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## COLEUS FORSKHOLII: PHYTOCHEMICAL AND PHARMACOLOGICAL PROFILE

Mridul Bhowal\* and Darshika M. Mehta

PES College of Pharmacy, Rajiv Gandhi University of Health Sciences, Bengaluru - 560050, Karnataka, India.

### Keywords:

*Coleus forskohlii*, Forskolin, Phytochemical, Pharmacological, obesity, Volatile oil, Anti-diabetic

### Correspondence to Author:

**Mridul Bhowal**

B. Pharm  
PES College of Pharmacy,  
50 Feet Road, Hanumanthanagar,  
Bengaluru -560050, Karnataka, India.


**E-mail:** mridul.bhowal@gmail.com

**ABSTRACT:** *Coleus forskohlii* is an herb historically used in Ayurvedic medicine. Nowadays *Coleus forskohlii* is used as a fat burning supplement in various formulations and available in the Indian market. Forskolin the main constituent of this plant is used to treat allergies, skin conditions such as eczema and psoriasis, painful menstrual periods, irritable bowel syndrome (IBS), urinary tract infection (UTI), bladder infections, advanced cancer, blood clots, sexual problem in men, insomnia, and convulsions. Healthcare providers sometimes give forskolin intravenously (by IV) for heart failure. Some people breathe in (inhale) forskolin powder for asthma. Forskolin drops are used in the eyes to treat glaucoma. Because of its wide use, this plant some time been adulterated with its species and other varieties. The standardisation parameters are important for this plant in every herbal formulation. With the developments in modern instrumental methods it is high time for the herbal drug manufacturers to come out with the standard level of this drug to be included in the formulation. An extensive study of phytochemical constituents reported from *Coleus forskohlii* and pharmacological activities carried out are enlisted in this article.

**INTRODUCTION:** Medicinal plants are known as sources of phytochemicals, which are widely sought after worldwide for their natural properties. They are of great significance to the health of individuals and communities<sup>1</sup>. In many countries, herbal remedies are making a comeback as an alternative to modern medicine. India is one of the twelve mega biodiversity hot spot regions of the world and one fifth of all plants found in India are used for medicinal purpose<sup>2</sup>. *Coeleus forskholii* Briq. [Syn. *Coeleus barbatus* (Andr.) Benth] belonging to the family Lamiaceae is indigenous to India<sup>3</sup>.

The Indian herbal industries recognize it as most medicinally and economically important. Tuberos roots of coleus are found to be a rich source of Forskolin (Coleonol)<sup>4</sup>. Forskolin has a unique property of activating almost all hormone sensitive adenylate cyclase enzymes in a biological system<sup>5</sup>. It's used as a potential drug for hypertension, congestive cardiac failure, respiratory disorders, eczema, painful urination, colic, convulsions and insomnia<sup>6</sup>. Forskolin is reported to be useful in the treatment of glaucoma, asthma and certain type of cancers<sup>7</sup>. In addition, it has been shown to have anti-inflammatory property<sup>8</sup>.

The genus *Coleus* was first described by De Loureiro in the year 1970. The name *Coleus* is derived from the Greek word Koleos, which means sheath around the style<sup>9</sup>. The species name *forskohlii* was given to commemorate the Finnish botanist, Forskel. More than 150 species belong to genus *Coleus*.

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<b>DOI link:</b> <a href="http://dx.doi.org/10.13040/IJPSR.0975-8232.8(9).3599-18">http://dx.doi.org/10.13040/IJPSR.0975-8232.8(9).3599-18</a>	

In India, the major medicinal species of *Coleus* is the tuberous *C. forskohlii*; *C. amboinicus*, *C. blumei*, *C. zeylanicus*, *C. malabaricus* and *C. scutellaroides* and other species are mainly used to treat dysentery and digestive disorders<sup>10, 11</sup>. *C. forskohlii*, apart from its medicinal use is also used as a potent source of essential oil<sup>12</sup>. The essential oil present in tubers has an attractive and delicate odour with a spicy note<sup>13</sup>. The essential oil has potential use in the food flavouring industry and can be used as an antimicrobial agent<sup>14</sup>.

The focus of this review is to provide information on the advancement in the ethnopharmacological, phytochemical, pharmacological and toxicological profile of *Coleus forskohlii*.

**Plant Profile:** *Coleus forskohlii* is indigenous to India<sup>3</sup> and is recorded in Ayurvedic *Materia Medica* under the Sanskrit name 'Makandi' and 'Mayani'<sup>12, 15</sup>.

#### Taxonomical Hierarchy:<sup>16, 17</sup>

Kingdom: Plantae  
 Divison: Magnolophyta  
 Class: Magnoliopsida  
 Order: Lamiales  
 Family: Lamiaceae  
 Genus: *Coleus*  
 Species: *Forskohlii*

#### Vernacular names:

Sanskrit<sup>12, 15</sup>: *Makandi*, Pashanbhed, Mayani  
 Kannada: Makandiberu  
 English: *Coleus*  
 Hindi: Patharchur  
 Bengali: Paterchur

**Geographical Distribution:** *Coleus forskohlii* is an aromatic herbaceous species of medicinal importance. Indian sub- continent is considered as the place of origin of *C. forskohlii*<sup>4, 12</sup>. It grows wild in the sub-tropical warm temperate climates of India, Nepal, Burma, Sri Lanka and Thailand. Apparently, it has been distributed to Egypt, Arabia, Ethiopia, tropical East Africa and Brazil<sup>11</sup>.

<sup>18, 19</sup>. In India, the crop is cultivated in the parts of Gujarat, Maharashtra, Rajasthan, Karnataka and Tamil Nadu. In Tamil Nadu, it is approximately grown in Salem, Dharmapuri, Trichy, Erode, Coimbatore and Dindigul districts of 6000 acres. It grows wild in the Himalayan region from the Shimla hills extending throughout the Kumaon and Garhrwal hills, Parasnath hills of Bihar and Western Ghats<sup>19</sup>.

#### Botanical Description:

TABLE 1: BOTANICAL FEATURES OF *COLEUS FORSKOHLII*

Plant " <i>Coleus forskohlii</i> "		Overall Height: 45-60cm
Leaves	Size	Length: 7.5-12.5cm Width: 3-5cm
	Shape Colour	Tear drop shape Shimmering green framing bright purple centre; varies depending on the amount of shade.
Inflorescence Flowers	Features	Pubescent, narrowed into petioles Raceme; length: 15-30cm
		Stout; size ranges from 2-2.5cm; perfect and calyx inside
Calyx		Upper lip of calyx is broadly ovate
Ovary		Ovary is four parted and stigma is two lobed.
Root	Colour	Golden brown
	Type	Fibrous, thick, radially spreading, tuberous and fasciculated
	Shape	Conical fusiform
	Size	Length: 20cm Diameter: 0.5-2.5cm
	Odour	Strongly aromatic



FIG. 1: (A, D) *COLEUS FORSKOHLII* PLANT, (B) *COLEUS FORSKOHLII* TWIG, (C) ROOTS

**Ethnopharmacology:** Traditionally, the roots have been used as condiments in pickles and also for medicinal purposes by the ayurvedic schools of medicines<sup>20</sup>. Root juice is given to children suffering from constipation<sup>21</sup>. Kothas, the native tribes of Trichigadi (Kota) in Nilgiri, South India consider the decoction of tuberous roots as tonic<sup>22</sup>. Ethnomedicinal uses of *Coleus forskohlii* for relief of cough, eczema, skin infections, tumors and boils were also reported<sup>23</sup>. In Ayurvedic system of medicine, *Coleus forskohlii* has been used to treat hypertension, congestive heart failure, eczema, colic, respiratory disorders, painful urination, insomnia, and convulsions, asthma, bronchitis, intestinal disorders, burning sensation, constipation, epilepsy and angina<sup>20</sup>. Clinical studies of the plant and the forskolin constituent support these traditional uses, but also indicate that it may have therapeutic benefit in psoriasis, and prevention of cancer metastases<sup>8</sup>.

