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Ethnopharmacology, Phytoconstituents, Essential Oil Composition and Biological Activities of the genus *scutellaria*

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Abstract

Plants are used in different traditional systems of Indian medicine. *Scutellaria* (Lamiaceae) includes about 350 species commonly known as skullcaps is widespread in Europe, the United States and East Asia with a long history of traditional uses in many countries in the world. Phytochemical investigations have revealed that the plant contain flavonoids and diterpene compounds known to possess multiple health beneficial effects. This review presents the comprehensive overview of traditional uses, phytochemical constituents and pharmacological properties of *Scutellaria* genus such that the potential use of this plant in various traditional medicines can be systematically evaluated.

Key Words: *Scutellaria* genus, Essential oil, Structure, Biological activity

INTRODUCTION

Scutellaria (Lamiaceae) includes about 350 species commonly known as skullcaps [1] is widspread in Europe, the United States and East Asia. Have already been reviewed the ethnopharmacology, the biological activities and the correlated chemical compounds of *Scutellaria* species. More than 295 compounds have been isolated, among them predominantly flavonoids and diterpenes has been reported. Studies show that *Scutellaria* and its active principles possess wide pharmacological actions, such as antitumor, anti-angiogenesis, hepatoprotective, antioxidant, anticonvulsant, antibacterial and antiviral activities [1,2]. Individual compounds have been screened for pharmacological activity from *Scutellariavivo* and *in vitro*. Currently many more compounds, biological activities, essential oils from *Scutellaria* have been reported.

To our knowledge, till date, no particular review is available with an updated information on *Scutellaria genus*. Therefore, the present review is aimed to compile an up-to-date and comprehensive review of Scutellaria that covers its ethnomedicinal uses, phytochemical contents and scientifically proven pharmacological properties. Hopefully the information provided in this review will be useful and applicable for future research works aiming towards exploiting the plants nutraceutical potentials. Increasing data supports application and exploitation for new drµgdevoelopment.

The genus is widespread in temperate regions and tropical mountains including Europe, North America and East Asia [3]. Plants of this genus have been widely used in local medicine for thousands of years [4]. Modern pharkmacology research has confirmed that the extracts or monomeric compounds of the genus *Scutellaria*posses antitumor, hepatoprotective, antioxidant, anti-inflammatory, anticonvulsant, antibacterial and antiviral effects [1].

The chemical compounds of the genus *Scutellaria* have been studied since 1889 more than 295 compounds have been obtained from 35 species. Phenolic compounds (Flavonoids, Phenylethanoid glycosides) and terpenes (Iridoid glycosides, Diterpenes and Triterpenoids) are the two main groups of constituents, and the plants also contain alkaloids, phytosterols and polysaccharides among others. The main compounds of flavonoids, baicalin, baicalein, wogonin and ganhuangenin possess anti-cancer, anti-HIV, anti-bacterial, anti-viral, anti-inflammatory and anticon-vulsant effects. Jodrellin A, jodrellin B, scutalbin A and scutecyprol B, which are the main compounds of diterpenes have antifeedant effects, etc. In this review, the advances in ethnopharmacology, phytochemistry, biological and pharmacological activities of the genus *Scutellaria* are already reported.

BIOLOGY AND ETHNOPHARMACOLOGY

Most *Scutellaria* species are annual or perennial herbaceous plants from 5 cm to 1 m tall, but a few are subshrubs and some are aquatic. They have four-angled stems and opposite leaves. The flowers have upper and lower lips. The genus is most easily rec- ognized by the typical shield on the calyx [4].

In East Asia, some *Scutellaria* species are widely used as traditional medicine, especially in China, Korea and Japan due to its anti-inflammatory, antiviral, sedative, antithrombotic and antioxi- dant effects. The traditional uses of genus *scutellaria* is reported in **Table 1**.
The genus *scutellaria* is also used to activate blood circulation, intestinal catarrh, digestive system cancer and nerve tonics. In Canada, the skullcap herbs is generally sold as tea in health food stores [5,6].

