well from 100 to 1000 m of altitude (Sabithaet al., 2012). It is generallyfound in tropical and subtropical and humid climatic zone and hills of evergreen forests in India, Srilanka, China, Malaysia, Indonesia,Australia, Japan, Vietnam and tropical Africa(Yadav et al., 2001). "It is a perennial,upward growing, woody climber (up to 8 m length),and cylindrical,light brown, pubescent herb.The leaves are simple, green, reticulate venation, petiolate, entire, opposite, acute apex,elliptical toovate, 2-6 cm in length, 1-4 cm in width and pubescent on both the surfaces.Leaf is astringent and bitter having remarkablecharacteristic of paralyzing the sense of the taste buds for sweet substances"(Madhurima et al., 2009)."Flowers of the plantaresmall, yellow, auxiliary and lateral umbel in cymes.The follicles arelanceolate and terete length is about 3inches. The Calyx-lobes are ovate,pubescent, long and obtuse. The Corolla ispale yellow,valvate, campanulate, corona single, with 5 fleshy scales. Scales adnate to throat of corolla tubebetween lobes, anther connective produced into a membranous tip, pollinia 2, erect, carpels 2,unilocular having many ovuled in locules" (Gurav et al., 2007).Seeds are cotyledons,ovate, margined, ending in a silky coma,elliptic and radicle is cylindric (Mathew and Rani, 1983). Flowering occurs in March to August and the fruiting season is from October onwards. The *Gymnema*species are diploid with a chromosome number of2n = 22 (Sredeevi andNamboodiri, 1977).

Phytochemical Constituents

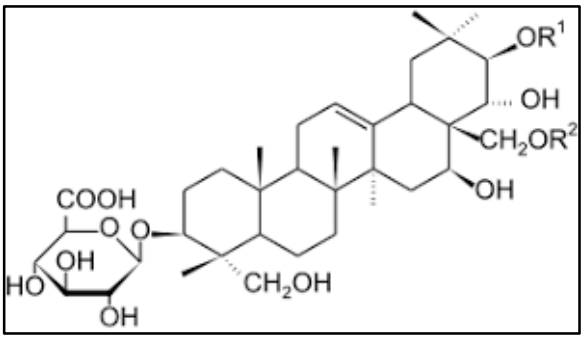
The bioactive components found in different parts including leaves of *G. sylvestre*contain gymnemic acids, gymnemasaponins, gymnemosides, gurmarin, gymnemanol, stigmasterol, d-

