REVIEW

The Genus *Plectranthus* in India and Its Chemistry

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Phytochemical constituents isolated from Indian species of the genus *Plectranthus* reported up to 2009 are compiled. In India, the genus *Plectranthus* is found in all the habitats and altitudes, particularly in the Himalaya, the Southern Ghats, and the Nilgiri region. *P. amboinicus*, *P. barbatus*, *P. caninus*, *P. mollis*, *P. coetsa*, and *P. incanus* are the most common species found in India. Phytochemical studies of the genus revealed that Indian *Plectranthus* species are rich in essential oil, and that the most abundant secondary metabolites are diterpenoids, *i.e.*, labdanes, abietanes, and *ent*-kauranes, as well as triterpenoids.

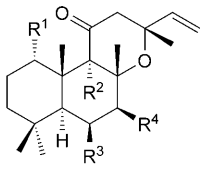
Contents

1. Introduction. – The Lamiaceae family belongs to the angiosperms and represents a valuable pool of species that contain biologically active compounds [1]. Lamiaceae species are found worldwide in most of the habitats and altitudes. They are divided in several genera, such as mint (*Mentha*), sage (*Salvia*), and basil (*Ocimum*). Another important genus of the Lamiaceae is *Plectranthus*, which is found in Asia, tropical Africa, and Australia. The first description of *Plectranthus* L' HÉR. was given by *Charles Louis L' Héritier de Brutelle*, published in 1784–1785 [2]. The genus *Plectranthus* (harp shrubs) belongs to the Lamiaceae subfamily Nepetoideae and the tribe Ocimeae [3]. The genus name *Plectranthus* hails from the Greek words *plektron* (spur) and *anthos* (flower), as the flowers have spurs at their base. Because of the odor of the plant, some *Plectranthus* species are also called moth king. The genus *Plectranthus* is related to the

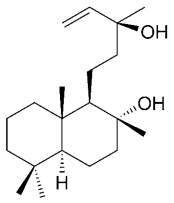
genera *Salvia*, *Rabdosia*, *Coleus*, and *Isodon* [4]. Some species that were formerly attributed to the genus *Plectranthus* are now known as *Isodon* species [5]. At the present time, *ca*. 62 *Plectranthus* species are used all around the world as ornamental plants and as medicines with economic interest, along with a rich diversity of ethnobotanical uses. They have antiseptic, vermicidal, and purgative activities and are used for the treatment of infections, toothache, stomachache, and allergies [6]. The chemistry of the genus *Plectranthus* remains relatively unknown, but several plants have been studied chemically, diterpenoids being the most common secondary metabolites. The majority of them are highly modified abietanoids, in addition to *ent*-kauranes and phyllocladanes. Essential oils, triterpenoids, flavonoids, and long-chain alkylcatechols were also isolated [7].

The genus *Plectranthus* consists of *ca*. 300 species, distributed from Africa to Asia and Australia [8]. In India, *ca*. 30 *Plectranthus* species are known [9], of which *P. amboinicus*, *P. vettiveroides*, *P. barbatus*, *P. mollis*, *P. coetsa*, and *P. incanus* are the most common species used in the traditional Indian Ayurvedic medicine since ancient times to treat many disorders and diseases [10][11]. However, very little is known about the chemical constituents and biological activities of *Plectranthus* species growing in India.

2. Chemical Constituents Isolated from Indian *Plectranthus* Species. – 2.1. *Essential Oils.* Essential oils are isolated from different parts of the plant and are complex volatile mixtures of secondary metabolites. They are responsible for the fragrance, the flavor, as well as the medicinal importance of the plant. Due to these virtues, they are used in the perfumery, food, and beverage industries, and also in therapeutic applications [12]. Essential oils are generally extracted by distillation. Other processes include solvent extraction. The genus *Plectranthus* of the Lamiaceae, subfamily Nepetoideae, is rich in essential oils [13]. The main constituents of the essential oils of *Plectranthus* species are mono- and sesquiterpenes. *P. amboinicus* was found to contain essential oils and fatty acids [14]. On a fused-silica capillary GC column, the essential oil of *P. amboinicus* was separated into α-pinene, camphene, oct-1-en-3-ol, β-pinene, myrcene, α-phellandrene, Δ^3-carene, α-terpinene, *p*-cymene, limonene, (*Z*)-β-ocimene, (*E*)-β-ocimene, α-phelandrene, γ-terpinene, α-terpinolene, linalool, camphor, 1-terpinen-4-ol, α-terpineol, thymol, carvacrol, α-cubebene, β-cubebene, β-elemene, β-caryophyllene, α-bergamotene, (*Z*)-β-farnesene, α-humulene, β-guaiene, (−)-α-selinene, β-bisabolene, δ-cadinene, caryophyllene oxide, δ-cadinol, α-cadinol, farnesol, calamenol, and (−)-aromadendrane-4β,7β-diol [15]. The major constituents of the essential oils of *P. barbatus* were α-pinene (22.2%) in the leaves, β-phellandrene (26.1%) in the stems, and (*Z*)-β-ocimene (37.6%) in the roots, when analyzed by GC/MS [16]. *G. Fournier et al.* [17] reported that the essential oil of *P. fruticosus* contained linalool, α-thuyene, aromadendrene, β-bourbonene, terpinen-4-ol, γ-cadinene, sabinene, α-elemene, sabinyl acetate, γ-terpinene, α-humulene, α-cubene, β-bisabolene, *trans*-copaene, and *trans*-farnesol. *P. melissoides* contained mostly oxygenated monoterpenes and monoterpene hydrocarbons. The main components of the oil were carvacrol (41.3%), *p*-cymene (17.4%), γ-terpinene (10.1%), methyl thymol (3.0%), thymol (7.9%), and carvacrol acetate (4.6%), as analyzed by GC and GC/MS [18]. When examining *P. rugosus* essential oil by GLC, NMR, and MS analyses, the main constituents identified were germacrene D, caryophyllene, α-pinene, α-phellandrene,



