A Comprehensive review on *Dichrostachys cinerea*

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Abstract

For a very long time, the medical plants have been used worldwide to treat human diseases and it serves as a safe source of drugs to cure several diseases and conditions through complementary medicine system. It is a native plant of Indian subcontinent, Africa and North Australia and is known to have significant pharmacological activities. The wide range of pharmacological activities of D.cinerea are due to the presence of different groups of active biological compounds present in it. Traditionally, D.cinerea has been used for the treatment the treatment of many diseases such as headache, toothache, dysentery, leprosy, coughs, syphilis and also as diuretic, anthelmintic, purgative and laxative. Research on the pharmacological, biological isolation of metabolites and biologically active compounds of this plant have already been done worldwide. However, the study to evaluate the complete therapeutic values of this plant still needed to conduct. This paper briefly reviews the various pharmacological properties of D.cinerea that could be useful for further experimental and clinical investigations.

Keywords : *Dichrostachys cinerea,* Pharmacological activities, therapeutic values

Introduction

Traditional medicine system remains the major source of health-care services worldwide [1,2]. Plants are the backbone of all the traditional medicinal practices used for the treatment of various health issues. Medicinal plants constitute a major growing part of modern high-tech medicine system. Rich heritage of medicinal plants are present in India with the availability of about 45,000 plants that are used in Ayurveda, Unani and Siddha medicine[3]. *Dichrostachys cinerea* is a potential medicinal plant that finds enormous uses as ethnomedicine[4,5]. Its bark is used for the treatment of headache, elephantiasis and dysentery. To treat coughs, syphilis, sore eyes and gonorrhea the root infusions are used. It is used as anthelmintic, strong diuretic and also as laxative[6].The leaves and bark of *D.cinerea* contain active drug compounds that are used for several ailments such as inflammations, toothache, fever, ulcers, wounds, chest problems, jaundice and rheumatism. It also possess aphrodisiac property[7,8]. In Orissa, the local tribes of Mayurbhanji use the bark of this plant for treating diabetes mellitus. In India, *D.cinerea* is also used as a veterinary medicine[9]. The root powder is used to massage for fractures. The leaves are used in the treatment of piles, eczema and arthritis[10].

In semi-arid areas in Kenya, Somalia and Eritrea *D.cinerea* is one of the useful wild medicinal plant[11]. The Mwaghal tribe in Mangu use *D.cinerea* as an effective antidiarrhoeal plant. The roots are used for bites or stings. In southern India, it is used as a Siddha medicine by the Tamil people for treating eczema, syphilis and gonorrhea[12]. In Ivory Coast traditional medicine, the stem bark of this plant is used for the treatment of airways infection[13,14]. The village people of Rayalaseema (Andhra Pradesh, India) use *D.cinerea* roots for treating renal troubles and urinary calculi[15,16].In Gabon, the bark of this plant is used to treat various pathologies[17]. This plant is used for the treatment of measles and dental caries. Its barks facilitate childbirth [18]. The plant extract was found to exhibit hepatoprotective activity[19]. The roots of this plant is reported as anodyne, astringent, febrifuge and are used against vaginitis[20,21,22,23]. Adioukrous peoples use *D.cinerea* root bark to treat asthma[24]. In Ayurveda, *D.cinerea* is used as yoniroga, trsna, mutraghata, asmari and sandhisula[25]. The plant extract is used by Maasai to treat

malaria[26]. The plant is also used for treating leucorrhoea[27]. Bark and leaf extract of this plant is used to treat boils[28].

Plant description:

Dichrostachys cinerea is a perennial, thorny much branched shrub sometimes a fast growing semi-deciduous to deciduous tree belonging to the family Mimosaceae[29,30,31]. It is native to Africa, North Australia and also found in the dry shrub forest and arid hills of northwestern, central and southern India[32,33]. This plant is commonly known as sickle-bush, Bell mimosa, Chinese lantern tree or Kalahari Christmas tree[34]. The plant reaches 3-7 m in height and have alternate strong thorns that are up to 8cm long[35,36,37]. The plant has a 3m wide open round crown. The young bark is green in color and as the tree grows it becomes grey-brown and fissured. The diameter of the stem is less than 23cm [35,38]. The leaves that grow up to 15cm long are bipinnate, petiolated and have 4-19 leaflets. The flower is a fragrant, cylindrical bicolored spike resembling Chinese lanterns with 6 to 8 cm long, that bears sterile, lilac or pale-purple flowers in the upper part and fertile, pale yellow-cream flowers in the lower part[35,37]. The plant has a narrow fruit with 10cm long, crowded, ondulate, glomerate, contorted, yellow or mustard brown color pods that are usually twisted or sickle shaped[34,36]. Four seeds present in the pod[35]. The plant has many lateral roots and a deep tap root[39]. *D.cinerea. ssp. africana and D. cinerea ssp. nyassanaare* the two recognized subspecies of this plant[34].