quercitol, β-amyrin related glycosides, anthraquinones, lupeol, hydroxycinnamic acids, and coumarols group. Triterpene saponins are come under oleanane and dammarene classes. Oleanane saponins are gymnemic acids and gymnemasaponins, while dammarene saponins are gymnemasides(Khramov et al., 2008). The major phytochemicalssuch asgymnemic acids and gymnemasaponins are parts of oleanane type of saponins while gymnemasides are dammarane saponins (Khramov et al., 2008).Acidic glycosides and anthraquinones and their derivatives are extracted from the leaves of the plant (Dateo and Long, 1973).Other phytochemicalssuch asflavones, anthraquinones, hentriacontane, pentatriacontane, phytin, resins, tartaric acid, formic acid, butyric acid, lupeol, β-amyrin related glycosides, stigmasterol, and calcium oxalate are found in the leaves(Sinsheimer et al., 1970). "The most important secondary metabolites in *G. sylvestre* comprises a group of nine closely related acidic glycosides, most important are gymnemic acid A–D which found in whole parts of the plant. In addition, a series of gymnemic acids (gymnemic acid I, II, III, IV, V, VI, and VII) are presentin dry leaves of *G. sylvestre"* (Yoshikawa et al., 1989). The derivatives of gymnemic acids are several acylated tigloyl, methylbutyryl group substituted members, derived from deacylgymnemic acid (DAGA) which is a 3-O-β-glucuronide of gymnemagenin (3β, 16β, 21β, 22α, 23, 28-hexahydroxy-olean-12-ene). Gymnemic acid A comprises of gymnemic acids A_1, A_2, A_3, and A_4 and named gymnemagenin. This constituent is a D-glucuronide of hexahydroxy-triterpene that esterifies with acids (Stocklin et al., 1967). Other five gymnemic acids, namely, VIII, IX, X, XI, and XII, were isolated and characterized later (Yoshikawa et al., 1992).Gymnemasaponins III is isolated from the plant function as an antisweet compound consists of 23 hydroxylongispinogenin as the aglycone moiety glycosylated with either one or two glucose molecules at both the 23 and 28 hydroxyl groups (Murakami et al., 1996).These compounds exhibited lesser antisweet effect than those of gymnemic acids (Yoshikawa et al., 1991).Gurmarin is extracted from *G. sylvestre*, an important 35 amino-acid peptide (Imoto et al., 1991).This polypeptide has antisweet effect on tongue because of change in pH (Chattopadhyay, 1999).Gymnemasins A, B, C, D and alkaloids are the other valuable bioactive constituents found in the leaves of the herb (Suttisri et al., 1995).Similarly different kinds of saponins including gymnemagenin, gymnestrogenin, gymnemic acid, deacyl gymnemic acid, and 23-hydroxylnogispinogenin are isolated from *G. sylvestre*(Sahu et al., 1996; Yoshikawa et al., 1997).Kaempferol 3-O-beta-D-glucopyranosyl-(1-->4)- alpha-Lrhamnopyranosyl-(1-->6)-beta-D-galactopyranoside are a flavonol glycosidepresent in aerial parts of *G. sylvestre*(Masayuki et al., 1997). Leaves of *G. sylvestre* contain carbohydrates, resins, lignin, cellulose, anthraquinone, tartaric acid, organic acid, formic acid, butyric acid,albumin,parabin, inositole alkaloids and calcium oxalate (Sinsheimer et al., 1970).The new compounds gymnemanol and aglyconehave been characterized as 3 beta-16 beta-22 alpha-23-28-pentahydroxyolean-12-ene.A new pentahydroxytriterpene called gymnestrogenin has been obtained from the leaves of *G. sylvestre*(Sahu et al., 1996).

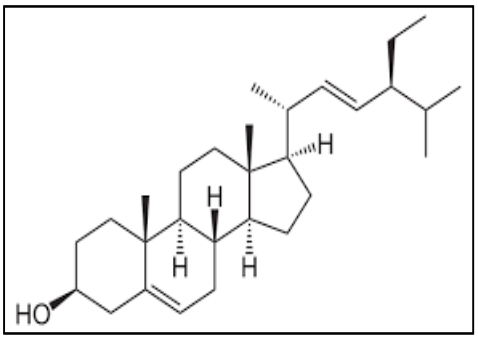




1. Gemnemagenin

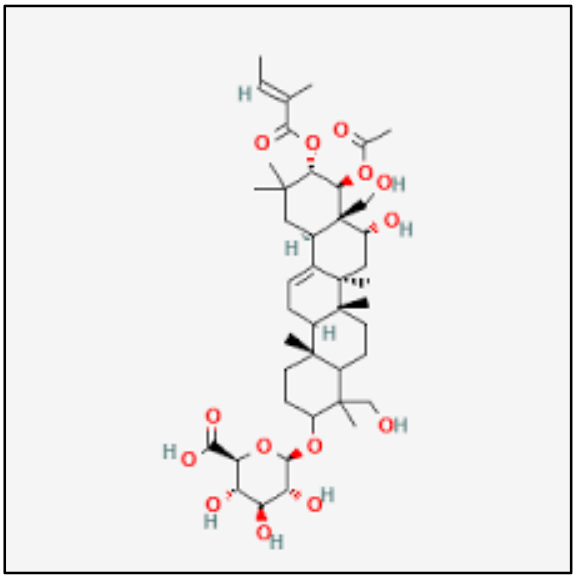


2. Gymnemanol



3. Gymnemic acid

4. Stigmasterol



5. Gymnemoside

Ethnopharmacological Importance

G. sylvestre is well described in Ayurveda and Sushrutaas neutralizing excess sugar in body and curing of urinary diseases (Nadkarni, 1986). Ethnic peoples traditionally use the leaves of the plant for the treatment of piles and diabetes and root is applied in insect bites