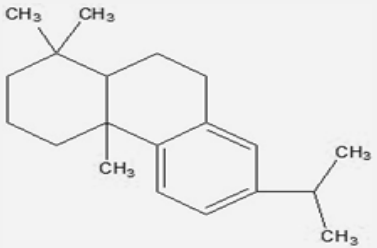
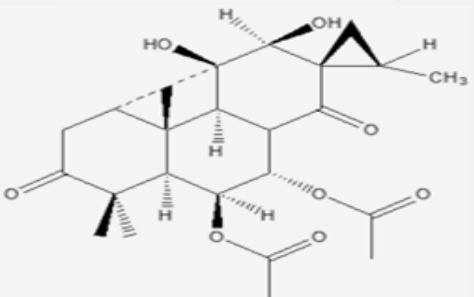
**Phytochemistry:** The major constituent which has been reported from *Coleus forskohlii* are diterpenoids and essential oils. The tuberous root extracts of *C. forskohlii* contain minor diterpenoids *i.e.*, deactylforskolin, 9-deoxyforskolin, 1, 9-deoxyforskolin, 1, 9-dideoxy-7-deacetylforskolin in addition to forskolin (7  $\beta$ - acetoxy - 8, 13-epoxy-1 $\alpha$ , 6  $\beta$ , 9  $\alpha$  - trihydroxyabd-14-en-11-one) which is the principle bioactive constituent of *Coleus forskohlii*<sup>10, 24</sup>. 1,6-diacetoxy-9-deoxyforskolin,

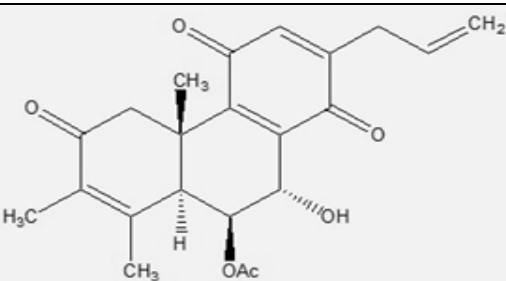
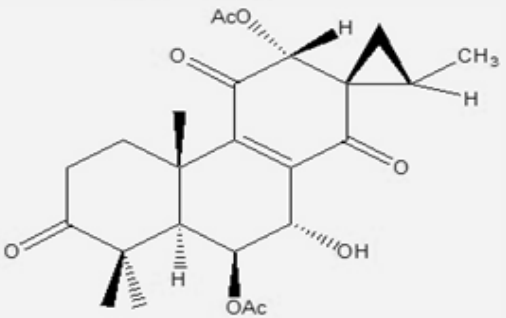
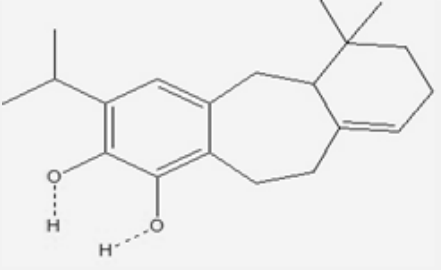
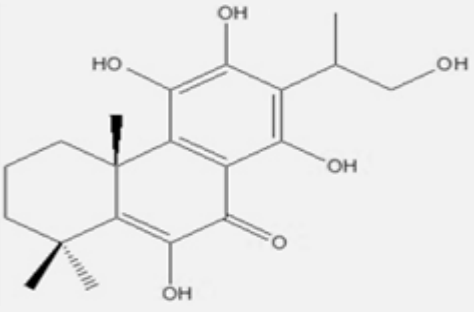
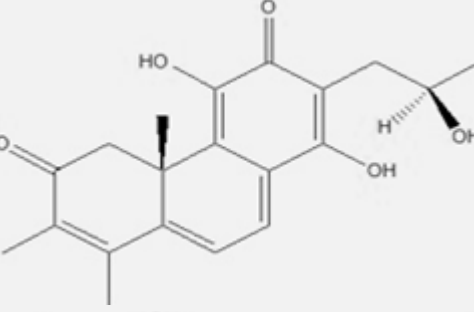
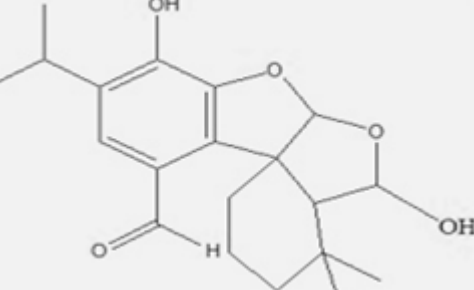
forskolin I, forskolin J, and forskolin L was isolated and reported from the Chinese species<sup>25</sup>. Two more diterpenoids *i.e.*, 6-acetyl-1-deoxyforskolin and 6-acetyl-1,9-dideoxy forskolin were also reported<sup>26</sup>. Further studies reports the presence of various forskolin derivatives like forskolin E, forskolin F or coleonol D, forskolin G, and forskolin H<sup>27</sup>. Jin and He<sup>28</sup> in the year 1998 isolated and reported 1-acetyl forskolin, Isoforskolin or coleonol B, and 1,6-di-O-acetylforskolin.