Figure 1: *Dichrostachys cinerea*- the whole plant

Table 1: Plant description

Picture	Parts	Description
	Seeds	The seeds are oval in shape

	Leaves and flowers	Bipinnate leaves, with bicolored spike bearing pale-purple flowers in the upper part and pale-yellow flowers in the lower part.
	Fruits with pods	Narrow fruits with crowded, yellow or mustard colored pods
	Stem –Bark	Grey-brownish and fissured

Distribution:

The species is native to Africa, North Australia and Indian subcontinent[33]. It is then spread to America, Southeast Asia and Carribean[40,41]. *D.cinerea* is also found in Nigeria, Zambia, Cameroon, Swaziland, Uganda and Ghana[34]. It is the common species of Nechisar National Park, Ethiopia[41]. The plant has also been found in Cuba and Peninsular Florida. The species grows in rainforest zones and it also occurs in thickets, hedges, teak forest, degraded lands, brushwood, frost-free areas, and grassland. In India, it is found in dry deciduous forest[40,34].

Taxonomical classification: [42]

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Eudicots
(unranked):	Rosids
Order:	Fabales
Family:	Fabaceae
Genus:	*Dichrostachys*
Species:	*D. cinerea*

Synonym :[43]

- *Caillieadichrostachys* Guill. et al.,
- *Caillieanutans* (Pers.) Skeels,
- *Dichrostachyscinerea* subsp. *lugardae* (N. E. Br.) Brenan &Brummitt,
- *Dichrostachyscinerea* var. *hirtipes* Brenan &Brummitt,
- *Dichrostachyscinerea* var. *lugardiae* Brenan &Brummitt,
- *Dichrostachysforbesii* Benth.,
- *Dichrostachysglomerata* (Forssk.) Chiov.,
- *Dichrostachysnutans* (Pers.) Benth.,
- D*ichrostachysnutans* var. *setulosa* Welw. exOliv.,
- *Dichrostachysnyassana* Taub.,
- D*ichrostachysplatycarpa* Welw. ex W. Bull,
- *Mimosa cinerea* L.,
- *Mimosa glomerata* Forssk.,
- *Mimosa nutans* Pers.

Common name: [44]

- English -Kalahari Christmas tree, Marabou-thorn, Sickle bush, Princess's Earrings, Painted Thorn Bush, chinese Latern tree
- Gujarati- Marud, Mordundiyun
- Hin- Vurtuli
- Hindi- □□□□Khairi, □□□□□□ Veerataru, □□□□□□ Kunali
- Irula- Odavarai
- Kannada- VaduvaradaGida, Wadu, Odavinaha
- Malayalam- Vedathala, Vitattal, Vidatthal, Veeravriksham
- Marathi- □□□□□□□□ SigamKathi, □□□□□□□□□□ DurangiBabool
- Oriya- Khoiridya
- Sanskrit- Viradru, Vellantaru
- Tamil- Vedathalaa, Veduttalam
- Telugu- Nellajammi

Phyto constituents:

Various studies have revealed that ethanol, methanol, chloroform, petroleum ether, Hexane, Ethyl acetate, Acetone and aqueous extract of different parts of *Dichrostachys cinerea* contains various chemical groups such as Alkaloids, Flavonoids, Carbohydrates, Saponins, Tannins, Anthocyanin and Betacyanin, Coumarins, Steroids and Phytosteroids, Phenols, Aminoacids and proteins, Terpenes, Triterpenes, Diterpenes, aliphatics, Cardiac glycosides[45,46,47,48,49,50] and cardiotonicHeterosides[51]. An extensive phytochemical analysis of *D.cinerea* revealed the presence of β- amyrin, β- sitosterol, esculetin, imperatorin, marmesin[52,53] α- amyrin, stigmasterol[50],octasanol, friedelin-3-one[54] ,friedelin, friedelin 3β-one[55] and 3-o-acyl mesquitol[56].

The flower showed the presence of quercetin. β- amyrin acetate was also reported in another study conducted by Sreedevi Adikay *et al.*, 2009[57]. Rao J.M *et al.*, (2004), reported the presence of epicatechin[58]. Earlier studies reported the presence of apigenin, kaempferol, myricetin,apigenin-7-*O*-apiosyl(1→2) glucoside, myricetin-3-*O*-rhamnopyranoside, myricetin-3-*O*-glucopyranoside , quercetin-3-*O*-rhamnopyranoside, quercetin-3- *O*-glucopyranoside ,chrysoeriol-7-*O*-apiosyl (1→2) glucoside andclovamide[59,60]. C. Long *et al.*, reported the presence of meroterpenederivatives, dichrostachines A-R[61]. The table below summarizes the reported phytoconstituents in *Dichrostachys cinerea* [58-65].