(KirtikarandBasu, 1975).Juice extracted from the leaf of the planthelp inpancreatic stimulation to release insulin (Persaud et al., 1999). The plant is effectively used as digestive, cardiotonic, diuretic, laxative, anthelmintic and antipyretic (Sastry, 1994; Sastry, 2005). The root bark is used as expectorant, emetic and analgesic and snakebite. In Ayurveda the plant leaf is given the patients of jaundice, glycosuria, urinary disorder, leukoderma and inflammation (Kirtikar and Basu, 1975; Chopra, 1956).In Siddha and Unani systems of medicine, the Gymnema leaves are used as an ingredient of different antidiabetic formulations (Anonymous, 1997; Chopra et al., 1992; Nadkarni, 1993). Some ethnic community used the plant root in snake bite (Singh et al., 2008). A herbal formulation is prepared by mixing of *Galega officinalis,Trigonellafoenum-graecum, Cynara cardunculus*and *Azadirachtaindica*which is effective in the treatment of diabetes and weight loss (Kerry, 2007).The herb is advised to the patient suffering from Parkinson disease (Anis et al., 2000).The extracts of root and flower are traditionally used in dysentery, vomiting and cold, and the paste prepared from fresh leaves mixed with mother milk is applied in the treatment of mouth ulcer(Ekka and Dixit, 2007; Agnihotri et al., 2004; Kirtikar and Basu, 1975).Some of the important ethnopharmacological properties of *G. sylvestre* are mentioned below.

Antidiabetic Properties:

The scientific study of ethnopharmacological properties of *G. sylvestre* has confirmed that theplant parts are useful in diabetes and effective in the balancing of blood glucose level.Thebioactive constituents of the plantstimulate to enhance insulin level by regenerating the pancreas and maintaining of homeostasis of the blood glucose (Shanmugasundaram et al., 1990; Charpurey, 1926; Paliwal et al.,2009; Patel et al., 2009). The important phytochemicals of the plant such as gurmarine, crude saponin and five triterpene have antihyperglycemic effect without any adverse effect (Sugihar et al.,2000). These phytochemicals keep delayed in the absorption of glucose in the blood. Gurmarindifferentiates sweet and bitter tastes by interfering with the ability of taste buds on the tongue.Likewise, it attaches to the receptor present in external layer of intestine and preventing the absorption of sugar molecules in blood (Sahu et al., 1996). The hypoglycemic effect of Gymnemic acid adjoinsa flow of actions starting from modulation of incretion activity thatstimulatesinsulin secretion. The pancreatic islet cells regenerated through the stimulationof insulin to increase enzyme mediated uptake of glucose.Gymnemic acid fused with glyceraldehyde-3-phosphate dehydrogenase which is a key enzyme in glycolysis pathway (Sugihara et al., 2000; Kanetkar et al., 2007).This processreduced glucose and fatty acid assimilation in the small intestine and intervenes in the capacity of receptors in mouth and intestine to sensation of sweetness (Bone, 2002).

Antiobesity: *G. Sylvestre*has antiobesity properties because of Gurmarin peptide which block the sweet taste ability and controlling of blood sugar levels (Pierce, 1999).The plant extracts, hydroxycitric acid and niacin-bound chromiumarehelpful in antiobesity activity. Body weight is also controlled by the hexane extract of the plant (Preuss et al., 2004).

Antimicrobial: Theethanolic extract of leaf of *G. sylvestre*is effective against some microbes such as*Bacillus pumilis, Staphylococcus aureus,Pseudomonas aeruginosa and B. subtilis* (Satdive et al., 2003; Yogisha and Raveesha, 2009). The ethanolic, ethyl acetate and chloroform extract of the aerial part of the plant are effective against *S. aureus Klebsellapneumonia, P. vulgaris,E. coli* and*P. aeroginosa*.The methanolic extract showed faireffect against *S. typhi, S. typhimurium and Salmonellaparatyphi*(Paul and Jayapriya, 2009).The aqueous leaves extract is highly effective against the *Salmonella* species (Pasha et al., 2009).