	R^1	R^2	R^3	R^4
1	OH	OH	OH	AcO
2	OH	OH	AcO	OH
3	H	OH	OH	OH
4	H	H	OH	OH



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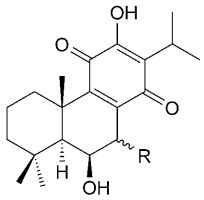
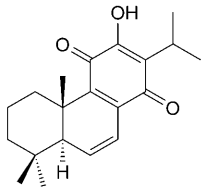


6 R = α-AcO
7 R = β-AcO
8 R = α-OH
9 R = β-OH



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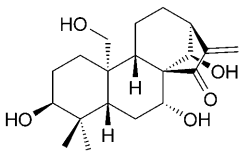

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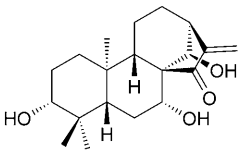

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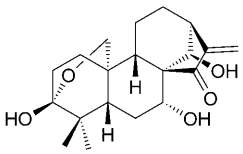

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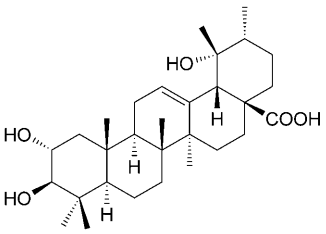

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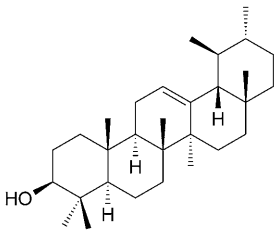

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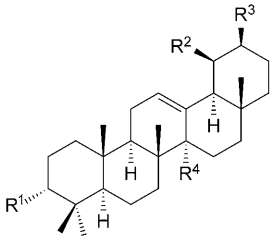
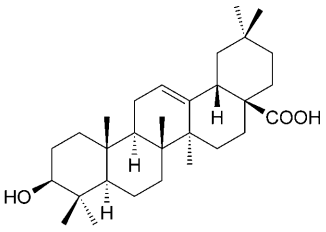


	R^1	R^2	R^3	R^4
16	OH	Me	COOH	Me
17	OH	Me	Me	COOH
18	OH	HO–CH_2	Me	Me
19	AcO	COOH	Me	Me
20	OH	COOH	Me	Me



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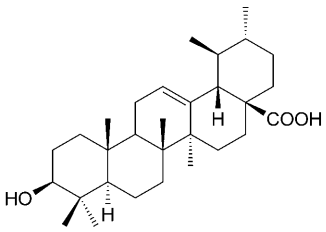

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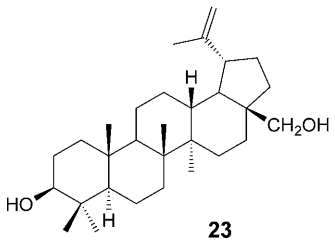

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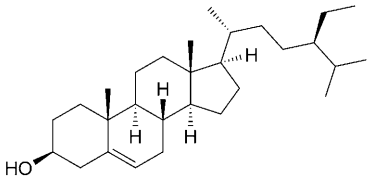

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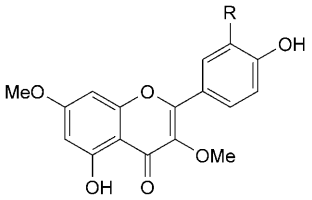
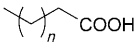
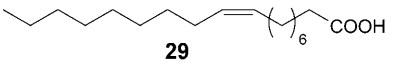


