

COMPARATIVE PHYTOCHEMICAL PROFILE OF INDONEESIELLA ECHIOIDES (L.) NEES LEAVES

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Indoneesiella echioides (or) Andrographis echioides (L) Nees is an important herb widely distributed in south India. This is commonly known as False water willow. Indoneesiella echioides (L) Nees is used as in traditional Indian medicine. The leaf juice of this plant is used to cure fever. Different pharmacological properties of Indoneesiella echioides have already been reported. Thus, the present study was performed to investigate the preliminary phytochemical screening, separation, identification of compounds and compare the phytochemical composition of various fraction of Indoneesiella echioides using gas chromatography-mass spectrometry. The plant was extracted for various solvents in increasing order of polarity from using n-hexane, chloroform, ethyl acetate, acetone, ethanol, butanol and methanol. The result obtained after GC-MS studies were confirmed by spectral analysis.

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Introduction

Indoneesiella echioides (L) Nees (Acanthaceae), also known as Andrographis echioides (L) Nees, is commonly known as False Water Willow and grows abundantly in south India. Indoneesiella echioides(L) Nees is medicinally highly important. The plants of genus Indoneesiella is used in goiter, liver diseases,1 fertility problems, bacterial infection and malarial and fungal disorders.² The leaf juice of this plant is used to treating fever.³ Several Indoneesiella species (about 40 species) has been used in treatment of influenza, malaria, dyspepsia and respiratory diseases. The plants of Indoneesiella species are also used as antidote for poisonous stings of some insects.^{4,5} The leaf juice is mixed and boiled with coconut oil used to control falling and greying of hair.⁶ Phytochemistry of Indoneesiella echioides has been investigated and reported to contain several flavonoids^{7,8} and labdane diterpinoids.⁹⁻¹⁴

In previous literatures only flavonoids are reported as a major component in *Indoneesiella echioides* (L) Nees extracts.¹⁵⁻¹⁸ It has been reported that variety of phytoconstituents like phenols, coumarins, lignans, essential oil, monoterpenes, carotenoids, glycosides, flavonoids, organic acids, lipids, alkaloids and xanthenes are also present.¹⁹

Hence the present investigation was carried out to determine the possible phytochemical compounds of *Indoneesiella echioides* by GC-MS studies.

Experimental

Collection of plant materials

The leaves of *Indoneesiella echioides* was collected from Poondi village, Thanjavur District, Tamilnadu, India. The botanical identity (Voucher No: A.A.R 001 on 04-02-2015) of the plant was confirmed by Dr. S. John Britto, Rapinat Herbarium, St. Joseph's College, Tiruchirappalli, India.

Preparation of extracts

The fine powder (5 kg) was extracted with 95% ethanol at room temperature for ten days. The extract were filtered and concentrated under reduced pressure in a rotary evaporator and extracted with various solvents in increasing order of polarity, starting from n-hexane, chloroform, acetone, ethanol, butanol and methanol. The extract was taken in a beaker and kept in a water bath and heated at 30-40 °C till all the solvent is evaporated. The dried extracts were subjected to preliminary phytochemicals and GC -MS studies. All the extracts were tested for the presence bioactive compounds by using standard methods.

Phytochemical screening

The preliminary phytochemical analysis of *Indoneesiella echioides* (L) *Nees* was carried out as per standard methods (Table 1).

Identification of phytocompounds by GC-MS

GC-MS, one of the most reliable biophysical method for its specificity and repeatability, was utilized for the phytochemical profiling of *Indoneesiella echioides* (L) *Nees* leaves. Table 1. Preliminary phytochemical constituents of Indoneesiella echioides (L) Nees leaves.