Antiarthritic: It was reported that the aqueous and petroleum leaves extractof *G. sylvestre*areeffective in joint pain andarthritis due to saponin glycosides, triterpenoids and steroids (Malik et al., 2010). The phytoconstituents isolated from the plant is effective against the joint cartilage and bone damage in chronic arthritic (Malik et al., 2010).Paw swelling is reduced because ofblocking the response of inflammatory cells or inhibiting the release of mediators like cytokines (IL-Ib and TNF-a), GM-CSF, interferons and PGDF from petroleum ether extracts of the plant. It also control the pain of damaged of bone and cartilage (Eric and Lawrence, 1996).

Anti-Inflammatory: The aqueous extract of leaf of *G. sylvestre*was observed effectiveagainst inflammations in rat (Malik et al., 2007). Saponins and tannins isolated fromthe plantare used as anti-inflammatory agents (Diwan et al., 1995).

Anticaries: Different scientific study show that methanolic, chloroform and petroleum ether leaf extracts of *G. sylvestre*at a range of concentrations are effective in dental caries caused by various kinds of gram positive cariogenic bacteria. Ethnic people used leaves of *Gymnemasylvestre* or Gurmar as a tooth powder as an anticaries(Marsh and Martin, 1992; Devi and Ramasubramaniaraja, 2010).

Antihyperlipidemic:*G. sylvestre* has the properties of antihyperlipidemic that protect heart from coronary artery diseaseand atherosclerosisby reducing the level of serum cholesterol (Hardman et al., 2010; Kaushik et al., 2011).The hydroalcoholic extract of the plantleavesnotably reduce thelevels of lipidswith increase inHDL-C as compared to highcholesterol diet control given to rats. It was observed that the hexane leaf extract ofthe plantimprove the good cholesterol,triglyceride, LDL, andHDL levels.Thehexane extract have the potential to treat the heart diseases (Rachh et al., 2010; Bishayee and Chatterjee, 1994).

Hepatoprotective: A study was conducted in rat where it was observed that the hydroalcoholic extract of fresh leaf of *G. sylvestre*was effective as a hepatoprotective and reduces the D-galactosamine-induced hepatotoxicity. The cells showedrevival of the altered biochemical parameters towards the normal when compared to D-galactosamine treated groups in a dose-dependent manner (Srividya et al., 2010).

Immunostimulation: Regulation or control of the immunitywhich involves the enhancement or reduction in the immune responses is called immunostimulation. It is regulated by agent that enhances or suppresses its action (Trease and Evans, 1983). Leaves of *G. sylvestre* have

the properties of immunostimulation(Gupta et al., 2010).Aqueous extracts of the leaf has remarkableimmunostimulatory property(Malik et al., 2009).

Wound Healing: Flavonoids of the leaf of *G. sylvestre* has wound healing properties. It was observed in rat that the alcoholic extract of leaves heal wounds (Alam et al., 2011; Kiranmai et al., 2011; Malik et al., 2009).

Anticancer:Some of the studies revealed that phytoconstituents such as saikosaponins, soyasaponins and ginsenosidesof *G. sylvestre* show significant anticancer activity. The same anticancer potential was reported by applyinggymnemagenolof *G. sylvestre*on *HeLa* cancer cell lines in *in vitro* conditions(Jain et al., 2007). It was not toxic to the growth of normal cells under *in vitro* conditions (Khanna and Kannabiran, 2009).

Drug Safety

G. sylvestre has no any toxic effect when it was taken in adequate dose. High doses of the drug may cause any side effects such as hypoglycemia, shakiness, musculardystrophy and weakness.It was reported by few researchers that drug-induced liver injury or toxic hepatitis is cause by the crude plant materials.Gymnemic acid has complex structure and poor lipid solubility; therefore it is hard to pass through the bio-membranes for its absorption in circulatory system(Shiyovich et al., 2010).

Conclusion

Medicinal plants are one of the important sources of basic healthcare in the developing countries as these are safer for human use.*G. sylvestre* has diverse ethnopharmacological importance in the world because of high market value and efficacy. The plant has various clinical evidences in effective treatment of diabetes and other diseases. The tradition formulations of the plant has hypoglycemic potential that increases secretion of insulin, regenerate islet cells and enhance utilization of glucose. The phytochemicals present in the plant have different pathways to treat different ailments. The different secondary metabolites have increased pharmacological potential of the plant. This review will be useful to the scientists and researchers in further investigation and development of new drugsfor diabetes and other diseases.