Table-1**. Traditional uses of *Scutellaria* genus**

Name of the plants	Traditional uses	Reference
S.barbata	Traditional Chinese medicinal herb, used in treatment of digestive system cancer, hepatomalungs cancer, breast cancer and inflammatory.	[1,7]
S.viscidulà	Traditional Chinese medicinal herb widely used to treat inflammatory and bacterial diseases.	[8,9]
S.*lateriflora*	American traditional medicinal herb, used for treating nervous disorders as well as antispasmodic used to treat anxiety, neuralgia and epilepsy.	[10]
S.discolor	Used as folk medicine common cold, cuts and insect strings.	[11]
S. amoena	Traditional Chinese medicinal herb used for clinical treatment of hyperlipemia, atherosclerosis, hypertension, dysentery, common cold and inflammatory diseases such as atopic dermatitis.	[1,12]
S.flavescene	Traditional Chinese medicinal herb used for antiviral and Anti-RSV effect.	[13]
S.galericulata	American traditional medicinal herb used to cure nervine, sore. cold and fever.	[10]
S.*parvula*	America traditional medicinal herbs used to treat inflammatory and bacterial diseases.	[6]
S.polydon	American traditional medicinal herb used for curing viral diseases	[15]
S.ovata	American traditional medicine.	[15]
S .alpine	European traditional medicinal herb used as antispasmodic, diaphortic and local medicine.	[2,5]
*S .alpine*subsp.*javalanbrensis*	Traditional Chinese medicine	[14]
*S.rubicunda*subsp.*rubicunda*	Used to cure fungal diseases and also used as feeding agent.	[3]
S .hypericifollia	Traditional Chinese medicinal herb and well known ancient drµg in China.	[16]
S. rehderiana	Traditional Chinese medicinal herb, used as a key ingredient combination with other Chinese herbs to cure diabetes, hyphoidl fever and its complications.	[1]
S. likiangensis	Traditional Chinese medicinal herb, used as a ingredient combination with other Chinese herbs for number of prescriptions.	[8]
S.tenax	Traditional Chinese medicinal herb, used as an ancient drug for inflammation.	[1]
S.scandens	Nepalese crude drug used to treat wounds and swelling by insects.	[15]
S. indica	Used as analgesin, detoxification and promoting blood circulation effect.	[17]
S. postrata	Asian traditional medicinal herb. It has long been used traditional medicine in Asia, Europe	[18]
	and America.	
S.linearis	Used as traditional medicine by peoples in Asia, Europe and America.	[8,9]
S. grossa	It as long been used traditional medicine in Asia, Europe and America.	[18]
S. strigillosa	Used as traditional medicines in Asia and Europe.	[17]
S.*seleriana*	Used as traditional medicine by peoples in Asia , Europe and America	[19]
S. altissima	Traditional Chinese medicinel herb used for treatment of cancer, bronchitis and hepatitis.	[20,21]
S.albida	Anti-spasmodic, diaphortic and febrifµgal.	[4]
S.rubicunda	Anti-feedent and Anti - fungal	[22]
S.baicalensis	Pneumonia, Hypertension, Jaundice, dysentery, intestinal catarrch and Pyogenic infection.	[1]
S.rivularis	It is a folk medicine of Taiwan, used for the treatment of tumors, hepatitis, liver cirrhosis, jaundice	[23]
S.litwinowii	Used as traditional Indian medicinal herbs for the anti-cancer activity.	[24]
S.pinnatifida A	Used as a traditional Chinese medicinal plant that has utilised in folk medicine for its antioxidant and antimicrobial effects.	[10]
S.sieberibenth	Used as a herbal medicine as diaphortic, febrifµgae, tonic, etc….	[25]
S.immaculata and S.ramosissima	Used as Uzbek traditional medicines to treat epilepsy, inflammation, allergies, chorea, nervous tension status and high blood pressure.	[26]
S.rivularis	It is used as a folk medicine in Taiwan for the	[1]
	treatment of tumours,hepatitis, liver cirrhosis, Jaundice and other diseases	
S.volubilis	They are traditionally used for nervous system treatment, as well as to cure heart and kidney affections.	[57,1]
S.repens	Used as a traditional Chinese medicine and herbal medicine to treat various diseases in human and veterinary ailments.	[4]

COMPOUNDS

The medicinal value of plants lies in some chemical substrates that produce a definitive physiological action on the human body.

From the genus *scutellaria* already about 295 compounds was reported including flavanoides, phenyl ethanoid glycosides, Iridoidglysocides ,diterpenoid,triterpenes, alkaloids and other compounds. Some of the compounds displayed May bioactivities *in vivo* or *in vitro*.In addition to the compounds already reported [25] the following 52 compounds from the *scutellarian* species has been reported (**Table2**) in the present review **CHART 1**.

Bioassay-guided fractionation was conducted on an EtOAc-soluble extract of the whole plants of *S.barbata*, monitored by inhibition of Epstien- Barr virus (EBV) lytic replication (). Twenty six neo-clerodanediterpenoids were reported out of which 13 compounds are new (scutolides A→L) and 13 previously known. The configuration of new compounds Scutolides A and Scutolide K were confirmed by single-crystal X - ray diffraction. All the 26 compounds were evaluated for inhibitory effects against EBV lyric replication. Eleven compounds exhibited moderate to potent inhibition, EC50 values from 3.2 to 23.6 μM and selective index (SI) values from 2.1 to 109.2 More specifically the new compound showed most potent activity, which EC_{50} and SI values of 3.2 μM and 46.1, respectively, while compound barbatin D (EC_{50}=16.4 μM) exhibited the highest SI of 109.2 .This study is first to report that neo-clerodanediterpenoids demonstrate significant effect against EBV lyric replication [28] .

LC-MS investigation of *S.immaculata* and*S.ramosissima* plants allowed the identification, for the first time, of an additional 9 and 16 flavanoids respectively. The methanol, chloroform and water extracts from those plants and six flavanoids (scutellarian, chrysin, apigenin, apigenin -7-O-glucoside ,cynarosid and pinocembrine) exhibited significant inhibition of cell growth against HeLa, HepG-2 and MCF-7 cells . The chloroform eextract of*S.ramosissima* showed potent cytotoxic effects with IC_{50} value 9.25±1.07 mg12.83 ±1.49 μg/ml and 17.29±1.27 μg / ml, respectively. The highest anti-trypanosonal effect against T.b.brucei was shown by the chloroform eextract of*S.ramosissima* with an IC_{50} value of 61 μg / ml. The pure flavanoids showed IC_{50} range between 3 and 29 uM , with cynaroside as the most active compounds with an IC_{50} value of 3.961+ 0.133 μg / ml . The chloroform eextract of*S.ramosissima* showed potent antimicrobial activity against *Streptococcus pyogenes* (minimum inhibitory concentration, MIC = 0.03mg / ml. Pinocenbrine exhibited a strong activity against the all bacteria except *Escherichia coli* and yeast. Water extracts of S.ramosissimasndS.immaculata exhibited potent antioxidant activity with IC_{50} value of 5.62 + 0.51 μg/ml and 3.48+0.02 μg/ml respectively. *Scutellarin* exerted stronger anti - oxidant activity than other flavonoids [26].

