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A CRITICAL REVIEW ON POTENTIAL PHARMACOLOGICAL AND PHYTOCHEMICAL PROPERTIES OF *GYMNEMA SYLVESTRE* R. Br.

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ABSTRACT

This review aims to present the potential information related to pharmacological actions and chemical composition of *Gymnema sylvestre* R.Br. (Asclepiadaceae), which is used in many Asian countries as a traditional medicine especially for the treatment of diabetes mellitus. Our main objective was to collect information about pharmacological actions and active constituents of this plant. Review of literature included PubMed, Science Direct searches *with 'Gymnema sylvestre' and 'gurmar'* as initial key words. The search was further refined by looking for terms such as 'Constituents' (or composition) and 'Activity' (or effect) within the results. The major bioactive constituents of *G. sylvestre* are a group of triterpenoid glycosides known as gymnemic acids with gymnemagenin as common aglycone. *G. sylvestre* has good prospects in the treatment of diabetes as it shows positive effects on blood sugar homeostasis, controls sugar cravings, and promotes regeneration of pancreas. The herbal extract is used in dietary supplements because it reduces body weight, blood cholesterol, and triglyceride levels. The *G. sylvestre* is a rich source of chemically novel compounds and needs elaborate screening strategies to dwell into the pharmacological effects of its phyto-constituents at the molecular level.

INTRODUCTION

This review aims to present the potential information related to pharmacological actions and chemical composition of *Gymnema sylvestre* R.Br. (Asclepiadaceae), which is used in many Asian countries as a traditional medicine especially for the treatment of diabetes mellitus. Review of literature included PubMed, Science Direct searches *with 'Gymnema sylvestre' and 'gurmar'* as initial key words. The search was further refined by looking for terms such as 'Constituents' (or composition) and 'Activity' (or effect) within the results. The major bioactive constituents of *G. sylvestre* are a group of triterpenoid glycosides known as gymnemic acids with gymnemagenin as common aglycone. *G. sylvestre* has good prospects in the treatment of diabetes as it shows positive

effects on blood sugar homeostasis, controls sugar cravings, and promotes regeneration of pancreas. The herbal extract is used in dietary supplements since it reduces body weight, blood cholesterol, and triglyceride levels and holds great prospects in dietary as well as pharmacological applications.

Gymnema sylvestre R.Br. (Asclepiadaceae) is a herb native to the tropical forests of southern and central India and Sri Lanka. Chewing the leaves suppresses the sensation of sweet taste. It has been used as traditional medicine for the treatment of diabetes.[9] Sushruta describes *G. sylvester*, as a destroyer of madhumeha (glycosuria) and other urinary disorders. The plant is also used as bitter, astringent, acrid, thermogenic, anti-inflammatory, anodyne, digestive, liver tonic, emetic, diuretic, stomachic, stimulant, anthelmenthics, laxative, cardiotonic, expectorant, antipyretic and uterine tonic. It is useful in dyspepsia, constipation, jaundice, haemorrhoids, renal and vesical calculi, cardiopathy, asthma, bronchitis, amenorrhoea, conjuctivitis and leucoderma.[10] However, to best of our knowledge, till date systemic studies to understand the molecular basis of diabetes and related complications preventing properties of active constituent of *G. sylvestre* (gymnemic acids) has not been reported. Hence, the present review aims to compile an up-to-date information on the progress made in the protective role of *G. sylvestre* and or gymnemic acids in diabetes mellitus and related complications with the objective of providing a guide for future research on this plant and bioactive molecule. Hence, we planned to collect the research articles related to *G. sylvestre* and gymnemic acids from various scientific databases and write a systemic review of its potential pharmacological role in management of diabetes mellitus and related cardiovascular complications. The review papers also enlisted phytochemistry of *G. sylvestre*.

METHADOLOGY

The information on the *G. sylvestre* and gymnemic acids in diabetes mellitus and related complications were collected from several databases such as Science direct, Pubmed, NCBI, Springer and Google scholar etc., from 1962 to 2018. Some information also collected from the official websites, such as IDF, and WHO. The keywords used for the searching, such as *G. sylvestre* and diabetes mellitus, *G. sylvestre* and antihyperlipidaemic activity, *G. sylvestre* and antioxidant activity, *G. sylvestre* and anti-inflammatory activity, and analytical reports and pharmacokinetics of gymnemic acids.

PHYTOCHEMICAL REPORTS

The major bioactive constituents of *G. sylvestre* are a group of oleanane type triterpenoid saponins known as gymnemic acids. The chemical structures of phytoconstituents isolated from *G. sylvestre* are summarized in Figure 1. Triterpenoid saponins of gymnemic acid A, B, C and D with sugar residues such as glucuronic acid, galacturonic acid, ferulic and angelic acids attached through carboxylic acids. The leaves also contain betaine, choline, gymnamine alkaloids, inositol and 1-quercitol.[11]

Hydrocarbons such as nonacosane, hentriacontane, tritriacontane, pentatriacontane, phytin, resin, tartaric acid, formic acid, butyric acid, amino acids such as leucine, isoleucine, valine, alanine, γ-butyric acid has been reported.[12] Gymnestrogenin, a pentahydroxy triterpene from the leaves of *G. sylvestre* has been reported.[13]

Four tritepenoid saponins, gymnemasins A, B, C and D isolated from the leaves of *G. sylvestre*, are characterized as 3-*O*-[*β*-D-glucopyranosyl (1→3)-*β*-D-glucuronopyranosyl]- 22-*O*-tigloyl-gymnemanol, 3-*O*-[*β*-D-glucopyranosyl (1→3)-*β*- D-glucuronopyranosyl]-gymnemanol, 3-*O*-*β*-D-

glucuronopyranosyl-22-*O*-tigloyl-gymnemanol and 3-*O*-*β*-D-glucuronopyranosyl-gymnemanol, respectively. The aglycone, gymnemanol, is characterized as 3*β*,16*β*,22*α*,23,28-pentahydroxyolean-12-ene.[14]