S. No.	Phytochemicals	Hexane extract	Chloroform extract	Acetone extract	Ethanol extract	Butanol extract	Methanol extract
1.	Alkaloids	-	-	Present	Present	-	-
2.	Flavonoids	-	Present	Present	Present	Present	Present
3.	Terpenes	Present	Present	-	-	-	-
4.	Triterpenoid saponins	-	Present	Present	-	-	-
5.	Saponins	-	Present	Present	Present	Present	Present
6.	Glycosides	-	-	-	-	-	-
7.	Steroids	Present	Present	Present	-	-	-
8.	Carbohydrates	-	-	-	-	-	-
9.	Phenolic compounds	Present	Present	Present	-	Present	Present
10.	Tannins	-	-	-	-	-	-
11.	Amino acids	-	-	Present	Present	-	Present

Table 2. Phytochemical components identified for n-hexane extract of Indoneesiella echioides (L) Nees (GC-MS study).

S.N	RT	Name of the compound	Molecular formula	Molecular weight	Peak area (%)	Compound nature	Activity
1.	12.85	Undecanoic acid,	C ₁₃ H ₂₆ O ₂	214.3443	87	-	No activity reported.
2.	15.07	10-methyl-, methyl ester Methyl tetradecanoate	$C_{15}H_{30}O_2$	242.3975	100	Myristic acid ester	Antioxidant,cancer- preventive, hypercholesterolemic, nematicide activities.
3.	15.72	Tetradecanoic acid, 12- methyl-, methyl ester	$C_{16}H_{32}O_2$	256.4241	100	Fatty acid methyl ester	No activity reported.
4.	16.95	(Z)-9-Hexadecenoic acid, methyl ester,	$C_{17}H_{32}O_2$	268.4348	63.9	Fatty acid methyl ester	No activity reported.
5.	17.17	Pentadecanoic acid, 14- methyl-, methyl ester	$C_{17}H_{34}O_2$	270.4507	100	Palmitic acid methyl ester	Antioxidant, antifungal, antimicrobial activities.
6.	18.15	Hexadecanoic acid, 14- methyl-, methyl ester	$C_{18}H_{36}O_2$	284.4772	100	-	No activity reported.
7.	18.93	10-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.4879	100	Fatty acid ester	antioxidant, antimicrobial actvities.
8.	19.1	Heptadecanoic acid, 16- methyl-,methyl ester	$C_{19}H_{38}O_2$	298.5038	100	Stearic acid	Used against skin cancer protein.
9.	19.72	Eicosanoic acid	$C_{20}H_{40}O_2$	312.5304	74.7	Fatty acid	No activity reported.
10.	20.92	Eicosanoic acid, methyl ester	$C_{21}H_{42}O_2$	326.5570	100	Arachidic acid	α-Glucosidase inhibitors activity.
11.	21.18	Hexadecanoic acid, 1,1-	$C_{20}H_{40}O_2$	312.5304	54.5	-	No activity reported.
12.	22.95	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354.6101	98.4	Fatty acid	Therapeutic, diagnostic activities.
13.	23.28	Benzoic acid, 2,4-dimethoxy- 6-methyl-,(8,8-dimethoxy-2- octyl) ester	$C_{20} H_{32} O_6$	368.46448	94.4	-	No activity reported.

Source: Dr. Duke's Phytochemical and Ethnobotanical Databases

Interpretation on Mass-Spectra GC-MS was conducted using the database of National institute Standard and Technology (NIST) having more 62,000 patterns. The spectrum of the unknown components was compared with the spectrum of known components stored in the NIST library.

The name, molecular weight and structure of the components of the test materials were ascertained. In the present study many phytochemical constituents have been identified from various fractions of *Indoneesiella echioides*(L) Nees leaves by GC-MS analysis.

Analysis of n-hexane extract

Thirteen phytocomponents which appeared in the nhexane extract of *Indoneesiella echioides* (L) Nees leaves are listed in Table 2. All these compounds were known compounds.

Analysis of chloroform extract

Nine phytocomponents were identified from the chloroform extract of *Indoneesiella echioides* (L) Nees leaves and are listed in Table 3.