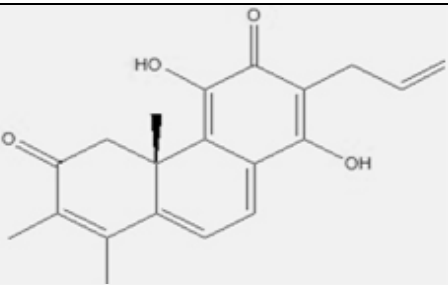
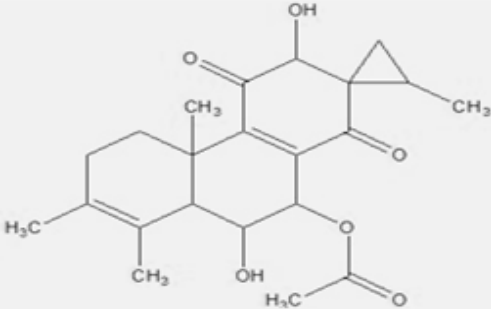
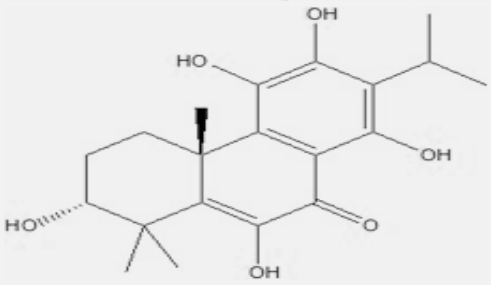
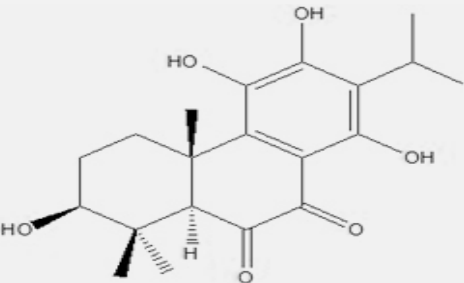
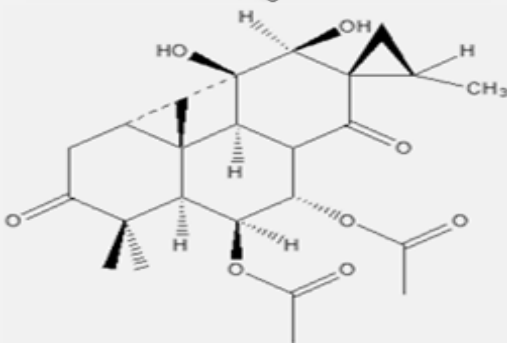
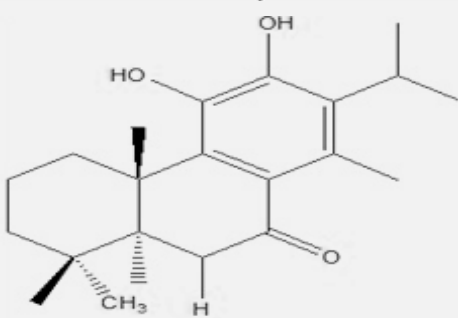
In the year 2007, Shan *et al.*,<sup>29</sup> extracted two diterpene glycosides namely forskoditerpenoside A and forskoditerpenoside B from the ethanol extract of the whole plant of *Coleus forskohlii*. Later, three new minor labdane diterpene glycosides, forskoditerpenoside C, forskoditerpenoside D, forskoditerpenoside E and a nobel labdane diterpene forskoditerpene A were isolated from the ethanolic extract of the whole plant of *Coleus forskohlii*<sup>30</sup>. Coleonol E and Coleonol F are reported from Indian species<sup>31</sup>.

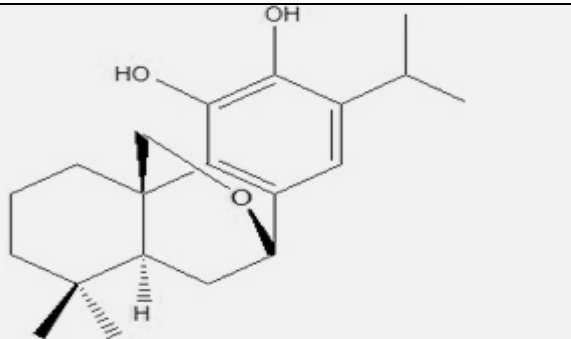
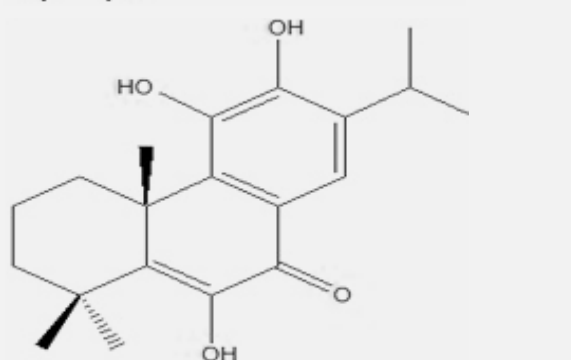
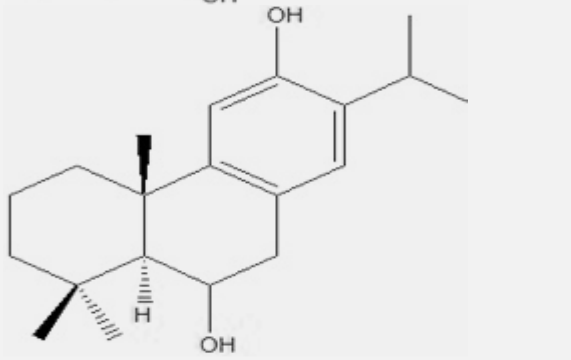
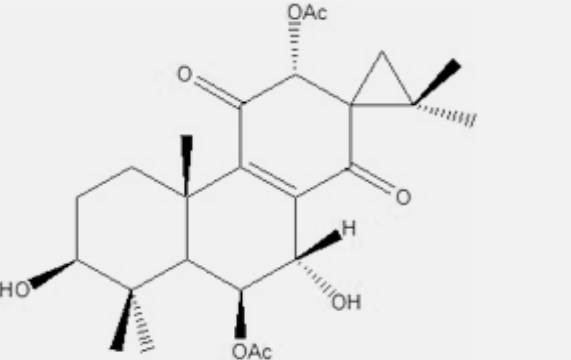
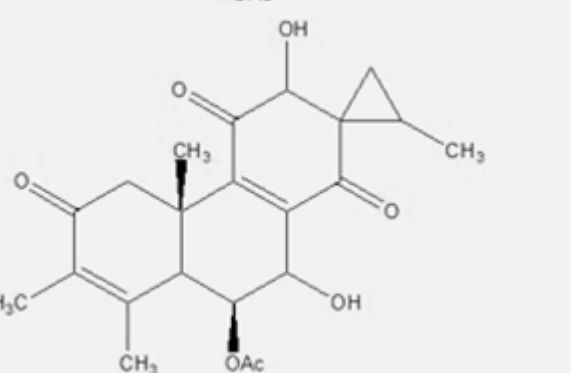
Coleol and coleosol were isolated from the roots of *C. forskohlii*<sup>32</sup>. In the Kenyan species coleon O and plectrin were reported from their leaves<sup>33</sup>. A study on whole plant extract conducted by Shan and Kong<sup>34</sup> in the year 2006, reports the presence of 3-hydroxy forskolin and 3-hydroxyisoforskolin.