The gymnemic acids reported from *G. sylvestre* includes gymnemic acids I-VII, gymnemosides A-F and gymnemasaponins.[15-16]

Six triterpene glycosides are isolated from the dried leaves of G. sylvestre and characterized as gymnemosides a, b, c, d, e, and f. The structures of gymnemosides a and b are determined as 21-*O*-tigloyl-22-*O*-acetylgymnemagenin 3-*O*-*β*-D-glucopyranosiduronic acid and 16-*O*-acetyl-21-*O*-tigloylgymnemagenin 3-*O*-*β*-D-glucopyranosiduronic acid, respectively.[17]

Six oleanane-type saponins were isolated from the leaves of *G. sylvestre*. The structures of the oleanane triterpene glycosides were characterized as longispinogenin 3-*O*-*β*-D-glucuronopyranoside, 21-*β*-benzoylsitakisogenin 3-*O*-*β*-D-glucuronopyranoside, 3-*O*-*β*-D-glucopyranosyl (1→6)-*β*-D-glucopyranosyl oleanolic acid 28-*O*-*β*-D-glucopyranosyl ester, oleanolic acid 3-*O*-*β*-D-xylopyranosyl (1→6)-*β*-D-glucopyranosyl(1→6)-*β*-D-glucopyranoside, 3-*O*-*β*-D-xylopyranosyl (1→6)-*β*-D-glucopyranosyl (1→6)-*β*-D-glucopyranosyl oleanolic acid 28-*O*-*β*-D-glucopyranosyl ester and 3-*O*-*β*-D-glucopyranosyl (1→6)-*β*-D-glucopyranosyl oleanolic acid 28-*β*-D-glucopyranosyl (1→6)-*β*-D-glucopyranosyl ester.[18]

Wen-Caiet al.,[19] isolated five triterpenes from the leaves of *G. sylvestre* namely30-hydroxylupeol, oleanolic acid, longispinogenin (3*β*,16*β*,28-trihydroxyolean-12-ene), sitakisogenin (3*β*,16*β*,21*β*,28-tetrahydroxyolean-12-ene) and chichipegenin (3*β*,16*β*,22*α*,28-tetrahydroxyolean-12-ene).

A flavonol glycosides, kaempferol 3-O-*β*-D-glucopyranosyl-(1→4)-*α*-*L*-rhamnopyranosyl-(1→6)-*β*-D-galactopyranoside have been isolated from the aerial parts of *G. sylvestre*.[20]

Two oleanane-type triterpenoid saponins, gymnemoside-W1 and W2 were isolated from the leaves of *G. sylvestre*, and characterized as 16*β*-hydroxyl olean-12-en-3-*O*-[*β*-D-glucopyranosyl (1→6)-*β*-D-glucopyranosyl]-28-*O*-*β*-D-glucopyranoside and 16*β*,21*β*,28-trihydroxyl-olean-12-ene-3-*O*-glucoronopyranoside.[21]

Eight compounds are isolated from stem of *G. sylvestre;* conduritol A, 1-heptadecanol, stigmasterol glucoside, 1-quercitol, 1-octadecanol, potassium nitrate, lupeolcinnamate and stigmasterol.[22]Few workers also isolated different chemical constituents from *G. sylvestre* mention in Figure 1.[23-26]

A mixture of gymnemicacids was precipitated from the water extract of leaves of *G. sylvestre* by acidification with mineral acid. The chromatographic separation of gymnemic acids mixture afforded four arylated gymnemic acids 23-O-β-D-glucopyranosyl-21-O-tigloyl-28-Obenzoyl-16,22-dimethoxygymnemagenin (1); 3-O-β-D-glucuronopyranosyl-16-O-acetyl-21-O-hydrocoumaroyl-16β,21β,23,29-tetrahydroxyoleanolic acid 28-O-β-D-glucopyranosyl ester (2); 3-β-O-D-glucopyranosyl21-O-hydrocinnamoyl-16β,21β,23,29-tetrahydroxyoleanolic acid 28-Oβ-D-glucopyranosyl ester (3) and 3-O-β-D-glucuronopyranosyl-21-O-hydrocinnamoyl-7β-hydroxygymnemagenin (4) along with a gymnemasaponin characterized as 3-β-O-D-glucopyranosyl 3β,16β,23,28-tetrahydroxyolean-12-ene (5).[27]

PHARMACOLOGICAL REPORTS: *Gymnema sylvestre* has a long history of human use in traditional medicine throughout the world. There is plethora of reports of experimental and clinical evidences related to its different uses that are summarized below (also in Table 1).

Antidiabetic and Hypolipidaemic activity

The ethanol extract of *G. sylvestre* at a dosage of 100 mg/kg orally was evaluated for its antidiabetic effects in normal and anterior pituitary extract induced hyperglycaemic rats. The results indicated insignificant reduction in blood sugar in normal rats, whereas significant reduction in anterior pituitary extract induced hyperglycaemic rats.[28-29]

G. sylvestre extracts and purified gymnemic acid showed inhibitory effects on Gastic Inhibitory Peptide (GIP) release in rats, the results suggested that a glucose receptor which interacted with the leaf extracts of *G. sylvestre* and purified gymnemic acid.[30] Gymnemoside b and gymnemic acids III, V, and VII showed a little inhibitory activity against glucose absorption, but the principal constituents, gymnemic acid I and gymnemasaponin V lack this activity in oral glucose-loaded rats.[31]

The alcoholic extract of *G. sylvestre* stimulated insulin release from HIT-T15, MIN6 and RINm5F β-cells and from islets in the absence of any other stimulus, and *G. sylvestre* stimulated insulin secretion was attributed to increased membrane permeability.[32]

Sugihara et al.[33]examined the antihyperglycemic action of a crude saponin fraction and five triterpenic glycosides (gymnemic acids I-IV and gymnemasaponin V) derived from the methanol extract of leaves of *G. sylvestre* in STZ-induced diabetic mice. The saponin fraction (60 mg/kg) reduced blood glucose levels 24 h after i.p. administration. Gymnemic acid IV significantly reduced the BGL after the administration comparable to glibenclamide, and did not change the BGL of normal mice.