Future Remarks

Gymnemasylvestre has been used as valuable medicinal plant for ancient Ayurveda andSiddha periods by the ethnic communities.The plant species needs to be conserved as it is a source of important phytochemical constituents. The research on the large scale production of secondary metabolites and bioactive substances of the plant through cell culture will provide new dimensions to this area of research and innovation. The plant accounts for different pharmacological significance because of its useforthetreatment different ailments including of diabetes. A number of clinical trials and experimental studies reported that *G. sylvestre* is a very useful source of bioactive compounds and phytoconstituents such asgymnemic acids that could be a good source of drug development in future.

Disclaimer (Artificial intelligence)

Option 1:

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

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.
2.
3.

References

Agnihotri, A.K., Khatoon, S., Agarwal, M.,Rawat, A.S.,Mehrota, S.,Pushpangadan, P. 2004. Natural Product Sciences.10, 4, 168 – 72.

Alam, G., Singh, M. P.,Singh, A. 2011. Wound healing potential of some medicinal plants. International Journal of Pharmaceutical Sciences Review and Research. 9, 136–145.

Anis, M., Sharma, M. P.,Iqbal, M. 2000. Herbal ethnomedicine of the Gwalior forest division in Madhya Pradesh, India. Pharmaceutical Biology.38, 4, 241–253.

Anonymous. 1997.Gurmar Buti: Standardization of Single Drugs of Unani Medicine: Part III. New Delhi: Central Council for Research in Unani Medicine, Ministry of Health & Family Welfare, Govt. of India. 115-23.

Bishayee, A.,Chatterjee, M. 1994. Journal of Phytological Research.8:2, 118-20.

Bone, K. 2002. *Gymnema*: a key herb in the management of diabetes. Phytotherapy Review and Commentary, National Institute of Herbalists: National Herbalists Association of Australia.

Charpurey, K.G. 1926. Indian Medical Gazette. New Delhi 155.

Chattopadhyay, R. R. 1999. A comparative evaluation of some blood sugar lowering agents of plant origin. Journal of Ethnopharmacology.67, 3, 367–372.

Chopra, R.N., Nayar, S.L.,Chopra, I.C. 1992. Glossary of Indian Medicinal Plants. Council of Scientific and Industrial Research, New Delhi. 319-22.

Dateo, G.P. Jr., Long, L., Jr. 1973. Gymnemic acid, the antisaccharine principle of *Gymnemasylvestre*. Studies on the isolation and heterogeneity of gymnemic acid A1. Journal of Agricultural and Food Chemistry.21, 5, 899–903.

Devi, B. P.,Ramasubramaniaraja, R. 2010. Pharmacognostical and antimicrobial screening of *Gymnemasylvestre*R.Br. and evaluation of Gurmar herbal tooth paste and powder, composed of *Gymnemasylvestre*R.Br extracts in dental caries. International Journal of Pharmacological and Biological Sciences.l,1, 3, 1–16.

Diwan, P. V., Margaret, I.,Ramakrishna, S. 1995. Influence of *Gymnemasylvestre*on inflammation. Inflammopharmacology3, 271–277.

Duke, J., A., Jones, P.M., Danny, B., Jony, D., Bully, P. 1997. The Green Pharmacy. Emmaus, Pennsylvania: Rodale Press, Inc.

Ekka, N.R., Dixit, V.K. 2007. International Journal of Green Pharmacy1, 1-4.

Eric, G. B.,Lawrence, J. L. 1996. Rheumatoid Arthritis and Its Therapy—The Text Book of Therapeutics:Drug and Disease Management,Williams and Wilkins Company, Baltimore, Md, USA, 16th edition, 16.

Gloria, Y. Yeh, David M., Eisenberg, Ted J.,Kaptchuk, Russell, Phillips, S. Systematic. 2003. Review of Herbs and Dietary Supplements for Glycemic Control in Diabetes. Diabetes Care. 26, 4,12771294.

Gupta, S. N., Pramanik,S.,Tiwari, O. P.,Thacker, N.,Pande, M.,Upmanyu, N. 2010. Immunomodulatory activity of *Gymnemasylvestre*leaves. International Journal ofPharmacology. 8, 2, 1531–2976.