Those compounds show almost no oe minor toxicity to normal epithelial and normal peripheral blood and myeloid cells. The Anti-tumor functions of those flavones are largely due to the ability to scavenging oxygen radicals, attenuate NF-kappa B activity ,supress COX-2 gene expression , inhibit several genes important for regulations of the cell cycle, and to prevent viral infection [26,1] . Baicalein and baicain were shown to protect several types of titissue against demages from reactive oxygen species (ROS) and these flavanoids are reported largely responsible for the antimicrobial effects Baicalein has also been shown to inhibit HIV-1 reverse transcriptase [26]. ,

investigation of*S.immaculata* and *S.ramosissima* allowed the identification of the following additional flavanoids, chrysin - 6-arabinosyl -8-C-glucoside , isorhammetin -7-O-rhammosyl-glucoside, rhammatin -7-O-rhammosyl-glucoside, Scutellarin, baicalin, 5,7,2',5'-tetrahydroxy -8,6'-dimethoxyflavanone , Oroxylin A - 7-O-glucoscide, 5,6,7-trihydroxyflavanone (dihydroxybaicalein)7-O-glucoscide, Norwogonin - 7-O-glucronide, Oroxylin-7-O-glucronide , wogonin -7-O-glucuronide, Norwogonin , 5,7,3-trihydroxy -4 - methoxyflavone , baicalein, 5,7,4 - trihydroxy-8-methoxy flavone, wogonin, Chrysin and 5.2-dihydroxy-6, 7 , 8-methoxy flavone [1].

Anti-feedent activity of neo-clerodanediterpenoids against colorado potato breedle larvae we can conclude that the presence in the clerodane structure of a spiroepoxide substituent at C-4 and two ester groups at C- 6 and C-19, together with hexahydro- or tetrahydrofurofuran moiety at C-9, is condition for development of activity. Such dependenc was reported in previously investigated on other insects [29]

All tested eleven neo-clerodanediterpenoids displayed a 2α, 19-hemiacetal or acetal functionality in the decalin ring, C - 4 - C - 18 spiroepoxide and an acetate group at C -6 position. At the C11-C 6 substructure there is a very common, for clerodane isolated from *Scutellaria*species ,hexahydrofuro[2,3b]furan moiety with the exception of compound scutalbin A with tetrahydrofurofuran ring and scutegalerin C , scutegalerin D , scutegalin D , in which C-15 and C-16 are involved in the concentration of a single ring hemiacetal (scutegalin D) or acetal (scutegalerin C and scutegalerin D) [2].

The ethanol extract of the aerial part of *Scutellaria barbata* eluted a while Slice crystal which was identified purely as (6S, 9R) 6-Hydroxy - 4, 4, 7a- Trimethyl -5,6,7 , 7a - tetrahydro -1-benzofuran -2(4H) - one [28] . The aerial part of *Scutellariabarbata* resulted in the isolation of ethyl-4 -hydroxy-3, 5-dimethoxy-benzoate. The crystal belonged to the monoclinic space group P (1)/c with a =11.5521 (6) À, b=13.5055(7) À, c=16.4171(7) À□,ββ117.240 (3) °and Z=8. [28].

Even though various types of chemical compounds have been identified from *Scutellaria*, research reports on isolated compound and the bioactivity and the mechanism of action of the isolated compounds are limited. Additionally the effects of these compounds on the ailments like cancer, HIV, blood pressure, cardio-vascular disease and others, need to be investigated in detail.

Table 2. Compound isolated from *Scutellaria* genus

Plant	Compounds	Reference
S.barbata	Scutolide A	[27]
	Scutolide B	
	Scutolide C	
	Scutolide D	
	Scutolide E	
	Scutolide F	
	Scutolide G	
	Scutolide H	
	Scutolide I	
	Scutolide J	
	Scutolide K	
	Scutolide L	
	Barbatellari ne B	
	Scutebarbatine Y	
	Barbatin D	
	Scutebarbatine L	
	6 - 7-di-O-acetoxbarbatin A	
	Scutebarbatine A	
	Scutebata J	
	Scutebarbatine K	
	Scutebata D	
	Scutebata F	
	Barbatine D	
	Barbatine A	
	Barbatine B	
	2 (S)-2', 7-Dihydroxy-5, 8 - dimethoxyflavanone	[28]
	(S)-2-(4-hydroxyphenyl)-6-methyl-2, 3-dihydro-4H-pyran-4-one.	
	(6S,9R)6-Hydroxy-4, 4, 7a-trimethyl-5, 6, 7, 7a-tetrahydro-1-benzouran-2 (H)-one	
	Ethyl-4 - hydroxy-3, 5-dimethoxy-benzo atherosclerosis	
S. litwinowii	Wogonin	[24]
	Neobaicalein	
	Baicalein	
	6-hydroxyfavone	
S.galericulata	Scutegalerin A	[22]
	Scutegalerin B	
	Scutegalerin C	
	Scutegalerin D	
	Scutegalerin E	
	Scutegalerin E	
	Scutalbin A	
	neoajµgapyrin A	
	14,15-dihydrojodrelli-T	
S.immaculata	Wogonin	[26]
	Scutellariàn	
	Baicalin	
	Baicalein	
	Chrysin	
	Norwogonin	
	Oroxylin A-7 - glucoside	
	Norwogonin-7-O-glucuronide	
	Wogonin-7-O-glucuronide	
	Chrysin-7-O-glucuronide	
	5,6,7-trihydroxyflavanone(dihydroxybaicalein)-7-O-glucuronide	
	5,7,3-trihydroxy-4'-methoxyflavone	
S.ramosissima	Wogonin	
	Norwogonin	
	Baicalin	
	Baicalein	
	Chrysin	
	Scutellarian	
	Oroxylin A-7 - glucoside	
	Oroxylin A-7 - glucucuronide	
	Norwogonin-7-O-glucuronide	
	Wogonin-7-O-glucuronide	
	5,7,3-trihydroxy-4'-methoxyflavone	
	5,6,7-trihydroxyflavanone(dihydroxybaicalein)-7-O-glucuronide	
	5,7,4'-trihydroxy-8-methoxyflavone	
	5,7,2',5'-tetrahydroxy-8-6'-dimethoxyflavone	
	5,2'-dihydroxy-6-7-8-trimethoxyflavone	
	Chrysin-6-arabinosyl-8-C-glucoside	
	Rhamnetin-7-O-rha-glu	
	Isorhamnetin-7-O-rha-glu	

ESSENTIAL OIL

Essential oil haashas been isolated and their composition was reported for 16 species (**Table 3**). Among them from *S.barbata*, *S.Orientalis* and *S.baicalensis* Essential oil has been isolated from different species and from different places. The essential oil of oly a few species of *Scutellaria* has been investigated and reported [29-31]. Recently some more species has been added to the list and presented in the **Table 3**. Caryophyllene, Linalool and Germacrene D appears to be major compounds, Exicept*S.Orientalis, S.laterfollia and S.parvula*whereHexadecanoic acid, aromadendrone, hexahydrofarmesylacetone, Cadinene and α-bisabolol are the main compounds, respectively germacrene D and β-caryophyllene occurs together and Linalool and α-terpineol present together.