G. sylvestre extract treatment once a day to rats fed with high fat diet or normal fat diet for 3 weeks, improved serum cholesterol and triglyceride levels through the influence over a wide range of lipid metabolism.[34]

G. sylvestre extract suppressed body weight gain and accumulation of liver lipids in high fat diet induced experimental diabetes whereas in normal fat diet, plasma triglyceride levels decreased.[35]The ethanolic extract of *G. sylvestre* leaf was examined *in-vitro* and *in-vivo* to investigate the hypoglycemic and antioxidants effects in diabetic rats. The extract exhibited strong antioxidant activity in the assays, including TBA (56%), SOD-like (92%), and ABTS (54%). Blood glucose levels in the diabetic rats fed *G. sylvestre* extract decreased to normal levels.[36] Methanolic extract of *G. sylvestre* and *Andrographis paniculata* was administered orally in graded doses of 30 mg/kg,50mg/kg Sprague dawly rats. *G. sylvestr e*and *A. paniculata* showed significant anti-hyperglycemic and anti-oxidative effect at a dose of 30mg/kg and 50mg/kg, respectively which was evident from the 1st week of treatment.[37]

The arylated compounds (1–4) showed dose dependent inhibition ofα-glucosidase that was found to be comparable to acarbose. The results revealed that the overall pattern of acyl and or aryl substitution and glycosylation of compounds affected their inhibitory activity. The bidesmosidic glycosides (2 and 3) showed improved potency than the monodesmosidic glycosides (1 and 4) possibly because the additional glucose unit in the former facilitated stronger hydrogen bonding at the catalyticsite. The current study provides relatively direct evidence of effectiveness of *G. sylvestre* against hyperglycemia.[27]The antidiabetic studies of *G. sylvestre* were also evaluated by several other workers.[38-47]The clinical studies on *G. sylvestre* were also reported by many workers.[48-50]

Leaf extract of *G. sylvestre* (25-100 mg/kg p.o.) administered to high fat fed hyperlipidaemic rats for two weeks reduced the elevated serum triglycerides, total cholesterol, VLDL and LDL-cholesterol in a dose dependent manner. Its anti-antheroscelrotic potential were almost

similar to that of a standard lipid lowering agent clifibrate.[51]The aqueous leaf extract of*G. sylvestre* in alloxan induced diabetic ratsat the dose of 400, 600 and 800 mg/kg were evaluated for 30 days. The fasting blood glucose, cholesterol and serum triglyceride content were found to be significantly reduced ($p<0.05$) in treated rats whereas the extract also showed the potent elevation in the level of serum HDL cholesterol.[52]

In the study, highcholesterol diet, standard atorvastatin, and high cholesterol diet with hydro-alcoholic extract of gymnemic acid were fed to female rats for seven days. It was observed that the rats fed with high cholesterol diet showed increase in serum cholesterol, serum triglycerides, low-density lipoprotein cholesterol, and very low-density lipoproteinandsignificantdecreaseinhigh-densitylipoproteincholesterolincomparison tonormal animals. The group administered with hydro-alcoholic extract of *Gymnema* leaves at a dose of 200mg/kg showed significant reduction in the levels of all lipids with increase in HDL-C as compared to high cholesterol diet control.[53]

A study demonstrated that the hexane extract of the leaves of *G. sylvestre*possessesantiobesityactivity.Itwas foundthat,after45daysofadministration of hexane extract of *G. sylvestre*, a significant reduction in increased body weight and high temperature due to obesity wasobserved.Also,thehexaneextractimprov edthecholesterol,triglyceride,LDL,andHD Llevels.Thehexaneextractof the leaves of *G. sylvestre* have the potential to treat obesity comparable with that of standard drug, atorvastatin.[54] The studies showed that the leaf extract has good prospects in the reduction of cholesterol levels and as a herbal medication for obesity.

Antimicrobial activity

In an *in-vitro* study, the ethanolic extract of *G. sylvestre* leaves showed antimicrobial activity against *Bacillus pumilis, B. subtilis, Pseudomonas aeruginosa* and *Staphylococcus aureus* and inactivity against *Proteus vulgaris* and *Escherichia coli*.[55]

The crude extracts of *G. sylvestre* leaves and purified gymnemagenol compound were studied against the early fourth-instar larvae of *Anopheles subpictus* and *Culex quinquefasciatu*.[56]

Hepatoprotective activity

The alcoholic extract of the *G. sylvestre* leaves at 300 mg/kg *p.o.* dose showed hepatoprotective activity against CCl_4-induced hepatic damage in rats. The extract showed a significant decrease in weight and volume of liver, levels of SGPT and ALP and reduced pentobarbitone (50 mg/kg, i.p.) induced sleeping time as compared to control group.[57]

Cytotoxic activity

Gymnemagenol, a saponin isolated from the methanolic extract of the leaves at 5, 15, 25 and 50 µg/ml concentrations showed dose-dependent *in-vitro* cytotoxic activity against HeLa (Human cervical carcinoma) cells with IC_{50} value being 37 µg/ml at 48 h exposure period.[58]

ANALYTICAL REPORTS

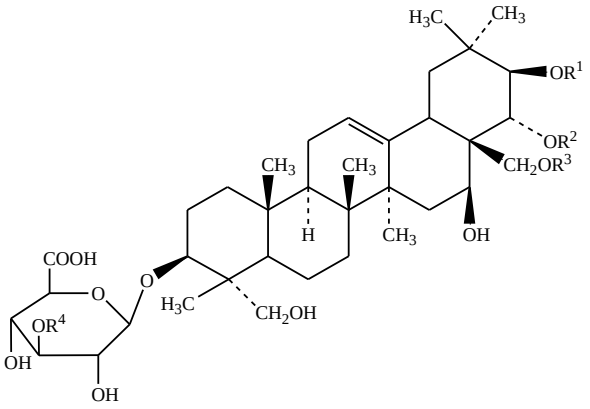
Given the importance of *G. sylvestre* in traditional systems of medicine, only few analytical methods have been reported for the estimation of its bioactive component gymnemic acid as gymnemagenin. An HPTLC method has been developed for the determination of gymnemagenin in *G. sylvestre* leaves. The gymnemagenin was separated on pre-coated silica gel 60 F_{254} plates with chloroform-methanol (9:1) and scanned using a densitometric scanner in the UV reflectance mode at 290 nm.[59]

HPTLC method has been developed for the standardisation of *G. sylvestre* with respect to gymnemagenin.