S.No.	RT	Name of the compound	Molecular formula	Molecular weight	Peak area (%)	Compound nature	Activity
1.	12.63	Phenol, 2,4-bis(1,1- dimethylethyl)-	C ₁₄ H ₂₂ O	206.3239	27	-	Antifungal, antimicrobial, antioxidant, antimalarial activities.
2.	14.52	1,4-Dicyano-2- cyclohexylbenzene	$C_{14}H_{14}N_2$	210.27436	3.5	-	-
3.	15.7	Flavone	$C_{15}H_{10}$	222.239	6.4	-	-
4.	17.15	Pentadecanoic acid, 13- methyl-, methyl ester	$C_{17}H_{34}O_2$	270.4507	15.5	-	-
5.	18.03	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256.4241	12.5	Fatty acid	Antioxidant, hypocholesterolmic, nematicide, pesticide, lubricant, Antiandrogenic, flavor, hemolytic, $5-\alpha$ - reductase inhibitor activities.
6.	18.83	10-Octadecenoic acid, methyl ester	$C_{19} H_{36} O_2$	296.4879	13.1	Fatty acid ester	Antioxidant, antimicrobial activities.
7.	19.45	Ethyl Oleate	$C_{20}H_{38}O_2$	310.52	24.9	Fatty acid ester	It is used as a vehicle for intramuscular drug delivery.
8.	21.4	3,5-Dicarbethoxy-1- methyl-1,4,5,6,7,8- hexahydropyrrolo[2,3- blazenin-4 7-dione	-	-	7.3	Unknown compound	-
9.	23.18	Butanoic acid, 3- methyl-, hexadecyl ester.	-	-	25.8	Unknown compound	-

Table 3. Phytochemical components identified for chloroform extract of Indoneesiella echioides (L) Nees (GC-MS study).

Source: Dr. Duke's Phytochemical and Ethnobotanical Databases

Table 4. Phytochemical	components identified f	for acetone extract of	of Indoneesiella e	chioides (L) Nees	(GC-MS study).
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S.N 0.	RT	Name of the compound	Molecular formula	Molecular weight	Peak Area (%)	Compound nature	Activity
1.	17.97	Hexadecanoic acid, ethyl ester	C ₁₈ H ₃₆ O ₂	284	100	Fatty acid	Antioxidant, Hypocholestero- lemic,Nematicide, Pesticide,Lubricant, Antiandrogenic, Flavor activities.
2.	19.57	Ethyl Oleate	$C_{20}H_{38}O_2$	310.52	100	Fatty acid ethyl ester	It is used for vehicle for intramuscular drug delivery.
3.	19.8	14-Hydroxy-15- methylhexadec-15- enoic acid, ethyl ester	$C_{19}H_{36}O_3$	312.48734	91.2	-	No activity reported.
4.	21.75	2a,3b,5b,6a- Tetramethoxy carbonyl- bicyclo(2,2,2)oct-7-ene	$C_{16}H_{20}$	340.325	23.3	-	No activity reported.
5.	23.37	Estra-1,3,5(10),6- tetraene-3,17- diol,diacetate, (17a')-	-	-	18	Unknown compound	-

Source: Dr. Duke's Phytochemical and Ethnobotanical Databases

S.No	RT	Name of the compound	Molecular	Molecular	Peak	Compound Nature	Activity
			formula	weight	area, (%)		
1.	12.68	O-Himachalene	C15H24	204.3511	4.3	-	Noactivity reported.
2.	14.15	Oxacyclotetradecan-2-one	-	-	15.2	Unknown compound	-
3.	14.5	Ar-tumerone	C ₁₅ H ₂₀ O	216.319	91.8	Sesquiterpenoid	Antivenom.Antidépr esseur, Anti- inflammatorie, Neuroprotecteuracti vities.
4.	14.9	Curlone	$C_{15}H_{22}O$	218.33458	41.4	Ketone	No activity reported.
5.	17.28	Pentadecanoic acid, 14- oxo, methyl ester	$C_{16}H_{30}O_3$	270.40800	7.2	-	Antioxidant, nematicide, pesticide, hypo- cholesterolemicactiv ities.
6.	17.93	4'-Methoxy-5,7- dihydroxy isoflavone	$C_{16}H_{12}O_5$	284.2635	6.4	Flavone	Used as a pharmaceutical intermediates.
7.	19.05	E,E,Z-1,3,12- Nonadecatriene-5,14-diol	$C_{19}H_{34}O_2$	294	4.4	-	Antimicrobial
8.	19.55	(Z,Z)-Ethanol,2-(9,12- octadecadienyloxy)-	$C_{20}H_{38}O_2$	310	5.6	Alcoholic compound.	Antimicrobial
9.	21.63	Tricosan-2-ol	-	-	7.8	Unknown compound	-