Gurav, S., Gulkari, V.,Durgkar, N.,Patil, A. 2007. Systematic review: Pharmacognosy, Phytochemistry and clinical application of *Gymnemasylvestre*R.Br. Pharmacognocy Review.1, 2, 338-343.

Hardman, J. G., Limbird, L. E.,Goodman, L. S., Gilman, A. G. 2001. Goodman and Gilman's the Pharmacological Basis of Therapeutics. Mc Graw Hill, New York, USA, 10th edition.

Hiji,Yasutake. 1990. Cariostatic materials and foods, and method for preventing dental caries. United States Patent. Patent no. 4,912,089.

Imoto, T., Miyasaka, A.,Ishima, R.,Akasaka, K. 1991. Anovel peptide isolated from the leaves of *Gymnemasylvestre*-I. Characterization and its suppressive effect on the neural responses to sweet taste stimuli in the rat. Comparative Biochemistry and Physiology.100, 2, 309–314.

Jain, K. S., Kathiravan, M. K.,Somani, R. S.,Shishoo, C. J. 2007. The biology and chemistry of hyperlipidemia. Bioorganic and Medicinal Chemistry15, 14, 4674–4699.

Khanna, V.,Kannabiran, K. 2009. Anticancer-cytotoxic activity of saponins isolated from the leaves of *Gymnemasylvestre*and *Ecliptaprostrata*on *HeLa* cells. International Journal of Green Pharmacy3, 3, 227–229.

Khramov, V.A., Spasov, A.A.,Samokhina, M.P. 2008. Chemical composition of dry extracts of *Gymnemasylvestre* leaves. Pharmaceutical Chemistry Journal. 42, 1, 30–32.

Kanetkar, P., Singhal, R., Kamat, M. 2007. Journal of Clinical Biochemistry and Nutrition41, 77-81.

Kapoor, L.D. 1990. Handbook of Ayurvedic Medicinal Plants. Boca Raton, FL: CRC Press, Inc. 200-1.

Kaushik, M., Kaushik, A.,Arya, R.,Singh, G.,Malik, P. 2011. Antiobesity property of hexane extract from the leaves of *Gymnemasylvestre*in high fed cafeteria diet induced obesity rats. International Research Journal of Pharmacy2, 112–116.

Kerry, B. 2007. Gymnema: a key herb in the management of diabetes. (Phytotherapy Review & Commentary). National Institute of Herbalists, National Herbalists Association of Australia.

Keshavamurthy, K.R., Yoganarasimhan, S.N. 1990. Flora of Coorg – Karnataka, Vimsat publishers, Banglore 282.

Khramov, V. A., Spasov, A. A.,Samokhina, M. P. 2008. Chemical composition of dry extracts of *Gymnemasylvestre*leaves. Pharmaceutical Chemistry Journal42, 1, 30–32.

Kini, R.M., Gowda, T. V. 1982. Studies on snake venom enzymes: Part I purification of ATPase, a toxic component of *Najanaja* venom and its inhibition by potassium gymnemate. Indian J. Biochem. Biophys 22, 2, 152154.

Kiranmai, M., Kazim, S.M.,Ibrahim, M. 2011. Combined wound healing activity of *Gymnemasylvestre*and *Tageteserectalinn*. International Journal of Pharmaceutical Applications2, 135–140.

Kirtikar, K.R., Basu, B.D. 1975. Indian Medicinal Plants. Delhi: Periodicals Experts. 3, 1625.

Kumar, C. S., Sarada, D.V.L.,Rengasamy, R. 2008. Indian Journal of Science and Technology1:3:1-5.

Madhurima, S.H., Ansari, P.,Alam, S.,Ahmad, M.,Akhtar, S. 2009. Pharmacognistic and phytochemical analysis of *Gymnemasylvestre*R. (BR.) Leaves. Journal of Herbal Medcie and Toxicology 3,1, 73-80.

Malik, J. K., Manvi, F. V.,Nanjware, B. R. 2009. Wound healing properties of alcoholic extract of *Gymnemasylvestre*R.Br. leaves in rats. Journal of Pharmacy Research 2, 1029–1030.

Malik, J. K., Manvi, F. V.,Alagawadi, K. R. 2007. Evaluation of anti-inflammatory activity of *Gymnemasylvestre*leaves extract in rats. International Journal of Green Pharmacy2, 114–115.