Table 1. Pharmacological and Clinical Activities of *G. sylvestre*

S. No.	Fraction/ Constituents	Pharmacological activities	References
1	Ethanol extract	*G. sylvestre* at a dosage of 100 mg/kg orally shows insignificant reduction in blood sugar in normal rats	[28-29]
2	Gymnemosides	Gymnemoside b and gymnemic acids III, V, and VII showed inhibitory activity against glucose absorption	[31]
3	Alcoholic extract	The alcoholic extract of *G. sylvestre* stimulated insulin release	[32]
4	Gymnemic acids	The crude saponin fraction and gymnemic acids I-IV and gymnemasaponin V showed antidiabetic activity in STZ-induced diabetic mice	[33]
5	Extract	*G. sylvestre* extract treatment improved serum cholesterol and triglyceride levels	[34]
6	Ethanolic extract	The extract showed blood glucose lowering effect in diabetic rats	[36]
7	Methanolic extract	Methanolic extract showed significant anti-hyperglycemic and anti-oxidative effect	[37]
8	Gymnemic acids	The arylated gymnemic acids showed dose dependent inhibition of α-glucosidase enzyme in *in-vitro*	[27]
9	Leaf extract	Leaf extract of *G. sylvestre* showedanti-antheroscelrotic potential in experimental animal model	[51]
10	Aqueous leaf extract	The aqueous leaf extract of *G. sylvestre* showed anti-hyperlipidemic effects in experimental animal model	[52]
11	Hexane extract	The hexane extract of the leaves of *G. sylvestre* possesses antiobesity activity	[54]
12	Ethanolic extract	In an *in-vitro* study, the ethanolic extract of *G. sylvestre* leaves showed antimicrobial activity against	[55]
13	Alcoholic extract	The alcoholic extract of the *G. sylvestre* leaves showed hepatoprotective activity against CCl4-induced hepatic damage in rats	[57]
14	Gymnemagenol	Gymnemagenol showed dose-dependent *in-vitro* cytotoxic activity against HeLa (Human cervical carcinoma) cells	[58]

Triterpene saponins: (Sahu et al.[14]; Kuzukoet al.[15]; Masayuki et al.[16]; Liu et al.[23])

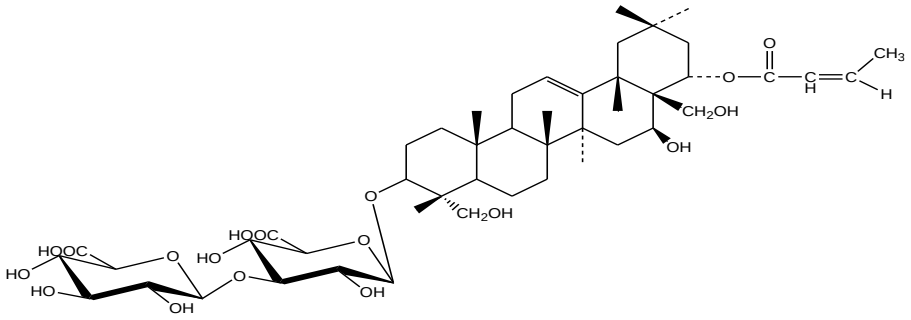


Gymnemic acids

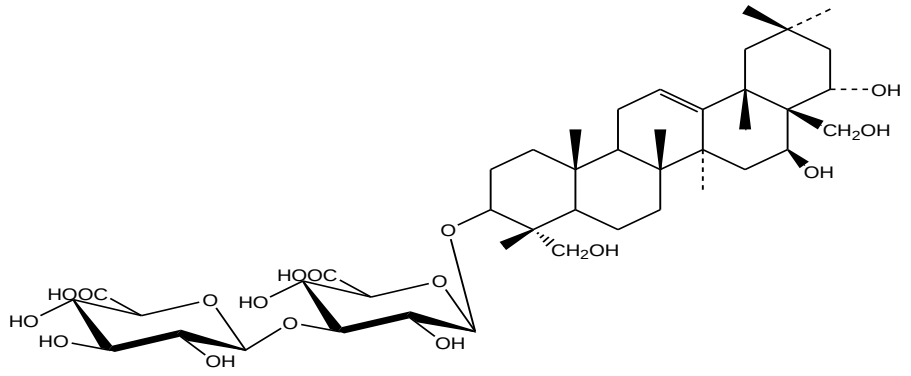
Gymnemic acid	R^1	R^2	R^3	R^4
I	*-tga*	*-H*	*-Ac*	*-H*
II	*-mba*	*-H*	*-Ac*	*-H*
III	*-mba*	*-H*	*-H*	*-H*
IV	*-tga*	*-H*	*-H*	*-H*
V	*-tga*	*-tga*	*-H*	*-H*
VIII	*-mba*	*-H*	*-H*	*-OG*
IX	*-tga*	*-H*	*-H*	*-OG*
X	*-H*	*-H*	*-Ac*	*-H*
XI	*-tga*	*-H*	*-tga*	*-H*
XII	*-tga*	*-H*	*-Ac*	*-glu*
XIII	*-H*	*-H*	*-mba*	*-H*
XIV	*-H*	*-H*	*-tga*	*-H*