Source: Dr. Duke's Phytochemical and Ethnobotanical Databases

Table 6. Phytochemical components identified for butanol extract of Indoneesiella echioides (L) Nees (GC-MS study).

S.No.	RT	Name of the compound	Molecular formula	Molecular weight	Peak area (%)	Compound nature	Activity
1.	12.12	E-2-Tetradecen-1-ol	C ₁₄ H ₂₈ O	212.3715	3.1	Unsaturated alcohol	No activity reported.
2.	12.67	6,10-Dodecadien-1- ol,3,7,11-trimethyl- ,(E)-(n)-	C ₁₅ H ₂₈ O	224.38222	11.9	-	No activity reported.
3.	14.15	E,E-6,8-Tridecadien-2- ol, acetate	-	-	16.3	Unknown compound	-
4.	14.45	Ar-tumerone	C ₁₅ H ₂₀ O	216.319	91.8	Sesquiterpenoid	Antivenom, Anti- dépressant, Anti- inflammatory, Neuroprotector
5.	15.93	5-Hexenoic acid,(9- decen-2-yl) ester	-	-	15.7	Unknown compound	-
6.	17.22	4',5,7-Trihydroxy isoflavone	$C_{15}H_{10}O_5$	270.2369	11.7	Flavone	Antitumor agent, antioxidant, antiangiogenic and immunosuppre- ssive activities.
7.	17.88	Ethyl 9-hexadecenoate	$C_{18}H_{34}O_2$	282.4614	6.2	Fatty acid ester	No activity reported.
8.	19.15	16-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.49	7.2	Fatty acid ester	Inhibit eukaryotic DNA polymerase activities <i>in vitro</i>
9.	19.5	(Z,Z)-Ethanol,2-(9,12- octadecadienyloxy)-	$C_{20}H_{38}O_2$	310	6.5	Alcoholic compund	Antimicrobial activity.
10	21.63	Eicosanoic acid, 3- methyl-, methyl ester	-	-	7.8	Unknown compound	-

Source: Dr. Duke's Phytochemical and Ethnobotanical Databases

S.No.	RT	Name of the compound	Molecular formula	Molecular weight	Peak area (%)	Compound nature	Activity
1.	16.5	Methyl 2,8- dimethyltridecanoate	$C_{16}H_{32}O_2$	256.42408	11.1	-	No activity reported.
2.	18.8	4'-Methoxy-5,7-dihydroxy isoflavone	$C_{16}H_{12}O_5$	284.2635	61.7	Flavone	Used as a pharmaceutical intermediates.
3.	19.15	Cyclohexan-1-ol-3-one-1- carboxylic acid, 6-(2,3- dimethoxyphenyl)-	-	-	14	Unknown compound	-
4.	19.72	Ethyl Oleate	$C_{20}H_{38}O_2$	310.52	42.2	Fatty acid ester	It is used for intra- muscular drug delivery
5.	21.78	Elaidic acid, isopropyl ester	$C_{21}H_{40}O_2$	324.541	13.9	-	Anti-inflammatory, hypocholesterolemic, cancer preventive, hepatoprotective
6.	23.38	Isopropyl stearate	$C_{21}H_{42}O_2$	326.568	10.1	Stearic acid	Skin conditioning agent,binder and humectant activities.
7.	25.53	Estra-1,3,5(10)-trien-17a'- ol, 3-methoxy-17-(2- methylallyl)-	-	-	7.2	Unknown compound	-

Table 7. Phytochemical components identified for methanolic extract of Indoneesiella echioides (L) Nees (GC-MS study).