Malik, J. K., Manvi, F. V., Nanjware, B. R.,Dwivedi, D. K.,Purohit, P.,Chouhan, S. 2010. Anti-arthritic activity of leaves of *Gymnemasylvestre*R.Br. leaves in rats. Der Pharmacia Lettre2, 336–341.

Marsh, P., Martin, M. 1992. *Oral Microbiology*, Chapman and Hall, London, U.K. Vol. 3.

Masayuki, Y., Toshiyuki, M.,Masashi, K.,Yuhao, L.,Nubotoshi, M.,Johji, Y. 1997. Chemical and Pharmaceutical Bulletin 45, 10, 1671-76.

Mathew, K.M., Rani, N. 1983. Asclepiadaceae. In: the flora of the Tamil Nadu Carnatic Part Two. Rapinat herbarium, Diocesan press, Madras, India 945-947.

Mitra, S.K., Madhavan, S. G.,Muralidhar, T.S.,Seshadri, S.J. 1996. Effect of D-400, a herbomineral formulation a liver glycogen content and microscopic structure of pancreas and liver in streptozotocin induced diabetes in rats. Indian Journal of Experimental Biology 34, 964-967.

Murakami, N., Murakami, T., Kadoya, M., Matsuda, H., Yamahara, J., Yoshikawa, M. 1996. New hypoglycemic constituents in “gymnemic acid” from *Gymnemasylvestre* . Chemical and Pharmaceutical Bulletin. 44, 2, 469–471.

Nadkarni, K.M. 1993. Indian Materia Medica. Popular prakashan, Bombay 596-9**.**

Nadkarni, K.M. 1986. Gymnemasylvestre: Indian Materia Medica with Ayurvedic Unani. Vol. I. Bombay: Popular Prakashan 596-9.

Paliwal, R., Kathori, S.,Upadhyay, B. 2009. Effect of Gurmar (*Gymnemasylvestre*) power intervention on the blood glucose levels among diabetics. Ethno-Medicine 3, 2, 133-135.

Pasha, C., Sayeed, S.,Ali, S.,Khan, Z. 2009. Turkish Journal of Biology33:59-64.

Patel, S. S., Shah, R. S.,Goyal, R. K. 2009. Antihyperglycemic, antihyperlipidemic and antioxidant effects of Dihar, a polyherbal ayurvedic formulation in streptozotocin induced diabetic rats. Indian Journal of Experimental Biology 47, 7, 564–570.

Paul, J.P.,Jayapriya, K. 2009. Pharmacologyonline3:832-836.

Persaud, S.J., Majed, H.A.,Raman, A.,Jones, P.M. 1999.Journal of Endocrinology 163, 207-212.

Pierce, A. 1999. Gymnema Monograph: Practical guide to natural medicine, Stone song Press Book, New York 324-26.

Potawale, S.E., Shinde,V.M.,Anandi, L.,Borade, S., Dhalawat, H.,Deshmukh, R.S. 2008. Pharmacology online2:144-157.

Preuss, H.G., Bagchi,D.,Bagchi, M.,Rao, C.V.,Dey, D.K.,Satyanarayana, S. 2004. Diabetes Obesity and Metabolim6, 3, 171-80.

Rachh, P. R., Rachh, M. R.,Ghadiya, N. R. 2010. Antihyperlipidemic activity of *Gymenmasylvestre*R.Br. leaf extract on rats fed with high cholesterol diet. International Journal of Pharmacology6, 2, 138–141.

Rana, A.C., Avadhoot, Y. 1992. Experimental evaluation of hepatoprotective activity of *Gymnemasylvestre* and Curcuma zedoaria. Fitoterapia63, 60.

Sabitha, R.A., Nagamani, V.,Patnaik, S.,Saidulu, B. 2012. *Gymnemasylvestre*R. Br. An important antidiabetic plant of India: A Review. Plant Sciences Feed2**,** 12, 174-179.

Sahu, N.P., Mahato, S. B., Sarkar, S.K.,Poddar, G. 1996. Triterpenoid saponins from *Gymnemasylvestre.* Phytochemistry41, 4, 1181–1185.

Satdive, R.K., Abhilash, P.,Devanand, P.F. 2003. Fitoterapia74, 699-701.