(Where: -Ac = acetyl; -Glu = glucose; -OG = *β*-arabino-2-hexulopyranosyl, tga = tigloyl, mba = 2-methyl butyroyl)

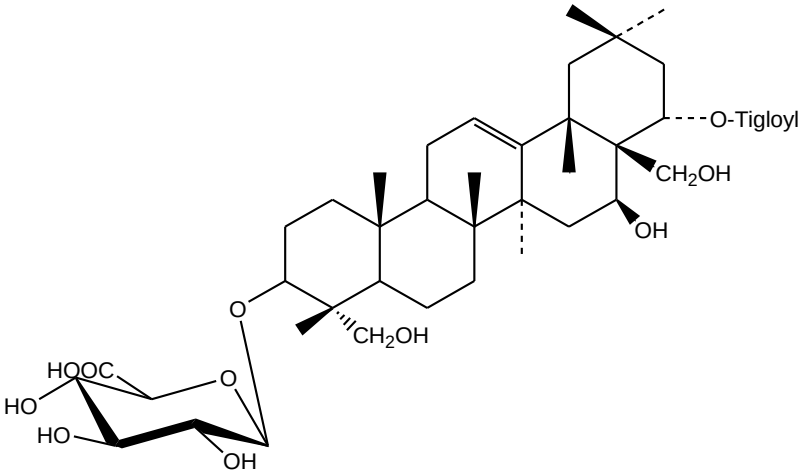
Triterpenoid saponins: (Sahu et al.[14])



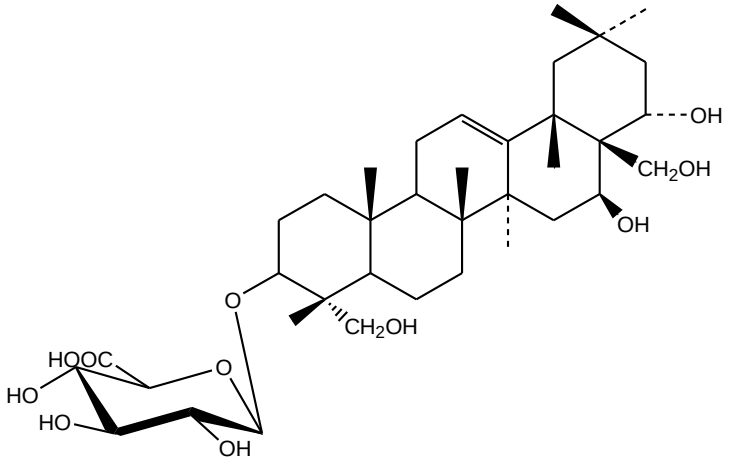
Gymnemasins A (3-*O*-[*β*-D-glucopyranosyl (1→3)-*β*-D-glucuronopyranosyl]- 22-*O*-tigloyl-gymnemanol)



Gymnemasins B (3-*O*-[*β*-D-glucopyranosyl (1→3)-*β*- D-glucuronopyranosyl]-gymnemanol)

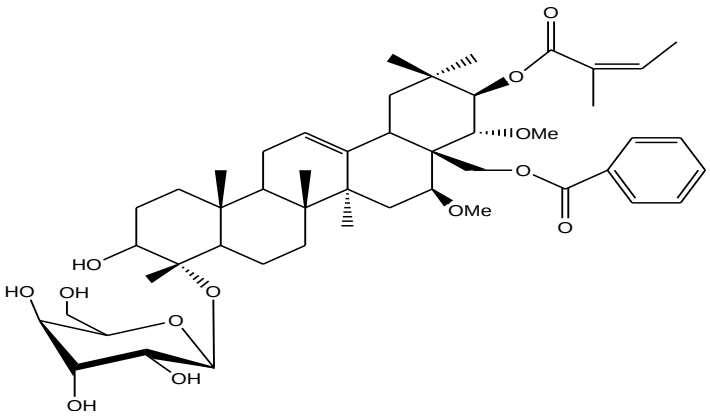


Gymnemasins C (3-*O*-*β*-D-glucuronopyranosyl-22-*O*-tigloyl-gymnemanol)

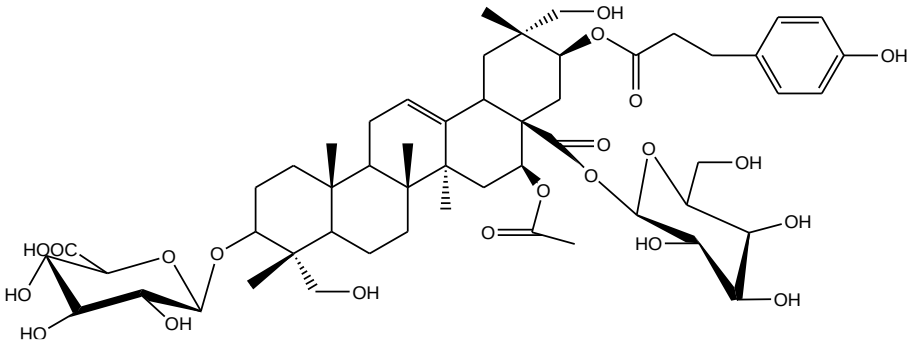


Gymnemasins D (3-*O*-*β*-D-glucuronopyranosyl-gymnemanol)

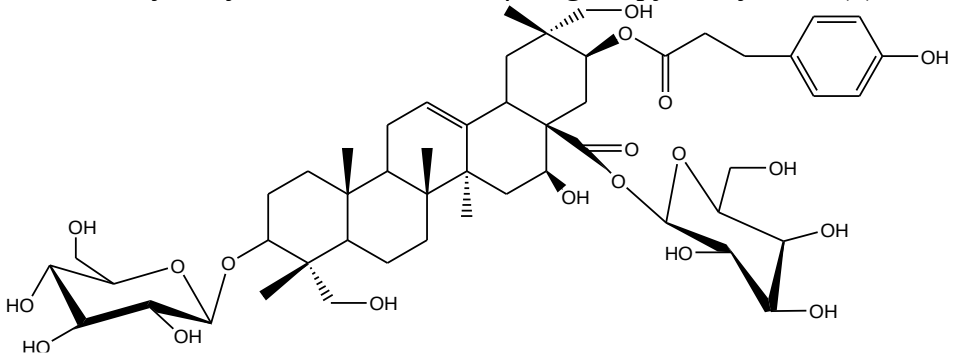
Arylated gymnemic acids: Alkefai et al.[27]