Source: Dr. Duke's Phytochemical and Ethnobotanical Databases.

Out of the nine phytochemicals obtained from chloroform extract, two (Table 3, S. No. 8 and 9) are unknown compounds.

Analysis of acetone extract

Five phytocomponents were isolated from the acetone extract of *Indoneesiella echioides* (L) *Nees* plant leaves (Table 4). Out of five components, only one (at S. No. 5) is unknown compound.

Analysis of ethanolic extract

Nine phytocomponents isolated from the ethanolic extract of *Indoneesiella echioides* (L) *Nees* leaves and are listed in Table 5. Out of these, only one compound (at S. No. 9) is unknown compound.

Analysis of butanol extract

Ten phytocomponents were isolated from the butanol extract of *Indoneesiella echioides* (L) Nees leaves and are listed in Table 6. Out of these three (at S. No. 3, 5 and 10) are unknown compounds.

Analysis of methanolic extract

Seven isolated from the methanolic extract of *Indoneesiella echioides* (L) *Nees* plant leaves and are listed in Table 7. Out of these compounds, two (at S. No. 3 and 7) are unknown compounds.

The mass spectra of unknown compounds isolated from the extracts made by various solventscan be found in the supplementary material.

Results and Discussion

Shen et al^{20} reported that the new compounds of androgechoside A (5,8,2'-trihydroxy-7-methoxyflavone-5-O- β -D-glucopyranoside), androgechoside B (2*R*)-5,2'dihydroxy-7-methoxyflavanone-5-O- β -D-glucopyranoside), androechioside A $(2-O-\beta-D-glucopyranosyl-4-methoxy-$ 2,4,6-trihydroxybenzoate), androechioside B (methyl 3-(2hydroxyphenyl)-3-oxopropanoate 2- O-β-D- glucopyranoside) are isolated and structurally elucidated by spectral analysis and chemical transformation and 37 known compounds were identified to be, 2',6'-dihydroxyacetophenone 2'-O-β-D-glucopyranoside, echioidinin 5-O-β-Dglucopyranoside, echioidinin, pinostrobin, andrographidine C, dihydroechioidinin, tectochrysin 5-glucoside, methyl salicylate glucoside,7,8-dimethoxy-5-hydroxyflavone,5,7,8trimethoxyflavone, skullcapflavone I 2'-methyl ether, acetophenone-2-O-B-D-glucopyranoside, androechin, skullcapflavone I 2'-O-β-D-glucopyranoside, tectochrysin,5,7,2'trimethoxyflavone, echioidin, skullcapflavone I, 5,7dimethoxyflavone, negletein 6-O-β-D-glucopyranoside, andrographidine E, 4-hydroxy-3-methoxy-trans-cinnamicacid methyl ester, 4-hydroxybenzaldehyde, 4-hydroxy-transcinnamic acid methyl ester, O-coumaric acid, 2,6dihydroxybenzoic acid, 132-hydroxy-(132-R)-phaeophytin, (E)-phytyl-epoxide, phytol, phytene 1,2-diol, (+)dehydrovomifoliol,3β-hydroxy-5α, 6α,-epoxy-7-megastigmen-9-one, β-sitosterol,β-sitosteryl-3-O-β-glucopyranoside, squalene, 1*H*-indole-3-carbaldehyde, andloliolide comparision of their physical and spectral data with those reported in the literature.

In the present study preliminary phytochemical analysis of the *Indoneesiella echioides* (L) Nees revealed the presence of flavonoids, alkaloids, terpenoids, triterpenoids saponins, saponins, phenolic compound, sterols and amino acids are qualitatively analysed and the results are listed in table 1. These phytochemicals were found to be dihydroechioidinin, along with four unknown flavones, echioidinin, echioidin, skullcapflavone I 2'-O-methyl ester and skullcapflavone I 2'-O-glucoside.¹⁹ GC-MS studies indicated the presence of many phytocomponents such as flavones, sesquiterpenoids, fatty acid methyl ester, palmitic acid methyl ester, steroid, fatty acid ester, stearic acid, oleic acid, arachidic acid, myristic acid ester and unsaturated alcoholic compounds in the various extracts of the *Indoneesiella echioides* (L) *Nees* leaves.