**TABLE 2: THE DITERPENOID ISOLATED FROM COLEUS FORSKOHLII ALONG WITH THEIR STRUCTURES AND PLANT PARTS USED**

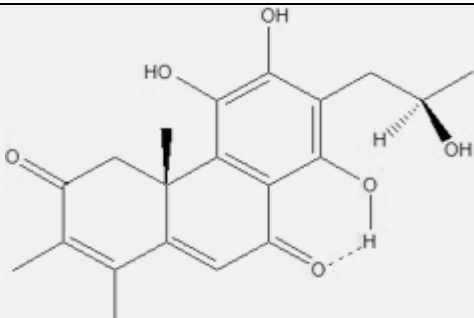
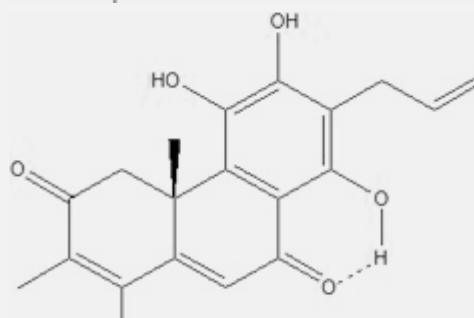
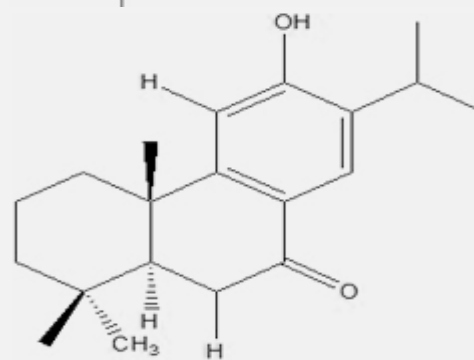
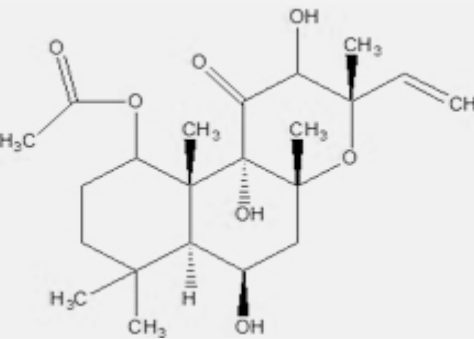
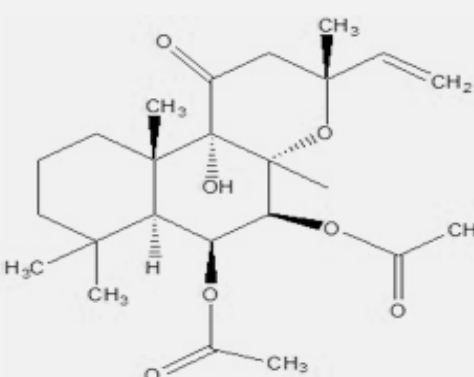
S.no.	Name of the compound	Structure	Plant parts used	Ref.
1.	Abietatriene (dehydroabietane)		Roots	35
2.	7 $\beta$ -Acetyl-12-deacetoxy-cyclobutatusin		Leaf	36

3.	(+)-Allylroyleanone (plectranthone J)		Leaf	37
4.	Barbatusin		Leaf	36, 38, 39
5.	Barbatusol		Stem	40
6.	Coleon C		Whole Plant	41
7.	(16R)-Coleon E		Leaf	37, 42
8.	Cariocal		Stem	43

9.	Coleon F		Leaf	37, 44
10.	Coleon O		Leaf	33
11.	Coleon S		Leaf	45, 46
12.	Coleon T		Leaf	45, 46
13.	Cyclobutatusin		Leaf	36, 38, 47
14.	Demethylcryptojaponol (11-hydroxysugiol)		Roots	48

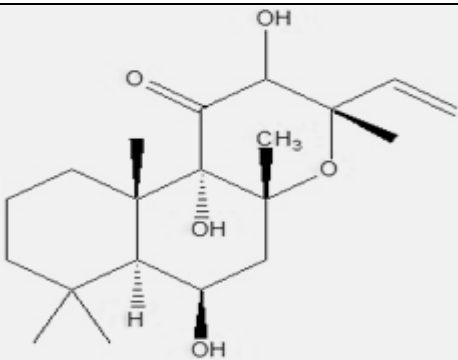
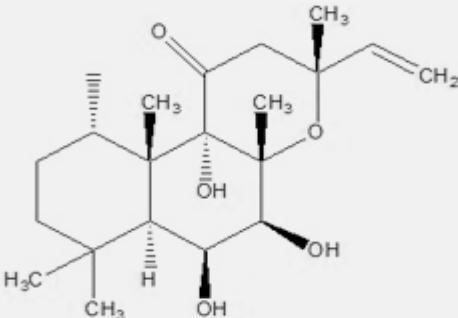
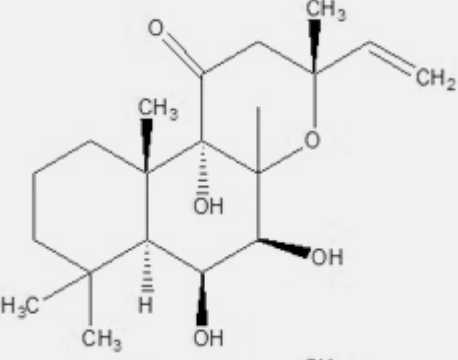
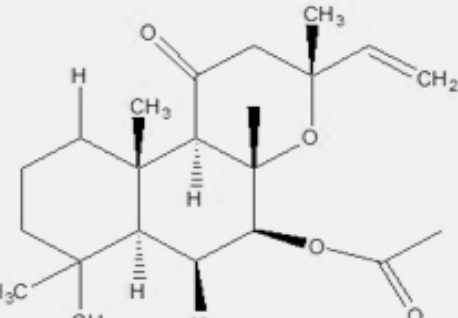
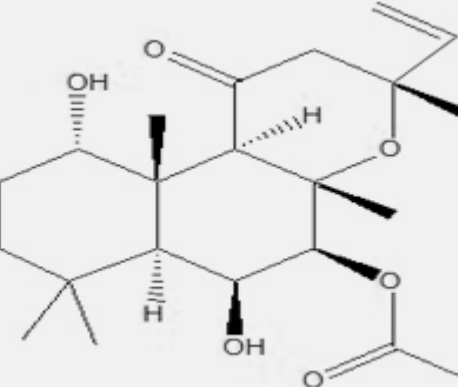
15.	20-Deoxocarnosol		Stem 49, 50
16.	14-Deoxycoleon U		Roots 48
17.	Ferruginol		Stem 40
18.	3β-Hydroxy-3-deoxybarbatusin		Leaf 38
19.	Plectrin		Leaf 33, 37