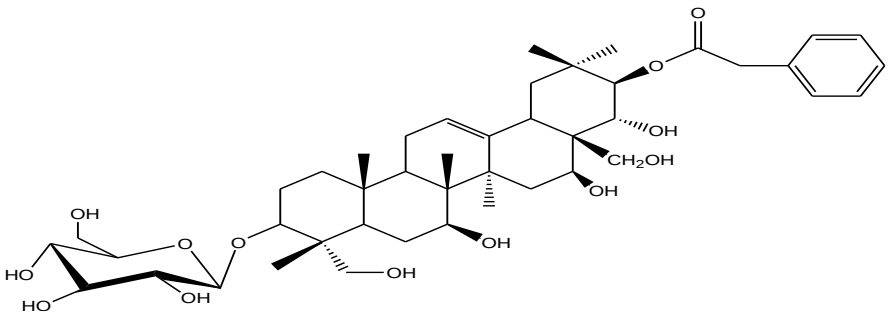
23-O-β-D-glucopyranosyl-21-O-tigloyl-28-Obenzoyl-16,22-dimethoxygymnemagenin (1)



3-O-β-D-glucuronopyranosyl-16-O-acetyl-21-O-hydrocoumaroyl-16β,21β,23,29-tetrahydroxyoleanolic acid 28-O-β-D-glucopyranosyl ester (2)

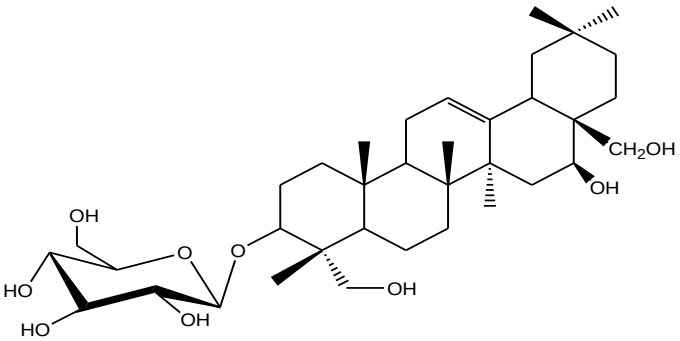


3-β-O-D-glucopyranosyl 21-O-hydrocinnamoyl-16β,21β,23,29-tetrahydroxyoleanolic acid 28-Oβ-D-glucopyranosyl ester (3)



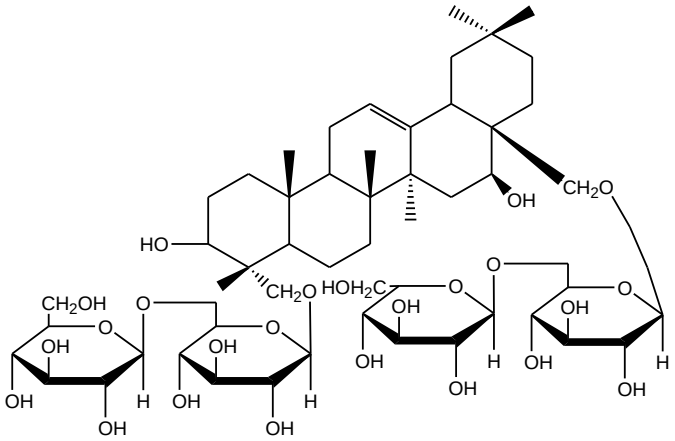
3-O-β-D-glucuronopyranosyl-21-O-hydrocinnamoyl-7β-hydroxygymnemagenin (4)

Gymnemasaponin: (Alkefai et al.[27])

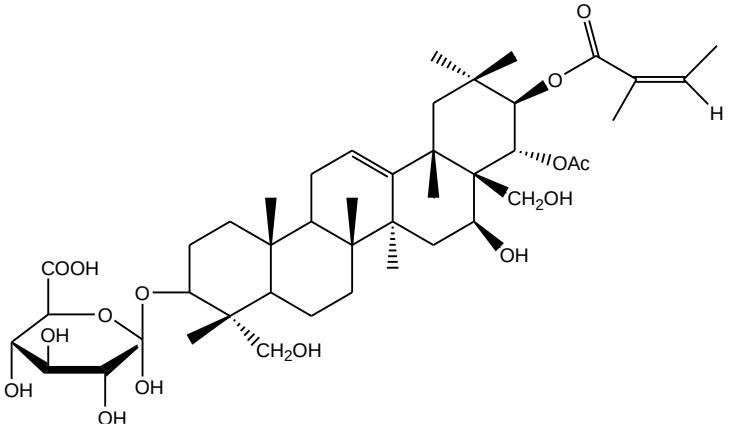


3-β-O-D-glucopyranosyl 3β, 16β, 23, 28-tetrahydroxyolean-12-ene (5)

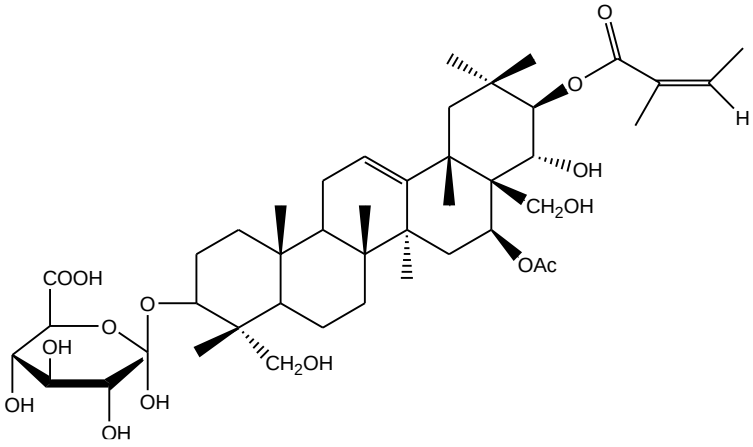
Oleanane saponins (Yoshikawa et al.[17])