25 R = H
26 R = OH



27 *n* = 13
28 *n* = 15



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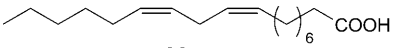

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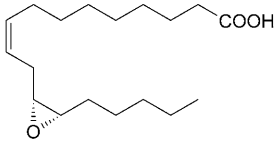

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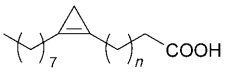

32 *n* = 5
33 *n* = 6

caryophyllene oxide, δ-cadinene, *p*-cymene, α-cadinol, limonene, β-phellandrene, and myrcene [9]. Essential oils were also isolated from *P. incanus* [19] and *P. japonicus* [20].

2.2. *Diterpenoids.* Diterpenes contain four isoprene units, hence possessing 20 C-atoms and four branched Me groups. Typical examples are vitamin A, retinene, and aconitina, all derived from geranylgeraniol pyrophosphate. Diterpenoids, a class of naturally occurring secondary metabolites with a large variety of structures, are found mainly in Angiospermae [21], and among the Angiospermae, the families from which most of them were isolated are Lamiaceae [22] and Asteraceae [23].

In *Plectranthus* species, numerous diterpenoids were isolated mainly from the leaf-glands. The diterpenoids found in Indian *Plectranthus* species, *i.e.*, compounds **1**–**13**, were labdanes, abietanes, and *ent*-kauranes. Their names are listed in *Table 1*, and the *Plectranthus* species from which they were isolated are compiled in *Table 2*.

2.3. *Triterpenoids and Related Compounds.* Triterpenoids contain 30 C-atoms and have been isolated from plants as well as from animals. Examples of important triterpenoids are squalene (acyclic), ambrein (tricyclic), lanosterol (tetratcyclic), and the amyrins (pentacyclic).

The names of triterpenoids **14**–**23** and the Indian *Plectranthus* species from which they were isolated are listed in *Tables 1* and *2*, respectively. Tormentic acid (**14**) and α-

Table 1. *Compound Class and Names of Chemical Constituents Isolated from Indian* Plectranthus *Species*

No.	Compound class and name	Ref.
	Diterpenoids	
1	Forskolin (syn. coleonol)	[24][25]
2	Isoforskolin	[25]
3	1-Deoxyforskolin	[25]
4	1,9-Dideoxyforskolin	[24][25]
5	13-*epi*-Sclareol	[26]
6	7α-Acetoxy-6β-hydroxyroyleanone	[27][28]
7	7β-Acetoxy-6β-hydroxyroyleanone	[28]
8	6β,7α-Dihydroxyroyleanone	[27]
9	6β,7β-Dihydroxyroyleanone	[28]
10	6,7-Dehydroroyleanone	[27]
11	Coestinol	[29]
12	Pseurata A	[29]
13	Plecostonol	[30]
	Triterpenoids and related compounds	
14	Tormentic acid	[31]
15	α-Amyrine	[31]
16	Plectranthoic acid A	[32]
17	Plectranthoic acid B	[32]
18	Plectranthadiol	[33]
19	Acetylplectranthoic acid	[33]
20	Plectranthoic acid	[33]
21	Oleanolic acid	[34]
22	Ursolic acid	[34][35]
23	Betulin	[34][36]
24	β-Sitosterol	[31][34][35]
	Flavones	
25	3,7-Dimethylkaempferol (kumatakinin)	[31]
26	3,7-Dimethylquercetin	[31]
	Fatty acids	
27	Palmitic acid	[37]
28	Stearic acid	[37]
29	Oleic acid	[37]
30	Linoleic acid	[37]
31	Vernolic acid	[37]
32	Malvalic acid	[37]
33	Sterculic acid	[37]

amyrine (**15**) were found in *P. caninus* collected in Mannanur, Andhra Pradesh [31]. Five triterpenoids, namely, plectranthoic acid A (**16**), plectranthoic acid B (**17**), plectranthadiol (**18**), acetylplectranthoic acid (**19**), and plectranthoic acid (**20**), as well as the phytosterol β-sitosterol (**24**), were isolated from *P. rugosus* [32][33][44]. Moreover, the triterpenes oleanolic acid (**21**), ursolic acid (**22**), and betulin (**23**), in addition to **24** and hexacosanol, were isolated from the same species by *Misra et al.* [34]. Compounds **21**, **22**, and **24** were also isolated from the roots of *P. straitus* [46].