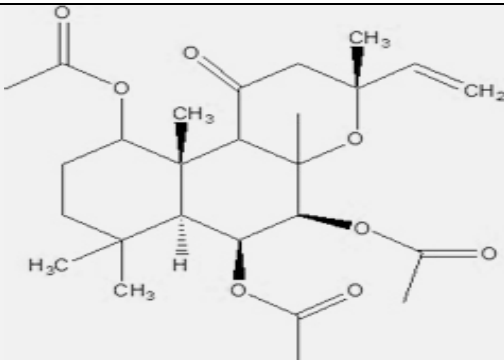
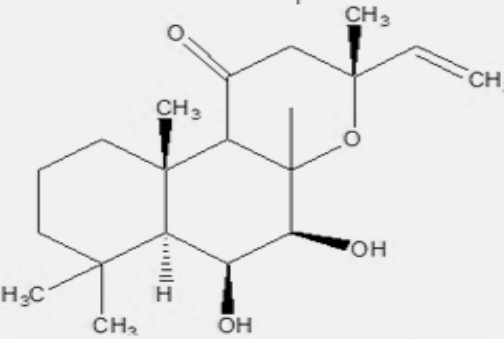
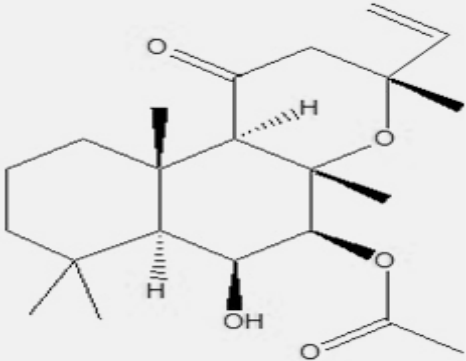
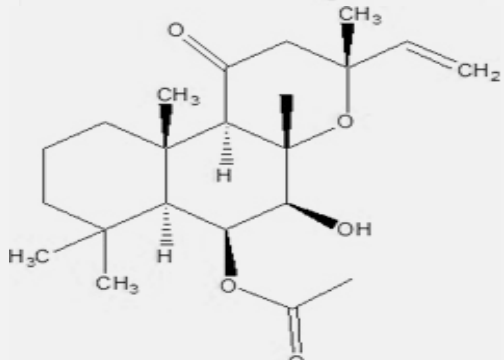
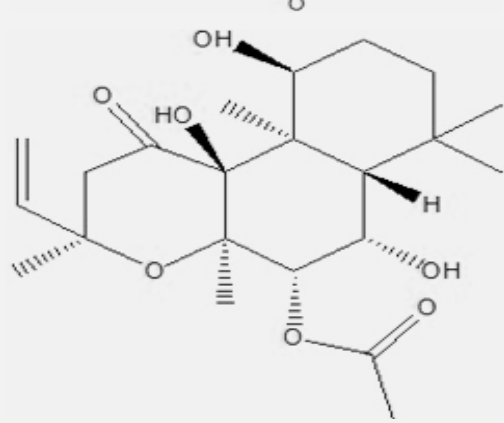


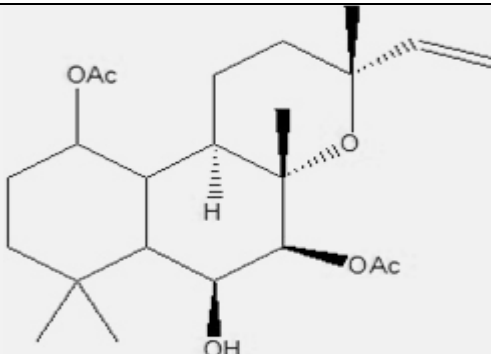
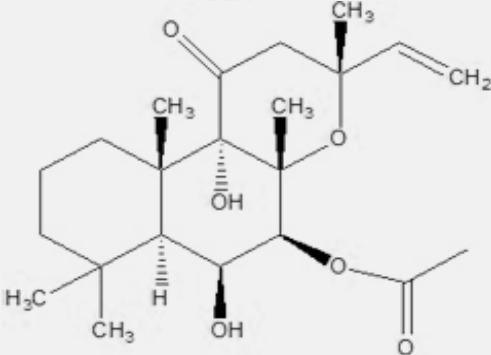
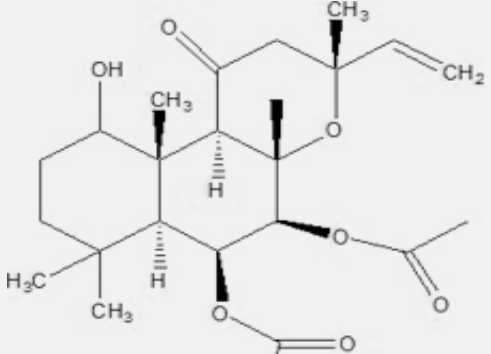
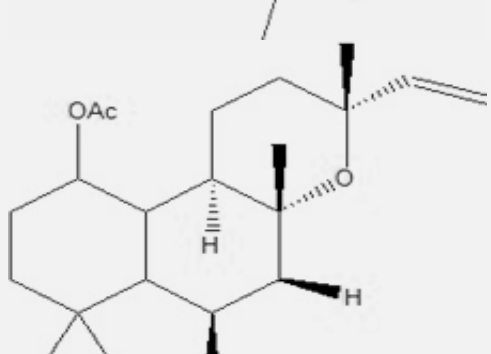
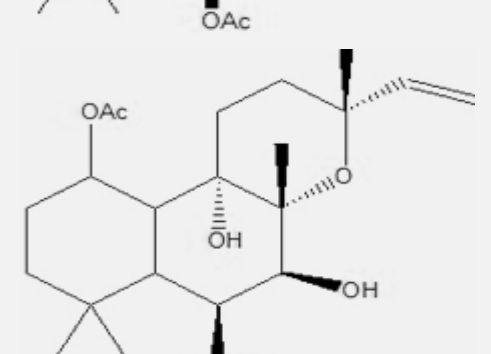
20.	(16R)-Plectrinon A		Leaf	37, 51
21.	Plectrinon B		Leaf	37
22.	Sugiol		Whole Plant	52
<b>8,13-Epoxy-labd-14-en-11-one-diterpenoids</b>				
23.	1-Acetoxy coleosol		Roots	53
24.	6-Acetyl-1-deoxyforskolin		Whole Plant	26

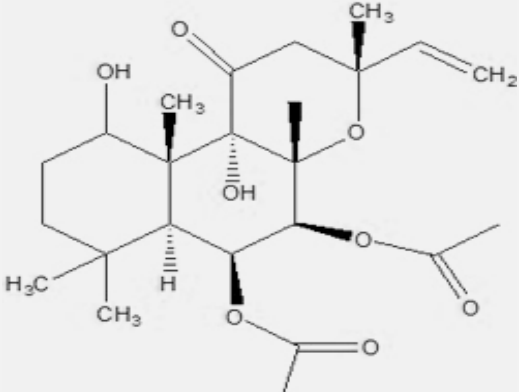
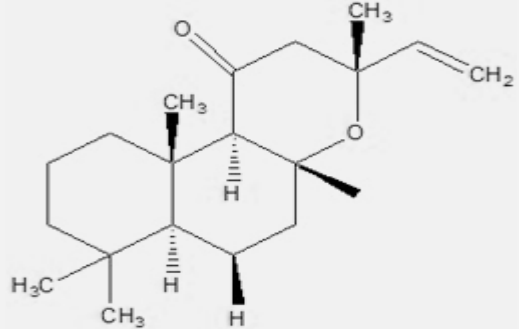
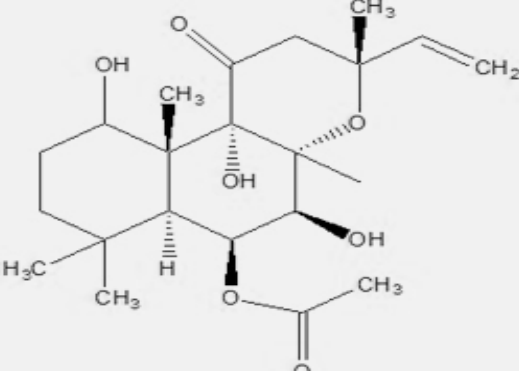
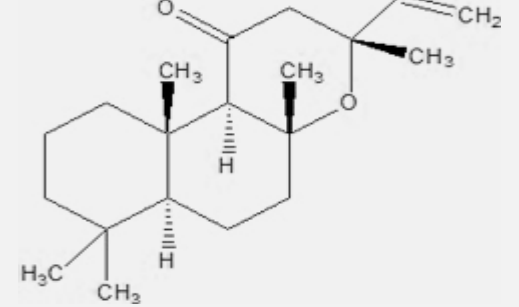
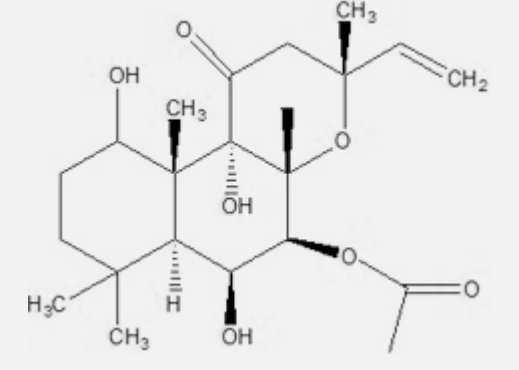
25.	1-Acetylforskolin		Roots, Whole Plant	28, 54, 55
26.	6-Acetyl-1,9-dideoxyforskolin		Whole Plant	26
27.	Coleol		Roots	32,56, 57, 58
28.	Coleonol E		Roots	59
29.	Coleonol F		Roots	59