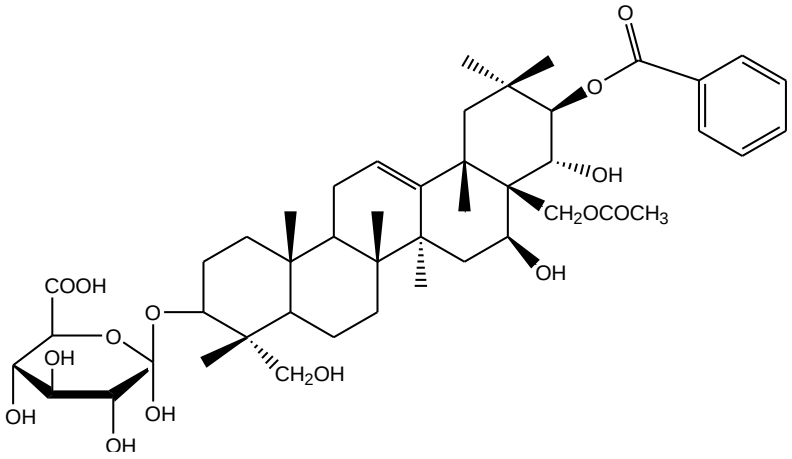
Gymnemasaponins V



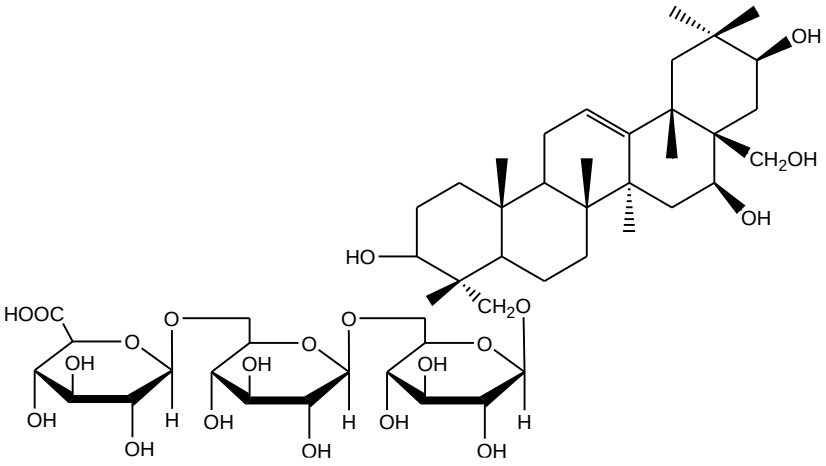
Gymnemoside A



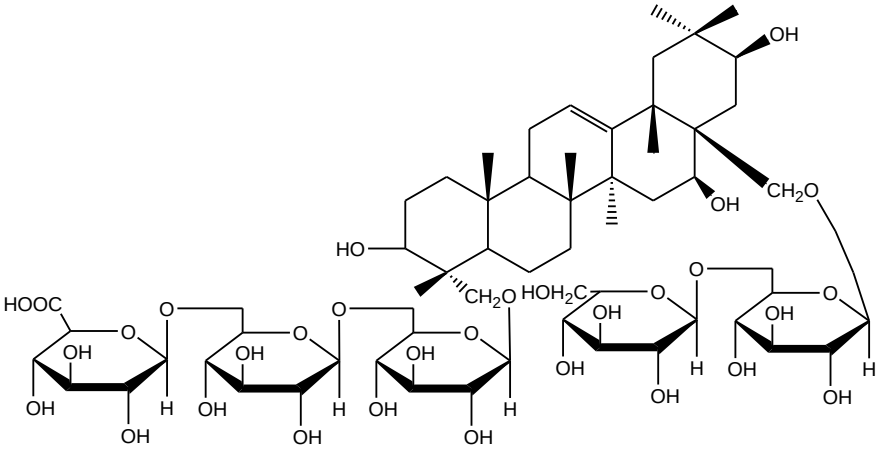
Gymnemoside B



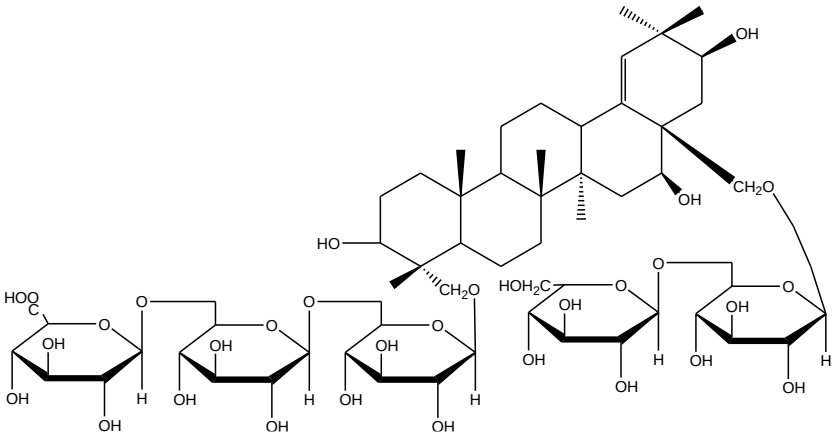
Gymnemoside C



Gymnemoside D

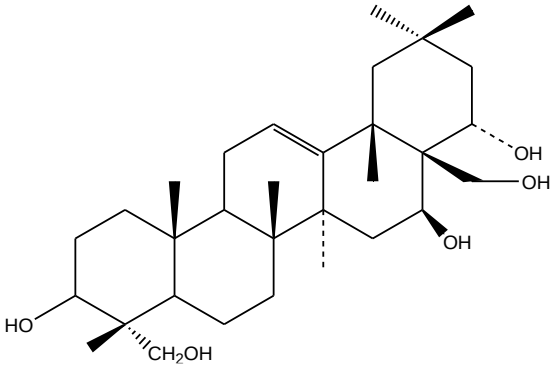


Gymnemoside E



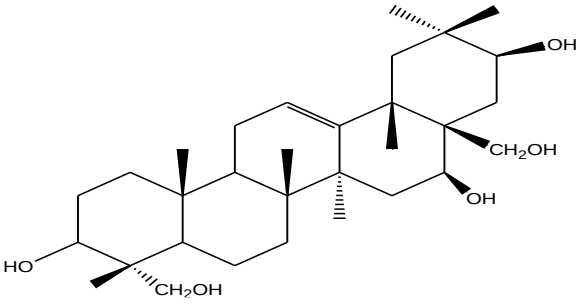
Gymnemoside F

Gymnemanol (aglycone): (Sahu et al.[14])



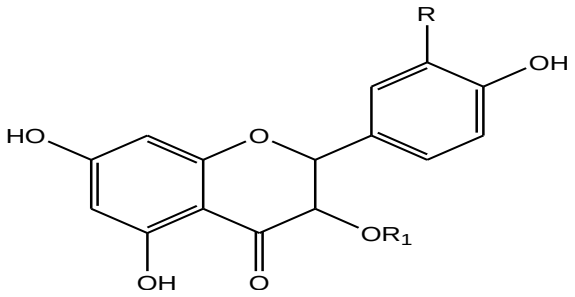
3, β-16, β-22, α-23-28-pentahydroyolean-12ene

Gymmestrogenin:(Yoshikawa et al.[17])



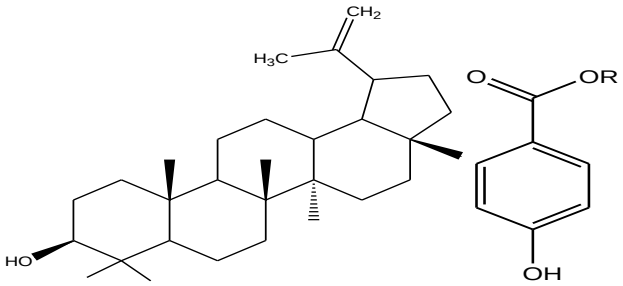
Pentahydroxytriterpene

Flavonol glycoside:(Liu et al.[25])



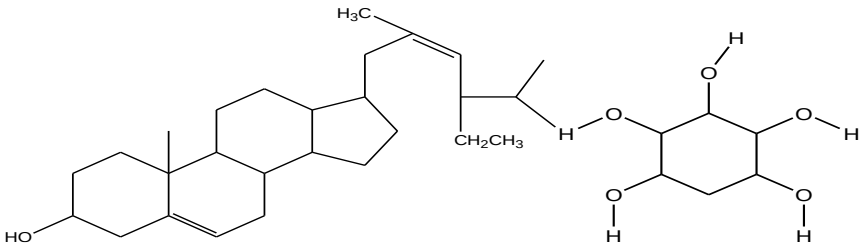
Kaemferol-3-O-β-D-glucopyranosyl-(1-4)-α-L-rhamnopyranosyl-(1-6)-β-D-galactopyranoside

Miscellaneous compounds:



Lupeol Paraben

(Sinsheimer et al.[24])



Stigmasterol D-Quercitol

(Potawale at al.[26])

Figure. 1. Chemical constituents reported from *G. sylvestre*

The method involves the initial hydrolysis of gymnemic acids, the active ingredients, to a common aglycone followed by quantitative estimation of gymnemagenin.[60]

An HPTLC method has been developed for the indirect determination of gymnemic acids as gymnemagenin in *G. sylvestre*. The method was found to be more sensitive, precise and accurate for quantification of gymnemagenin from plant leaf powder, extract and poly herbal marketed formulation.[61]

Another RP-HPLC method has been developed for the determination of gymnemagenin in leaves *G. sylvestre*.

Gymnemagenin was obtained after acidic hydrolysis followed by basic hydrolysis of the sample and extraction into ethyl acetate. The developed method was applied for the analysis of leaf samples of *G. sylvestre* collected from three different regions, a marketed *G. sylvestre* extract and an anti-diabetic polyherbal formulation containing *G. sylvestre* leaf powder.