Table 2. *Indian* Plectranthus *Species and Their Chemical Constituents*

Plectranthus Species	Isolated chemical constituents	Ref.
P. amboinicus Lour.	Essential oil, fatty acids	[38]
P. barbatus Andrews (syn. *Coleus forskohlii*)	**1**–**5**	[26][39][40]
	Essential oil	[16][41]
P. caninus Roth (syn. *C. spicatus*)	**14**, **15**, and **24**–**26**	[31]
P. coetsa Buch.-Ham.	**11**–**13**, **20**–**22**, and **24**	[29][30]
P. fruticosus L'Hér.	Essential oil, **6**, **8**, and **10**	[17][27]
P. hadiensis (Forssk.) Schweinf. ex Spreng. (syn. *P. zeylanicus* and *C. zeylanicus*)	**6**, **7**, and **9**	[28]
P. incanus Link	Essential oil	[19]
P. japonicus Burm. F.	Essential oil	[20]
P. melissoides Benth.	Essential oil	[18]
P. mollis (Aiton) Sprengel	**27**–**33** and terpenoids	[37][42][43]
P. rugosus Wall.	Essential oil, **16**–**24**, hexacosanol, and fatty acids	[9][32][34][44][45]
P. straitus Benth.	**21**, **22**, and **24**	[46]

2.4. *Flavones.* In addition to the triterpenoids **14** and **15**, the aerial parts of *P. caninus* afforded the flavones 3,7-dimethylkaempferol (**25**), also called kumatakinin, and 3,7-dimethylquercetin (**26**; *Tables 1* and *2*) [31].

2.5. *Fatty Acids.* From *P. mollis*, palmitic (**27**), stearic (**28**), oleic (**29**), linoleic (**30**), and vernolic acid (**31**) and the cyclopropenoid fatty acids malvalic (**32**) and sterculic acid (**33**) were isolated (*Tables 1* and *2*) [37].

3. Biological Activities. – The biological activities and therapeutic indications of some Indian *Plectranthus* species are listed in *Table 3*. Not for all of the *Plectranthus* species grown in India, the exact biological activity is known, nevertheless, they are used in the Indian Ayurvedic medicine since ancient times [10][11].

4. Conclusions. – Although the genus *Plectranthus* comprises many plants of medicinal and economic interest, the chemistry of Indian species of this genus remains poorly known. *P. amboinicus*, *P. barbatus*, *P. coetsa*, *P. incanus*, *P. mollis*, and *P. vettiveroides* are the most common species used in the traditional Indian Ayurvedic medicine since ancient times. In particular, *P. barbatus* is one of the most important species of this genus in India, with a wide variety of traditional medicinal uses in Hindu and Ayurvedic traditional medicines.

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Table 3. *Biological Activities and Therapeutic Indications of Indian* Plectranthus *Species*

Plectranthus species	Activity and/or therapeutic indication	References
P. amboinicus (Hindi name: Ajma paan, Pashanbhedi)	Antifungal activity	[14]
	Anti-HIV activity	[47]
	Antitumor activity	[48]
	Antimalarial activity	[49][50]
	Eye infections, asthma, and bronchitis	[51]
	Urinary disorders	[51]
	Dyspepsia, indigestion, diarrhoea	[50–52]
	Skin allergies	[53]
P. barbatus (Hindi name: Makandi, Patharchur, Pashan bhedi)	Antitumor and antiproliferative activity	[26]
	Hypotensive and spasmolytic activity	[54]
	Anti-HIV activity	[25]
	Glaucoma	[55]
	Promoting lean body mass	[56]
	Heart diseases, painful urinary disorders, ear and eye infections	[40]
P. beddomei Raiz.	Skin allergies	[57]
P. caninus (local name: scaredy cat)	Antitumor activity	[31]
P. coetsa (local name: Chichiri)	Skin allergy	[58]
P. hadiensis	Diarrhea	[28]
P. incanus (Hindi name: Chichittoni)	Antimicrobial activity	[59][60]
	Skin allergies	[61]
	Respiratory infections and fever	[62]
	Muscular–skeletal disorders	[63]
P. mollis (local name: Kala Basinga)	Antitumor activity	[59]
	Cardiac depressant activity	[64]
	Antipoisonous activity	[61]
	Nervous disorders	[61][65]
	Respiratory stimulant, vasoconstrictor, and stomach cleaning activity	[64]
P. vettiveroides (local name: Udicya)	Stomachaches, dyspepsia, nausea, and vomiting	[62][66]
	Burning eyes, diarrhea, fever, intrinsic hemorrhage, hyperdipsia, strangury, leprosy, leucoderma, ulcer, vomiting, skin diseases, giddiness, headache, and insanity; thirst quenching and hair growth stimulation	[67]
	Skin infections and fever, genito-urinary stimulant	[64]

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