However, additional works are warranted to search for possible biological activities of these volatile compounds including oils and also the possibilities for their commercial exploitation.

Table-3. Essential Oil isolated from *Scutellaria* genus

Plants	Major compounds	References
S.barbata	Hexadecanoic acid , 1-Octan-3-ol, 2,6-dimethylocta-2,7-diene-3-ol.	[1]
(Southern China)	Hexahydrofarmesylacetone(11%) 3, 7, 11, 15-tetramethyl-8-hexadecen-1ol (7.8%) Menthol (7.7%) 1-Octan-3-ol,(7.1%)	[25]
S.Orientalisssp.alpina	Hexadecanoicacid (7.6%) Caryophyllene (7.4%) Caryophyllene oxide (6.8%)	[1]
S.utriculata	Linalool (20.1%) 4-Vinyl guaiacol (15.5%) α-Terpineol (8.9%)	[7]
S.grossa (India)	Linalool (37%) 1-octen-3-ol (32%)	[32]
S.albidaSsp.albida (Turkey)	Linalool (52.63%) trans-nerolid (9.08%) Nonanal (6.73%)	[25]
S.baicalensis (India)	Caryophyllene (22.3-41.5%) GermacreneD(12.4-27.5%) Cadinene (3.1-5.4%)	[33]
	Acetophenone (E)-4 - phenyl-3-buton-2-ene Pelmeher Olic acid	[1]
S.diffusa (Turkey)	Hexadecanoic acid (29.9%) Caryophyllene oxide (8.5%) β-Caryophyllene (3.2%)	[34]
S.heterophylla (Turkey)..	Germacrene D (21%) Hexadecanoic acid (16.4%) β-Caryophyllene (13%)	[34]
S.salviifolia (Ecuador)	Germacrene D (40%) Bicyclogermacrene (14%) β-Caryophyllene (11%)	[34]
S.rupestrisssp.adenotricha (Greece)	Linalool (38.8%) Geraniol (8.1%) α-Terpineol (7.1%)	[25]
S.pinnatifida A (Iran)	Germacrene D (9.5%) α-pinene (5.37%) Cinnamate Born (4.09%)	[10]
S.laeteviolacea	1-octen-3-ol (27.2%) Germacrene D (21.7%) β-Caryophyllene (9.6%)	[17]
S.repensBuch-Harm.ex D (India)	Aromadendrene (30.7%) β-Funebrene (15%) Gurjuene (8%)	[10]
S.volubilis (Ecuador)	Germacrene D (20.4%) β -Caryophyllene (17.5%) α -humulene (14.7%)	[22]
S.brevibracteata (Italy)	Caryophyllene (14.4%) Hexadecanoic acid (12.6%) (E)-phytol (10.7%)	[1]
S.hastifolia (Italy)	Caryophyllene (12.9%) Germacrene D (7.7%) Caryophyllene oxide (6.9%)	[1]
S.havanensis (Cuba)	β-Caryophyllene (75.6 %) α - humulene(11.6^%) Caryophyllene oxide (2.6%)	[35]
S.Orientalisssp.alpina (Italy)	Hexahydrofarmesylacetone (11.7%) Hexadecanoic acid (7.6%) Caryophyllene oxide (6.8%)	[1]
S.lateriflora (Iran)	β-Cadinene (27.0 %) Calamenene (15.2 %) β - elemene (9.2 %)	[1]
S.porvula	Caryophyllene (29.4 %) trans-β-Farnesene (17.0 %)	[1]
S.wightianabenth (India)	Beta-Farnesene (22.07%) 1, 4 - benzenediol -2,5-dimethyl (21.58%) Pipertone oxide (16.133%)	[25]
S.rubicundasubsplinneana (Sicily)	Caryophyllene (28.7 %) Linalool (27.8%)	[1]

BIOLOGICAL ACTIVITIES

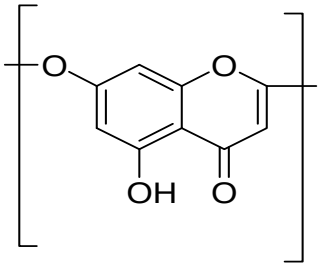
Even though several traditional uses of *Scutellaria* are recognized, a scientific validity and supporting evidence is a pre-essential for commercial exploitation. In the preceding text some of the available reports pertaining towards the pharmacological potential of the plant extracts are being discussed. **Table 4** provide an overview of some important works on the isolated chemical compounds and their activity undertaken on the *Scutellaria* plant.