Sredeevi, P.,Namboodiri, A. N. 1977. IOPB chromosome numbers reports. LVI, Taxon,26, 257-274.

Srinivasan, K., Kumaravel, S. 2016. Unraveling the potential phytochemical compounds of *Gymnemasylvestre* through Gc-Ms study. Int J Pharm Pharm Sci.8(1), 450-3.

Shanmugasundaram, E.R.B., Leela, K.G.,Radha, K.S., Rajendran, V. M. 1990. Possible regeneration of the islets of Langerhans in streptozotocin - diabetic rats given *Gymnemasylvestre*leaf extracts. Journal of Ethnopharmacology30, 265-279.

Shiyovich, A., Sztarkier, I.,Nesher, L. 2010. Toxic hepatitis induced by *Gymnemasylvestre*, a natural remedy for type 2 diabetes mellitus. *American Journal of the Medical Sciences* 340, 6, 514–517.

Singh, V. K., Umar, S.,Ansari, S.A., Iqbal, M. 2008. *Gymnemasylvestre*for diabetics. Journal of Herbs, Spices and Medicinal Plants14, 1-2, 88–106.

Sinsheimer, J.E., Rao, G.S. 1970. Journal of Pharmaceutical Sciences. 59, 5, 622-628.

Sinsheimer, J. E., Rao, G. S.,McIlhenny, H. M. 1970. Constituents from *Gymnemasylvestre*leaves. Isolation and preliminary characterization of the gymnemic acids. Journal of Pharmaceutical Sciences59, 5, 622–628.

Srividya, A. R., Varma, S. K.,Dhanapal, S. P., Vadivelan, R.,Vijayan, P.2010. *In vitro* and *in vivo* evaluation of hepatoprotective activity of *Gymnemasylvestre.*International Journal of Pharmaceutical Sciences and Nanotechnology2, 768–773.

Stocklin, W., Weiss, E., Resichstein, T. 1967. Gymnemasaure das anti saccharine prinzip von *Gymnemasylvestre* R.Br. isolierngen und identifizierungen. Helvetica Chimica Acta. 50(2), 474–490.

Sugihara, Y., Nojima, H.,Matsuda, H.,Murakami, T.,Yoshikawa, M.,Kimura, I. 2000. Antihyperglycemic effects of gymnemic acid IV, a compound derived from *Gymnemasylvestre*leaves in streptozotocin-diabetic mice. Journal of Asian Natural Products Research2(4), 321–327.

Suttisri, R., Lee, I. S.,Kinghorn, A. D. 1995. Plant-derived triterpenoid sweetness inhibitors. Journal of Ethnopharmacology 47(1), 9–26.

Trease, G. E., Evans, W. C. 1983. *Pharmacognosy*, vol. 12, Balliere Tindale, London, UK.

Yadav, S., Grover, J.K., Vats, V. 2001. Medicinal plants of India with anti-diabetic potential. Journal of Ethanopharmacology 81(1), 81-100.

Yoshikawa, K., Murakami, T.,Matsuda, H. 1997. Medicinal food stuffs. IX. The inhibitors of glucose absorption fromthe leaves of *Gymnemasylvestre*R.Br. (Asclepiadaceae): structures of gymnemosides A and B. Chemical and Pharmaceutical Bulletin 45(10),1671–1676.

Yoshikawa, K., Amimoto, K., Arihara, S., Matsuura, K. 1989. Gymnemic acid V, VI and VII from gur-ma, the leaves of *Gymnemasylvestre* R.Br. Chemical and Pharmaceutical Bulletin.37(3), 852–854.

Yoshikawa, K., Nakagawa, M., Yamamoto, R., Arihara, S., Matsuura, K. 1992. Antisweet natural products. V. Structures of gymnemic acids VIII-XII from *Gymnemasylvestre* R.Br. Chemical and Pharmaceutical Bulletin. 40(7), 1779–1782.

Yoshikawa, K., Arihara, S., Matsuura, K. 1991. A new type of antisweet principles occurring in *Gymnemasylvestre* . Tetrahedron Letters.32(6), 789–792.

Husen A, editor. Antidiabetic medicinal plants and herbal treatments. CRC Press; 2023 Jul 17.