Conclusion

The preliminary phytochemical analysis of *Indoneesiella echioides* (L) *Nees* leaves showed that they contain many bioactive chemicals like flavonoids, alkaloids, terpenoids, triterpenoids saponins, saponins, phenolic compounds, sterols and amino acids.

The GC-MS studies of *Indoneesiella echioides* (L) Nees leaves clearly indicate that the major compounds are the 4'-Methoxy-5,7-dihydroxy isoflavone (ethanol and methanol fractions),4',5,7-Trihydroxy isoflavone (butanol fraction), Ar-tumerone (ethanol and butanol fractions), Ethyl Oleate (chlorofrom, acetone and methanol fractions), Ethanol, 2-(9,12-octadecadienyloxy)-,(Z,Z)- (ethanol and butanol fractions) are identified.

Unknown compounds such as 3,5-dicarbethoxy-1-methyl-1,4,5,6,7,8-hexahydropyrrolo (2,3-b)azepin-4,7-dione, butanoic acid, 3-methyl-, hexadecyl ester, estra-1,3,5(10),6-tetraene-3,17-diol,diacetate,(17a')-, tricosan-2-ol, E,E-6,8-tridecadien-2-ol, acetate, 5-hexenoic acid,(9-decen-2-yl) ester, eicosanoic acid, 3-methyl-, methyl ester, 4'-methoxy-5,7dihydroxy isoflavone, cyclohexan-1-ol-3-one-1-carboxylic acid, 6-(2,3-dimethoxyphenyl)-, estra-1,3,5(10)-trien-17a'-ol, 3-methoxy-17-(2-methylallyl)- are identified.

Minor compounds such as undecanoic acid, 10-methyl-, methyl ester, methyl tetradecanoate, tetradecanoic acid, 12methyl-, methyl ester, 9-hexadecenoic acid, methyl ester, (Z)-, pentadecanoic acid, 14-methyl-, methyl ester, hexadecanoic acid, 14-methyl-, methyl ester, 10octadecenoic acid, methyl ester, heptadecanoic acid, 16methyl-, methyl ester, eicosanoic acid, eicosanoic acid methyl ester, hexadecanoic acid, 1,1-dimethylethyl ester, docosanoic acid methyl ester, benzoic acid, 2,4-dimethoxy-6-methyl-,(8,8-dimethoxy-2-octyl) ester, phenol, 2,4bis(1,1-dimethylethyl)-, 1,4-dicyano-2-cyclohexylbenzene, flavone, pentadecanoic acid, 13-methyl-, methyl ester, nhexadecanoic acid, 10-octadecenoic acid, methyl ester, ethyl Oleate, hexadecanoic acid, ethyl ester, 14-hydroxy-15methylhexadec-15-enoic acid, ethyl ester, 2a,3b,5b,6atetramethoxycarbonylbicyclo[2,2,2]oct-7-ene, O-himachalene, oxacyclotetradecan-2-one, curlone, pentadecanoic acid, 14-oxo-, methyl ester, E,E,Z-1,3,12-nonadecatriene-5,14-diol, E-2-tetradecen-1-ol, 6,10-dodecadien-1-ol,3,7,11-trimethyl-,

(E)-(n)-, ethyl 9-hexadecenoate, 16-octadecenoic acid, methyl ester, methyl 2,8-dimethyltridecanoate, elaidic acid, isopropyl ester, isopropyl stearate, 3-methoxy-17-(2-methylallyl)- were also identified.