Anti-tumor activity has been exhibited by *S.barbata* and *S.baicalensis* .Anti-RSV, Anti-HIV, anti-inflammatory, Hepatoprotective, Neuro protective, Anti-mutegen, Anti-HBV, Anti-convulsent activities has been reported from the compounds isolated from *S.baicalensis.* Anti-feedent activity was exhibited by*S.rubicunda*and*S.galericulata* .Anti-oxidant activity has been reported from the compounds isolated from *S.baicalensis, S.barbata**S.immaculata*and*S.wightiana.* . Anxiolytic activity was exhibited by Wogonin isolated *S.remosissina, S.barbata*and the essential oil of *S.sieberi, S.rupestris*and*S.grossa.* from *S.baicalensis* and Baicalin isolated from *S.laterfollia.* Anti-microbial activity was exhibited by *S.immaculata*,

Anti-feedent activity of neo-clerodanediterpenoids against colorado potato breedle larvae we can conclude that the presence in the clerodane structure of a spiroepoxide substituent at C-4 and two ester groups at C- 6 and C-19, together with hexahydro- or tetrahydrofurofuran moiety at C-9, is condition for development of activity. Such dependenc was reported in previously investigated on other insects [36].

From the **Table-2** it was observed that most of the biological activities are due to wogonin, baicalin and baicalein. Baicalin is a flavone glycoside. It is the glucuronide of baicalein. Baicalein is a trihydroxyflavone with the hydroxy groups at positions C-5, -6 and -7. It is the aglycone of baicalin. Wogonin is 5,7-Dihydroxy-8-methoxyflavone

As individual compounds the reports showed that wogonin, baicalein along with its analog baicalin, is a positive allosteric modulator of the benzodiazepine site and/or a non-benzodiazepine site of the $GABA_A$ receptor [37-42]. It displayed subtype selectivity for α_2 and α_3 subunit - containing $GABA_A$ receptors [34]. Accordingly baicalein has showed anxiolytic effects in mice without incidence of sedation or myorelaxation [40, 41, 43, 44]. Baicalein is also an antagonist of the estrogen receptor, or an antiestrogen [45] inhibit certain types of lipoxygenases [46] and act as an anti-inflammatory agent [47]. It has antiproliferative effects on ET-1-induced proliferation of pulmonary artery smooth muscle cell proliferation via inhibition of TRPC1 channel expression [48]. Possible antidepressant effects have also been attributed to baicalein in animal research [49]. Baicalein is an inhibitor of CYP2C9, an enzyme of the cytochrome P450 system that metabolises drugs in the body. Baicalein has been shown to inhibit Staphylococcus aureus biofilm formation and the quorum sensing system *in vitro* [50,51]. If we critically view all the above three molecules in addition to the other compounds like luteolin, oroxylin A, apigenin, 5,7,4'-trihydroxy-8-methoxy flavone and 3,5,7,2',6'-pentahydroxy flavanoneflavanone reported in the **Table-4** suggest that the ring B and C of the flavanoid moiety may or may not have any substitutions, but the ring A should have oxygen functions in the 5 and 7 position. In addition to this preferably there should be an oxygen function either in the 6th position or in the 8th position. This moiety may be considered as the pharmacophore which may be responsible for all the activities represented in the **Table-4**.



However, based on the availability of the reports, there is still a wide gap in looking for the biological activities. Hence, further studies in this view are deserved.

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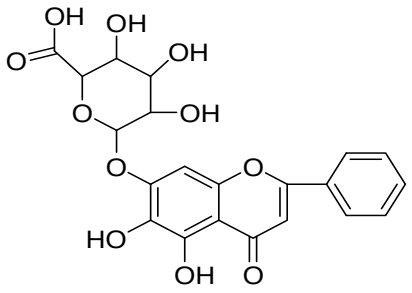
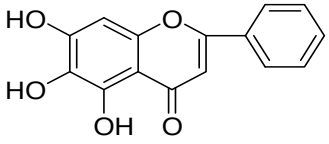
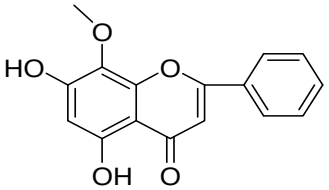


baicalin



baicalein



wogonin

Table-4. Biological activity in *Scutellaria* genus

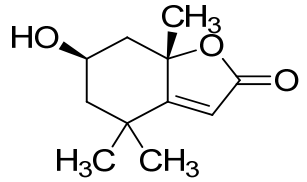
Name of Effect	Species	Compounds	References
Anti-tumor	*S.barbata*	Barbatins A-C	[5,32]
		Scutebarnatine B	[5,32]
		2',3',5,7-tetrahydroxy flavone apigenin	[32,6]
		Viscidula III	[32,6]
		Luteolin	[32,6]
	S, baicalensis	Wogonin	[8]
		Baicalin	[52]
		Baicalein	[52]
Anti-RSV	*S, baicalensis*	Scutellariàn	[13]
		5,7,4'-trihydroxy-8-methoxy flavone	[53]
		Oroxylin A	[13]
		Wogonin	[13]
		Ganhuangenin	[13]
		Baicalein	[14]
Antifeedant	*S.rubicunda*	Scutecyprol B	[3,54]
		Jodrellin A	[3]
		Jodrellin B	[3]
		Scutalbin A	[3]
	S.galericuleta	Scutalbin A Neo-clerodanedieterpenoids	[27]
Anti-inflammatory	*S.baicalensis*	Wogonin	[1]
		Baicalein	[55]
Hepatoprotective	*S.baicalensis*	Wogonin	[21]
		Baicalin	[21]
		Baicalein	[33]
Neuroprotective and memory improvement	*S. baicalensis*	Wogonin	[21,1]
		Baicalin	[1]
		Baicalein	[1]
Antimutagenic	*S.baicalensis*	Baicalein	[27]
		Baicalin	[56]
Anti-oxidant	*S.baicalensis*	Ganhuangenin	[21]
		3,5,7,2',6'-pentahydroxy flavanoneflavanone	[21]
		Baicalein	[1]
	S.barbata	Neo-clerodanedieterpenoids	[57]
	S.immaculata&S.ramosissina		[26,58]
			[22]
Anti-oxidative	*S.baicalensis*	Baicalin	[59]
Anxiolytic	*S.baicalensis*	Wogonin	[60]
	S.laterfollia	Baicalin	[61]
Anti-HIV	*S.baicalensis*	Baicalin	[62]
Anti-HIV-1	*S.baicalensis*	Baicalin	[62]
Anti-HBV	*S.baicalensis*	Wogonin	[27]
Anticonvulsant	*S.baicalensis*	Wogonin	[33]
Anti-microbial	*S.immaculata*	Essential oil	[26,58]
	S.ramosissina	Essential oil	[26]
	S. barbata	Essential oil	[18]
	S.albidaSsp.albida	Essential oil	[6]
	S.sieberibenth	Essential oil	[6]
	S.rupestrissspadenotricha	Essential oil	[6]
Antibacterial	*S.grossa*	Essential oil	[1]
Larvicidal activity	*S.wightianabenth*	Essential oil	[23]
Antioxidant	*S.wightianabenth*	Essential oil	[23]