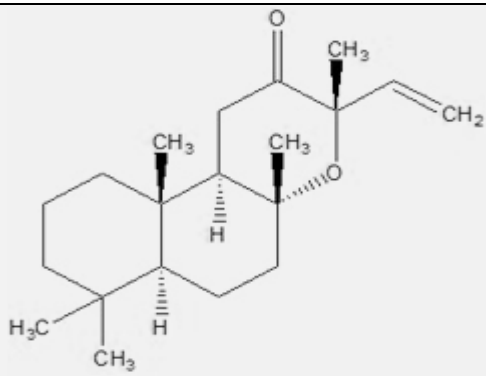
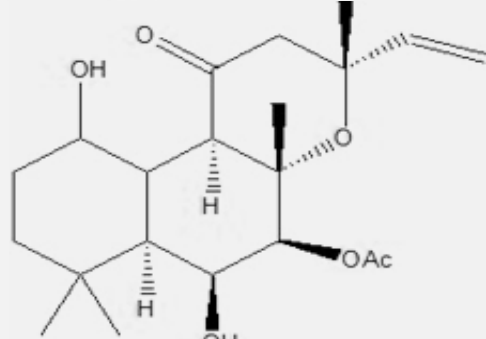
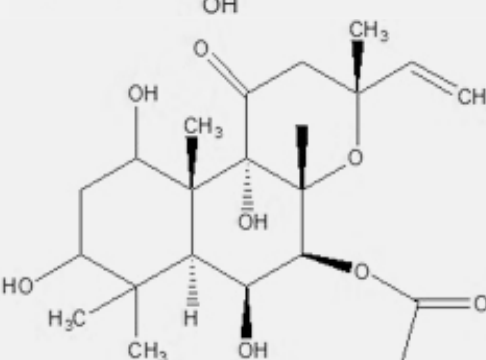
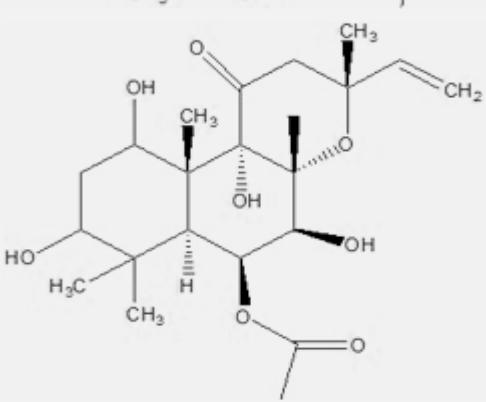
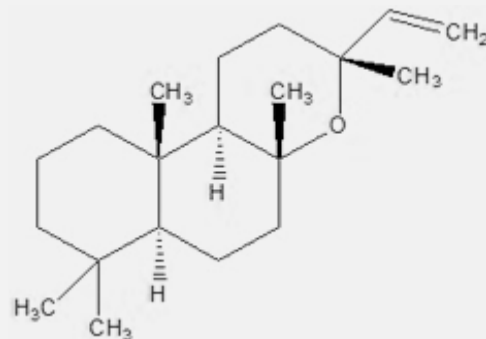


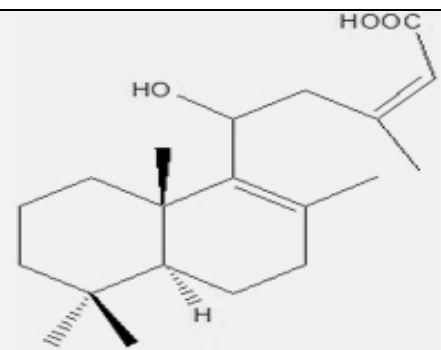
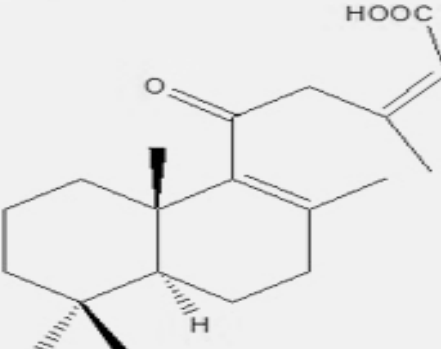
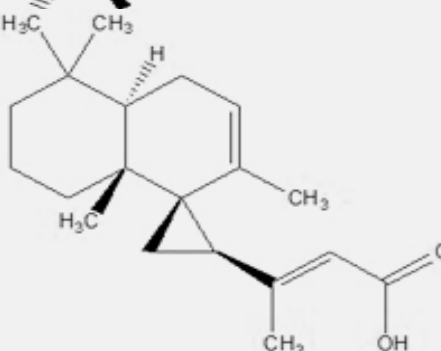
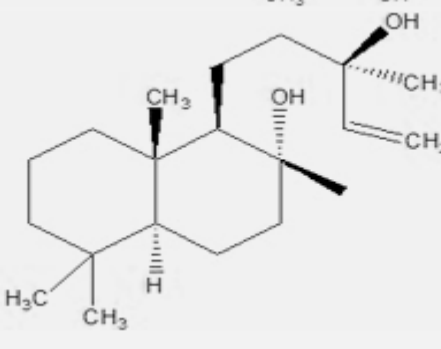
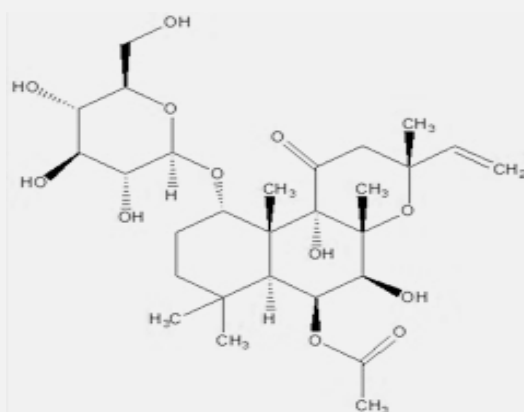
30.	Coleosol		Roots	32, 60
31.	7-Deacetylforskolin		Roots	28, 54, 55, 56, 61, 62
32.	Deacetyl-1-deoxyforskolin		Roots	56
33.	Deoxycoleonol		Roots	63
34.	9-Deoxyforskolin		Roots	56, 61, 64