These compounds are exhibited activities like antioxidant, cancer-preventive, hypercholesterolemic, nematicide, antifungal, antimicrobial. They are used as skin cancer protein, alpha-glucosidase inhibitors, therapeutic and diagnostic agents, an emollient, skin conditioning agent, binder, humectant, anti-inflammatory, hypocholesterolemic, hepatoprotective, cancer preventive, anticoronary, antieczemic, insectifuge. They are also used for vehicle for intramuscular delivery of drugs such as Progesterone. They selectively inhibit eukaryotic DNA polymerase activities. Some of these compounds are also find use as antitumor agent, antioxidant, antiangiogenic and immunosuppressive, nematicide, pesticide, lubricant, antiandrogenic and flavor agents. Hence Indoneesiella echioides (L) Nees is worthy for further investigation in natural drugs developments.

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References

- ¹Nadkarni A. K., Nadkarni K. M., *Indian Materia Medica*, Vol.1, Popular Prakashan, Bombay, **1976**.
- ²Qadrie, Z. L., Beena, J., Anandan, R., Rajkapoor, B., Rahamathulla, M., *Pak. J. Pharm. Sci.*, **2009**, *22*, 123-125.
- ³Kirtikar, K.R., Basu. B. D., in *Indian medicinal plants*, Vol. 3, Periodical Experts, New Delhi **1975**.
- ⁴Kirtikar, K.R., Basu. B. D., in *Indian medicinal plants*, Vol. 3, Periodical Experts, New Delhi **1975**, 1884-1886.
- ⁵Chopra, R. N., Nayer, S. L., Chopra, I. C., *Glossary of Indian Medicinal Plants*, Council of Scientific and Industrial Research, New Delhi, **1980**, 18.
- ⁶Pandi Kumar P., Ayyanar, M., Ignacimuthu, S., *Indian J. Tredit. Knowl.*, **2007**, *6*, 579-582.
- ⁷Harbone, J. B., *The Flavonoids: Advances in Research Science* 1986, Chapman and Hall: London, UK, **1994**, 280-290.
- ⁸Iinuma, M., Mizuno, M., *Phytochemistry*, **1989**, *28*, 681-694.
- ⁹Kleipool, R. J. C., Nature, 1952, 169, 33-34.
- ¹⁰Chan, W. R., Taylor, C. R., Willis, R. L., Bodden, R. L., *Tetrahedran*, **1971**, 27, 5081-5091.
- ¹¹Balmain, A., Connolly, J. D., J. Chem. Soc., Perkin Trans. I, 1973, 1247-1251.
- ¹²Fujita, T., Fujitani, R., Takeda, Y., Takaishi, Y., Yamada, T., Kido, M., Miura, I., *Chem. Pharm. Bull.*, **1994**, *42*, 1216-1225.
- ¹³Matsuda, T., Kuroyanagi, M., Sugiyama, S., Umehara, K., Ueno, A., Nishi, K., *Chem. Pharm. Bull.*, **1994**, *42*, 1216-1225.
- ¹⁴Reddy, M. K., Reddy, M. V., Gunasekar, D., Murthy, M. M., Caux, C., Bodo, B. A., *Phytochemistry*, **2003**, *62*, 1271-1275.

- ¹⁵Govindachari, T. R., Parthasarathy P. C., Pai, B. R., Subramaniam, P. S., *Tetrahedron*, 1956, 21, 2633-2640.
- ¹⁶Govindachari, T. R., Parthasarathy P. C., Pai, B. R., Subramaniam, P. S., *Tetrahedron*, 1956, 21, 3715-3720.
- ¹⁷Jayaprakasam, B., Damu, A. G., Gunasekar, D., Blond, A., Bodo, B. *Phytochemistry*, **1999**, *52*, 935-937.
- ¹⁸Jayaprakasam, B., Gunasekar, D., Rao, K. V., Blond, A., Bodo, B., J. Asian Nat. Prod. Res., **2001**, *3*, 43-48.
- ¹⁹Sharma, S. K., Ali M., Gupta J., *Phytochem Pharmacol.*, 2002, 2, 253-270.
- ²⁰Shen, D.-Y., Juang, S.-H., Kuo, P.-C., Huang, G.-J., Chan, Y.-Y., Damu, A. G., Wu, T.-S., *J. Mol. Sci.*, **2013**, *14*, 496-514.

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