CONCLUSION

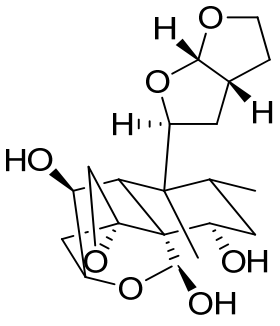
India is a country with an enormous wealth of medicinal plants. But most of these plants are not properly exploited. If these plants were properly exploited, we could have a large number of natural remedies for digits of ailments. The above study is meant to reveal some of the most available shrubs in the genus *Scutellaria.*

In this paper, we briefly summarized the ethnobotanical information, new compounds isolated, essential oil composition and biological activities of *Scutellaria* plant. Various literatures related to these areas were reviewed to gather all information related to the ethnobotanical, phytochemical, pharmacological properties of *Scutellaria* plant. A significant number of studies have provided important evidences that *Scutellaria* plants possesses adequate therapeutic potential and could be explored further for commercial purposes.

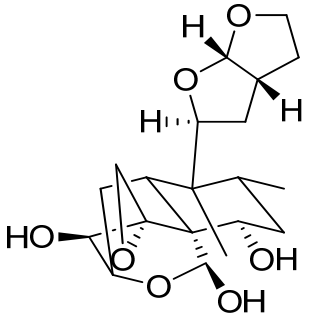
Even though there are various types of bioactive compounds isolated and identified from *Scutellaria* plant as highlighted in the phytochemical section, their contribution towards the plant claimed medicinal uses or demonstrated pharmacological activities were also not fully studied. Thus, the quest for new compounds from *Scutellaria* plant with specific pharmacological activity remains unsolved. It is suggested that researches should be increased to isolate, identify, and collect the compounds from *Scutellaria* species so that their pharmacological potential could be investigated thoroughly. In conclusion, it is hoped that this paper will serve as an encouragement for others to further explore the pharmacological potentials of the genus *Scutellaria* with hope of developing it as a new therapeutic agents, nutraceuticals and functional foods as it is considered as one of the important herbs, particularly in the Indian folk medicine. Most of the plants in this species have a tremendous medicinal value. But still there is a need to reveal more number of plants in this genus. Also the phytochemical and pharmacological evaluation should be done on these plants.



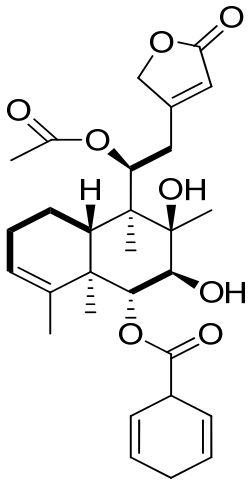
(6S,9R) 6-hydroxy-4,4',7a-trimethyl--5,6,7,7a-tetrahydro-1-benzofuran-2(4H)-one



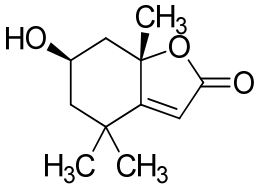
14,15-dihydrojodrellin T



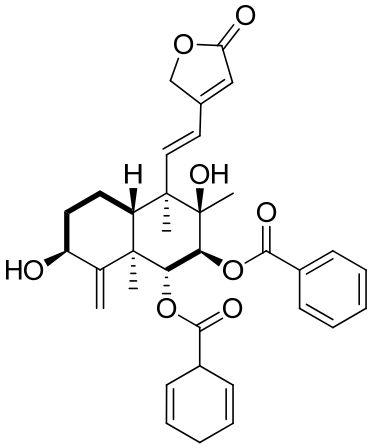
Scutegalerin A



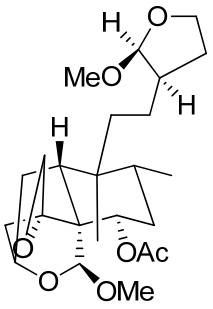
Scutolide F



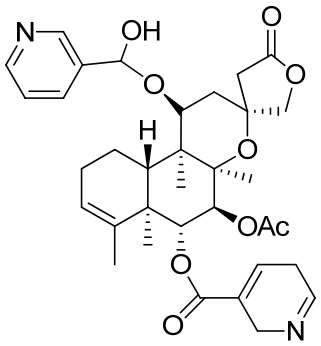
(6S,9R) 6-hydroxy-4,4,7a-trimethyl-5,6,7,7a-tetrahydro-1-benzofuran-2(4H)-one