35.	1,6-Diacetoxy-9-deoxyforskolin	 <p>The structure shows a complex polycyclic terpenoid skeleton with two acetoxy groups at positions 1 and 6, and a vinyl group at position 9. Stereochemistry is indicated with wedges and dashes.</p>	Roots, Whole Plant	26, 52, 65
36.	1,9-Dideoxy-7-deacetylforskolin	 <p>The structure features a polycyclic terpenoid core with a vinyl group at position 9 and a hydroxyl group at position 7. It lacks the acetoxy group at position 1.</p>	Roots	56, 61, 62
37.	1,9-Dideoxyfoskolin	 <p>The structure shows a polycyclic terpenoid skeleton with a vinyl group at position 9 and a hydroxyl group at position 1. It lacks the acetoxy group at position 7.</p>	Roots	56, 61, 62
38.	1,9-Dideoxycoleonol B	 <p>The structure is a polycyclic terpenoid with a vinyl group at position 9, a hydroxyl group at position 1, and an acetoxy group at position 7.</p>	Roots	53
39.	Forskolin	 <p>The structure represents forskolin, a complex polycyclic terpenoid with multiple hydroxyl groups and a vinyl group at position 9.</p>	Roots	3, 56, 61, 62, 66, 67

40.	Forskolin E		Roots, Whole Plant	28, 68
41.	Forskolin F		Roots, Whole Plant	27, 28, 32, 56, 68
42.	Forskolin G		Roots, Whole Plant	25, 27, 69, 70, 71
43.	Forskolin H		Roots, Whole Plant	25, 27, 71, 72
44.	Forskolin I		Roots, Whole Plant	25, 65, 69, 72

45.	Forskolin J		Roots	25, 65, 72
46.	6 $\beta$ -Hydroxy-8,13-epoxy-labd-14-en-11-one		Roots	25, 57, 65
47.	Isoforskolin		Roots	25, 28, 32, 45, 54, 55, 62, 67, 69, 73
48.	11-Oxomanoyloxide		Roots	56
		<b>8,13-Epoxy-labd-diterpenoids with some deviations</b>		
49.	Coleonol		Roots	63

50.	Coleonone		Roots	57, 58
51.	13-Epi-9-deoxycoleonol		Roots	74
52.	3-Hydroxyforskolin		Whole Plant	34
53.	3-Hydroxyisoforskolin		Whole Plant	34
54.	Manoyl oxide		Roots	35

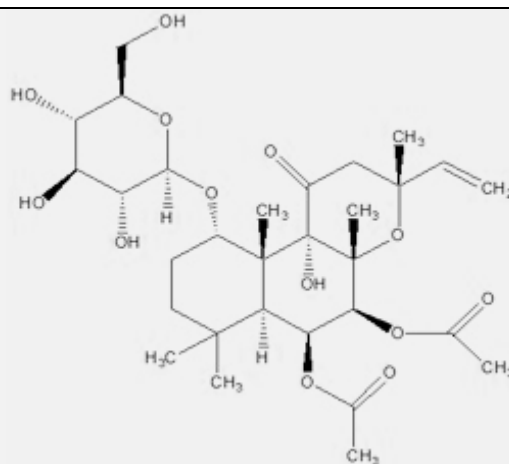
55.	Coleolic acid		Whole Plant	75
56.	Coleonic acid		Whole Plant	75
57.	Forskoditerpene A		Whole Plant	30
58.	13-Epi-sclareol		Roots	76
<b>8,13-Epoxy-labd-14-en-11-one-diterpene glycosides</b>				
59.	Forskoditerpenoside A		Whole Plant	29



60. Forskoditerpenoside B

Whole Plant

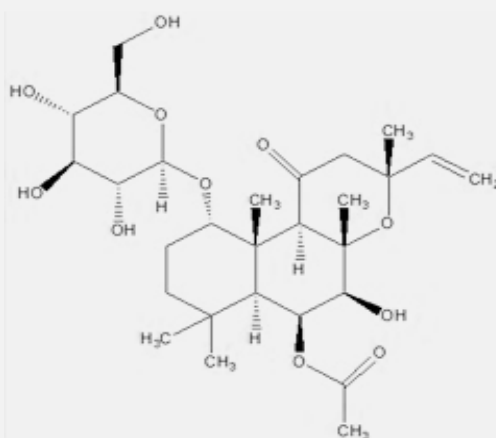
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61. Forskoditerpenoside C

Whole Plant

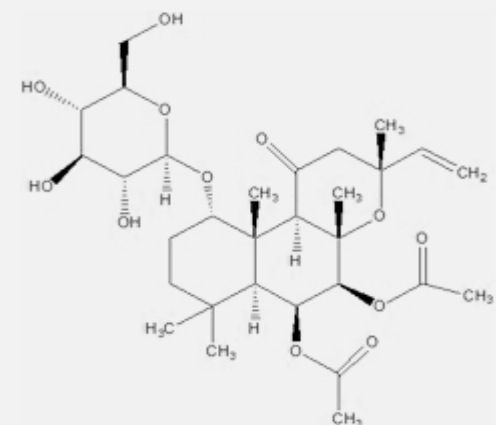
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62. Forskoditerpenoside D

Whole Plant

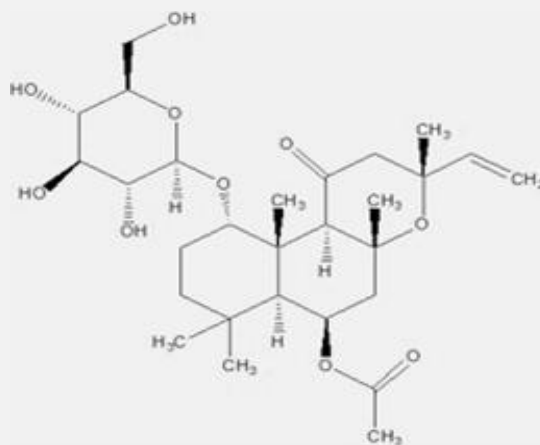
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63. Forskoditerpenoside E

Whole Plant

30



**Pharmacological Profile:** *Coleus forskohlii* has been used as a potential drug for hypertension, congestive cardiac failure, respiratory disorders, painful urination, colic, convulsions and insomnia<sup>6</sup>. It has been shown to have anti-inflammatory property as well<sup>8</sup>. Clinical studies of the plant and

the forskolin constituent support these traditional uses but also indicate that it may have therapeutic benefit in asthma, angina, psoriasis, and prevention of cancer metastases. The pharmacological studies carried out so far on *Coleus forskohlii* are given in **Table 3**.