[62] An indirect simultaneous estimation of gymnemic acid as gymnemagenin and charantin as β-sitosterol after hydrolysis has been developed. Aluminum-backed silica gel 60 F_{254} plates were used as stationary phase and toluene-ethyl acetate-methanol-formic acid (60:20:15:5, v/v) as mobile phase. Developed chromatogram was scanned at 550 nm after derivatization with modified vanillin–sulfuric acid reagent. The developed method was successfully applied for the analysis of leaf samples of *G. sylvestre* and fruits of *M. charantia* and herbal formulation containing *G. sylvestre*, *M. charantia* and *Enicostema littorale*.[63]

CONCLUSION

G. sylvestre hold saunique position among the sweetness modifying materials of natural origin. The herb accounts for multiple pharmacological significance as a naturopathic medication since ancient times and gaining popularity in the present scenario as well. Several clinical trials and experimental studies indicated that the plant is an invaluable source of bioactive compounds and phytoconstituents like gymnemic acids have been used as molecular targets in drug development. Besides having pharmacological importance, the herbal extract exhibits good prospects in dietary applications. Amongthemedicinalplants, *G. sylvestre* is a herb less exploited for its innumerable advantages. The aim of this review is to highlight the prospects of thisrareherbasapotentialmedicationfortreatmentofdiseases from diabetes, obesity to cardiovascular disorders. *G. sylvestre*is a rich source of chemically novel compounds and needs exhaustive screening against new targets in future.

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CONFLICTS OF INTEREST: None.

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