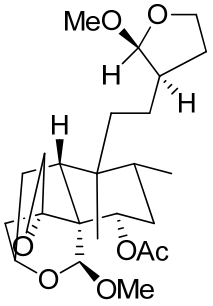
Scutolide L



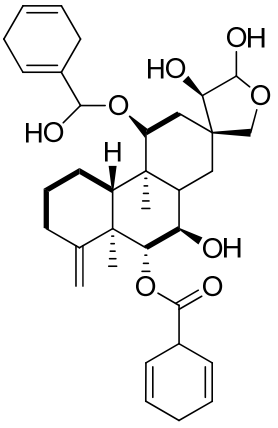
scutegalerin D



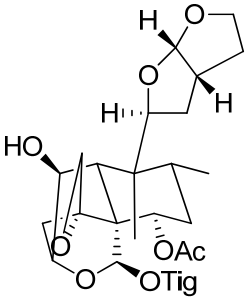
barbatineD



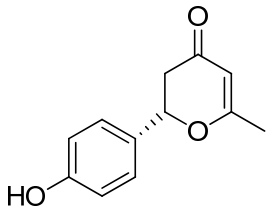
Scutegalerin C



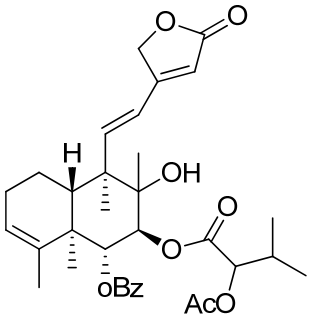
(14R)-14beta-hydroxyscutolide K



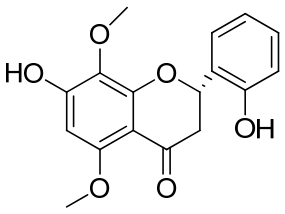
Scutegalerin A



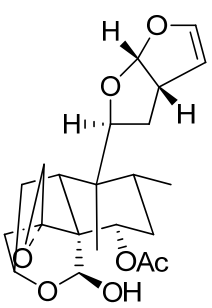
(S)-2-(-4-hydroxyphenyl)-6-methyl-2,3-dihydro-4H--pyran-4-one



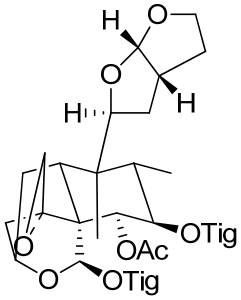
Scutolide D



2(S)-2',7-dihydroxy-5,8-dimethoxyflavanone



Scutalbin A



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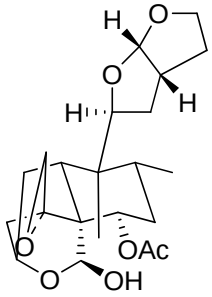
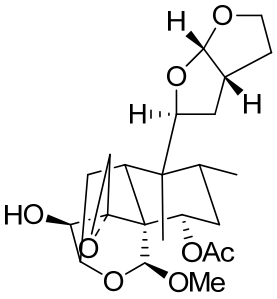
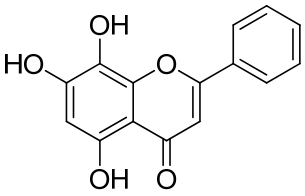


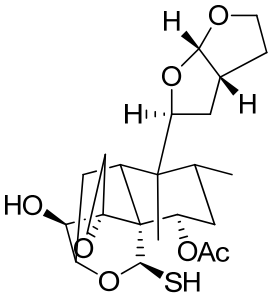
Scutecolumnin C



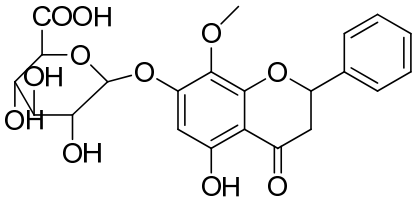
Scutegalerin E



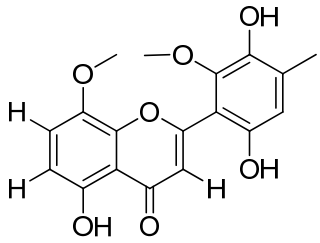
Norwogonin



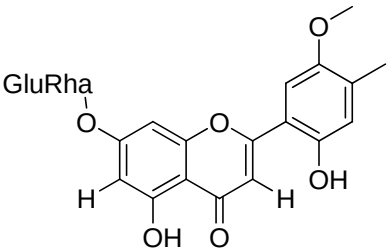
Neoajugapyrin A



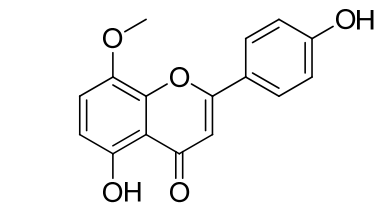
Wogonin-7-O-glucuronide



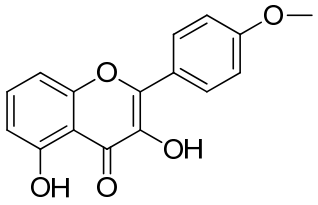
5,7,2',5,-tetrahydroxy-8,6'-dimethoxyflavones



Isorhammetin-7-O-rha-glu



5,7,4'-Trihydroxy-8-methoxyflavone



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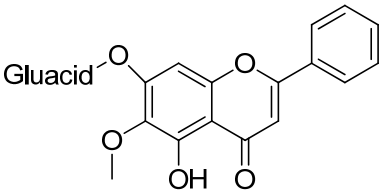
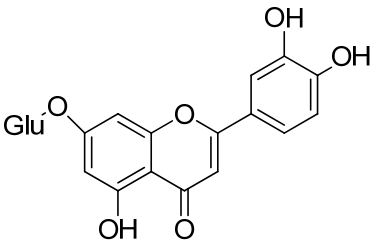
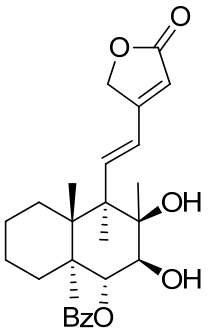