**TABLE 3: PHARMACOLOGICAL ACTIVITIES REPORTED FROM *COLEUS FORSKOHLII***

S. no.	Activity	Action	References
1	Antiglaucoma/Reduction in Intra Ocular Pressure (IOP)	Forskolin suspension (1% forskolin) obtained from <i>Coleus forskohlii</i> lowers the IOP in rabbits, monkeys, and humans by reducing the net aqueous inflow.	77
2	Asthma	Forskolin the active constituent of <i>Coleus forskohlii</i> was studied as bronchodilator for its potential use in asthma. It blocked bronchospasm and bronchitis in guinea pigs caused by histamine and leukotriene C-4	78
3	Antiobesity	The antiobesity effects of were investigated in ovariectomized rats and the administration of <i>Coleus forskohlii</i> extracts reduced body weight, food intake and fat accumulation in those rats.	79
4	Antiplatelet	The antiobesity effects of were investigated in ovariectomized rats and the administration of <i>Coleus forskohlii</i> extracts reduced body weight, food intake and fat accumulation in those rats	80
5	Antimicrobial	A study on antimicrobial efficacy of <i>Coleus forskohlii</i> against <i>Staphylococcus aureus</i> shown both bacteriostatic and bacteriocidal activity at Minimum Inhibitory Concentration (MIC) values ranging from 60 to 300µg/ml.	81
6	Anti-inflammatory	Forskolin administered through i.p. route significantly inhibits Carrageenan-induced paw edema in a dose-dependent manner in rats. Similar effects were also observed in adjuvant induced polyarthritis and Croton oil-induced ear inflammation in rats	8
7	Antihypertensive	Studies shown that forskolin increases the heart rate, and lowers the blood pressure in dogs and cats and also in spontaneously hypertensive and renal hypertensive rats. Another study reports that coleonol (distereoisomer of forskolin) isolated from a 50% ethanol extract of <i>Coleus forskohlii</i> have lowered the blood pressure of anesthetized cats and rats, as well as spontaneously hypertensive rats, due to the relaxation of the vascular smooth muscle.	20, 82
8	Antimetastatic & Antiproliferative	Forskolin was proved as a potent inhibitor of cancer metastasis in mice injected with malignant cells. As little as 82mcg administered to mice inhibited metastasis by 70%. 13-epi-sclareol showed antiproliferative activity in breast and uterine cancer cells <i>in vitro</i> . Coleon C when investigated on eight human tumor cell lines for its antiproliferative activity it was observed that the A375 was the most sensitive of all the cell lines and it was concluded that coleon C could effectively inhibit tumour cell proliferation and growth by inducing apoptosis with low toxicity. Barbatusin is reported to inhibit Lewis lung carcinoma and lymphocytic leukemia P 388 in mice	38, 77, 83, 84
9	Antidepressant	Forskolin indicates a strong antidepressant when studied using the forced swimming method in rats. Forskolin (0.01-0.1 mg/kg) dose-dependently decreased ratings of immobility, with effects similar to those of amitriptyline treatment. The maximum effects of forskolin were observed at 0.01 mg/kg dose which is 150 more times potent than that (15 mg/kg) of amitriptyline	85
10	Antidyspeptic	The aqueous extract of <i>Coleus forskohlii</i> decreases gastric secretion indicating antidyspeptic activity, and protects against stress induced gastric ulcers.	86
11	Antioxidant	Studies were carried out for the antioxidant properties of <i>Coleus forskohlii</i> and it was observed that the tubers possessed significant	87

		potential of both enzymatic and non-enzymatic antioxidants that could protect against oxidant and free radical injuries, in addition to having their medicinal properties	
12	Antiulcer	Studies shows that Plectrinon A inhibites the gastric H <sup>+</sup> , K <sup>+</sup> -ATPase, more effectively than the classic proton pump inhibitor omeprazole. This may be the mechanism underlying the anti-ulcer property of <i>Coleus forskohlii</i>	52
13	Antidiabetic	Forskolin stimulates glucose-induced insulin secretion <i>in vitro</i> . This appears to reflect a general stimulatory influence of forskolin on adenylate cyclase activity, obviating its specific suitability as an antidiabetic treatment	88, 89
14	Antimycotic	Antifungal studies were carried out on different fungi like <i>Aspergillus flavus</i> , <i>Trichoderma rubrum</i> , and <i>Microsporium gypseum</i> and it was observed that chloroform extract shows maximum inhibitory activity	90
15	Hepatoprotective	Forskolin and 1,9-dideoxyforskolin are efficacious agonist of the pregnane X receptor (PXR, NR1I2) and thus there is activation of PXR which mediates the hepatoprotective effect	91
16	Hypothyroidism	Forskolin and 1,9-dideoxyforskolin are efficacious agonist of the pregnane X receptor (PXR, NR1I2) and thus there is activation of PXR which mediates the hepatoprotective effect	92
17	Immune System Enhancement	Forskolin exhibits potent immune system enhancement (primarily through activation of macrophages and lymphocytes) in several models.	93, 94, 95
18	Psoriasis	Clinical studies were conducted in four patients with psoriasis and it was observed when they were given forskolin, there were improvement in psoriatic symptoms. The ability of forskolin to regulate cAMP levels in skin cells has been shown to have therapeutic benefit for sufferers of psoriasis	21
19	Relaxative effects	forskoditerpenosides A and B isolated from the ethanol extract of the whole plant of <i>Coleus forskohlii</i> showed relaxative effects on isolated guinea pig tracheal spirals <i>in vitro</i> .	29
20	Urinary Tract Infection (UTI)	Forskolin when injected directly into the bladder or administered intravenously to type 1 fimbriated uropathogenic <i>Escherichia coli</i> infected mice, it induced exocytosis of bladder epithelial cells fusiform vesicles in which <i>E. coli</i> is incorporated and thus reduced the number of intracellular <i>E. coli</i> and exposed the bacteria to the antibiotics	96
21	Vasculogenic properties	Investigations on forskolin for vasculogenic impotence were carried out and it was observed that forskolin can be used as an addition to a standard 3-agent pharmacotherapy for erectile dysfunction. Other <i>in vivo</i> and <i>in vitro</i> studies were carried out which elicits a possible role of forskolin in treating this condition.	97, 98

**Toxicology:** *Coleus forskohlii* and forskolin extracts have an excellent safety profile and are generally non-toxic or have no side effects at the recommended dosage<sup>99</sup>. Sclareol isolated from *C. forskohlii* reported to be non-cytotoxic to resting human peripheral blood mononuclear leukocytes and have LD<sub>50</sub> > 5mg/kg in rat<sup>100</sup>. The study on forskolin showed that it was extremely safe with an oral LD<sub>50</sub> of 3100 mg/kg<sup>101</sup>. Hydroalcoholic extract of *Coleus forskohlii* has been shown to interfere with embryonic implantation and to delay fetal development<sup>102</sup>.

**CONCLUSION:** India is the leading exporter of *Coleus forskohlii* extracts and its products to several countries. The main users of *Coleus* are

United States, Poland, South Korea, Australia, Japan, Italy, Spain, South Africa and Canada. Indian herbal industries has to utilise the opportunity by providing the quality formulations by standardising the product with respect to the marker compounds. There is an enormous opportunities to market *Coleus forskohlii* and its formulations in other countries too. Department of Ayush and other Government governing bodies have to encourage the herbal drug manufacturers to set up the quality control parameters.

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