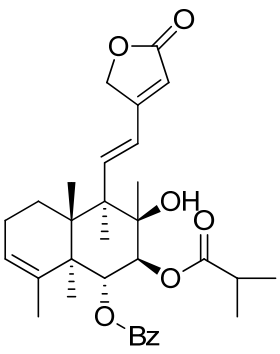
Oroxylin A-7-O-glucuronide



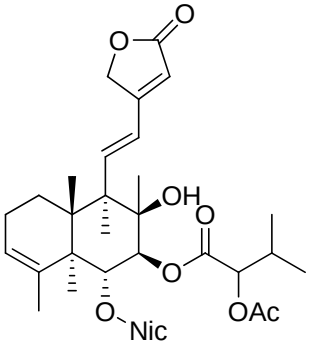
Cynaroside



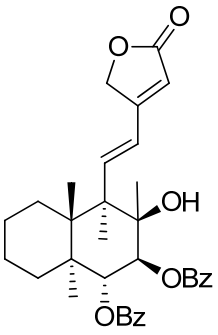
Scutebata J



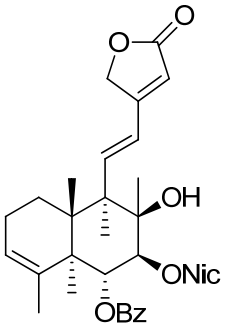
Scutolide C



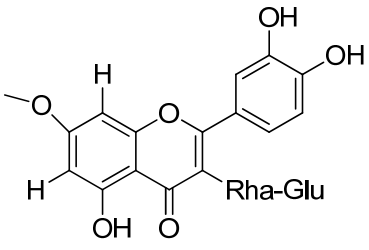
Scutebarbatine L



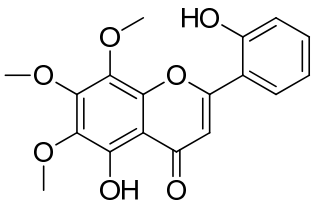
Barbatin D



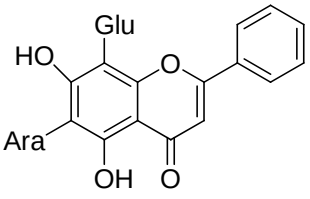
Scutebarbatine Y



Rhammetin-7-O-rha-glu



5,2'-Dihydroxy-6,7,8-trimethoxyflavone



Chrysin-6-arabinosyl-8-C-glucoside

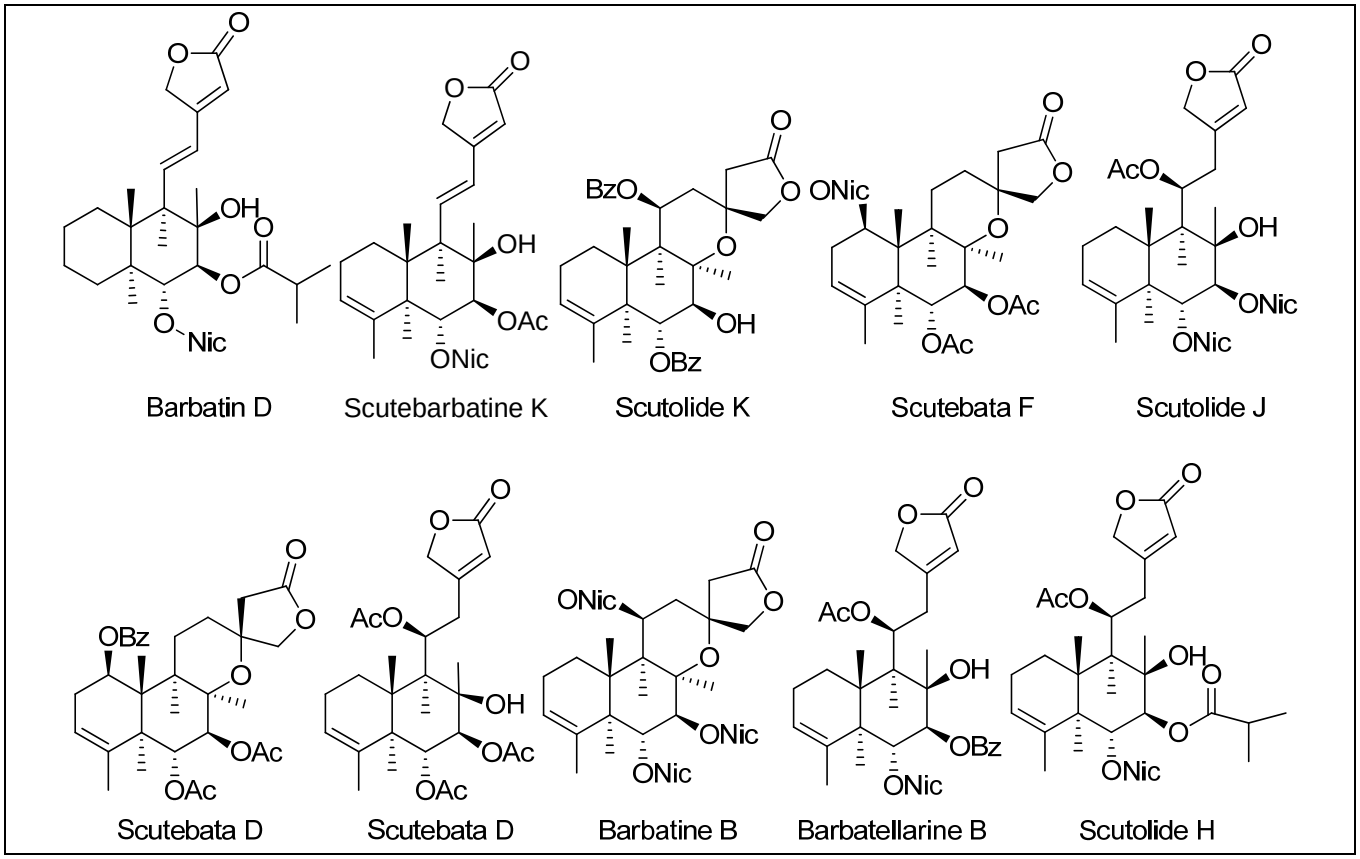


CHART 1. Compounds from the *scutellarian* species

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