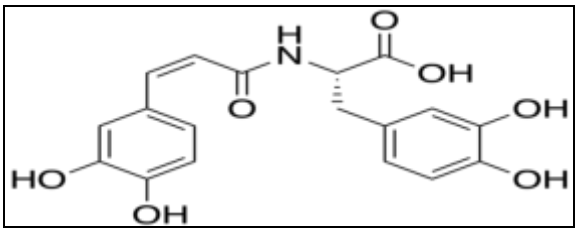

Figure-2: Clovamide

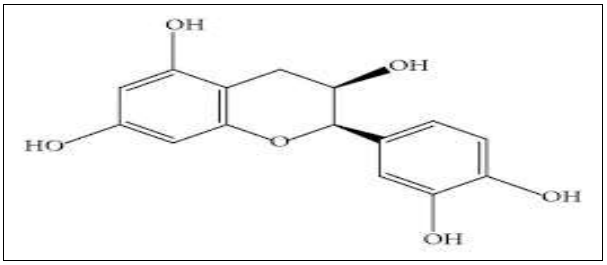

Figure-3: Epicatechin

Table 2: Reported phytoconstituents in *Dichrostachys cinerea*

compounds/ groups	**plant part**
[apigenin, kaempferol, myricetin apigenin-7-*O*-apiosyl(1→2) glucoside, myricetin-3-*O*-rhamnopyranoside, myricetin-3-*O*-glucopyranoside , quercetin-3-*O*-rhamnopyranoside, quercetin-3- *O*-glucopyranoside , chrysoeriol-7-*O*-apiosyl (1→2) glucoside andclovamide]	Leaves
Dichrostachins A-R	Bark and Root
[$C_{30}H_{50}O$ $C_{29}H_{58}O_4$ $C_{15}H_{10}O_4$]	Bark
$C_{15}H_{10}O_4$	

Pharmacological activities:

1. Hepatoprotective activity:

Several medicinal plants are used to treat degenerative fibrotic hepatic diseases caused by alcohol consumption[66]. A study conducted for 14days on albino mice and rats clearly indicated that the methanolic extract of *D.cinerea* leaves showed to have great hepatoprotective activity(ld50) against ccl4-induced liver damage, in which the methanol extract did not show any mortality up to a dose of 3500 mg/kg body weight[67].

2. Anti-diabetic activity:

An elaborate study was performed to determine the anti-hyperglycemic activity in various fractions of hydro-alcoholic extract of *D.cinerea roots*, treated on 12groups of Male Wistar rats. Among all the extracts, aqueous ethanolic and ethyl acetate extracts showed maximum anti-hyperglycemic activity at a dose of 400mg/kg and the efficacy of these two extracts (ethyl acetate and hydro-alcoholic) were found to be greater than the hypoglycemic activity of glibenclamide (10mg/kg) in the test rats[68].

3. Broncho-relaxation activity:

In order to determine the broncho-relaxation property of *Dichrostachys cinerea*, a study was carried out with the hydro-alcoholic extract of the plant's root sample in guinea-pig trachea preparations. The pre-contracted tracheal chain was found to be relaxed by the hydro-alcoholic root extract's (concentration up to 2mg/dl) active compounds. The plant possess this property by complying many facets such as by the opening effect of potassium channels, blocking calcium channels, acting via adrenergic receptors activation and/or by the antagonistic action on H_1- histaminergic receptors[69].

4. Nephro-protective activity:

Nephro-protective effect against cisplastin-induced renal injury in Wistar strain albino rats were studied in the alcoholic extract of *Dichrostachys cinerea* root(200 and 400 mg/kg). The alcoholic extract showed dose dependent protection in the curative regimen. The extract also showed better reducing property based on the dose and good nitric oxide scavenging activity even at lower concentration (50µg/ml)[57].

5. Antidiarrheal activity:

A study was conducted to investigate the antidiarrheal activity of ethanolic extract of *Dichrostachys cinerea* stem-bark(EDCB), ethanolic extract of *Dichrostachys cinerea* leaf(EDCL) and ethanolic extract of *Dichrostachys cinerea* root(EDCR) by small intestinal transit model and castor oil induced model. The extracts used at two doses (200mg/kg and 400mg/kg) reduced wet faecal matter and number of defaecation when compared to control. The percentage inhibition of EDCR, EDCL and EDCB was found to be 66.02%, 72.41% and 46.87% respectively at the dose of 400mg/kg. Tannins present in the *D.cinerea* plant, may be responsible for the antidiarrhoel activity by forming protein tannate that cause an astringent action[70]. In another study, conducted to analyse the in vitro antibacterial activity of the petroleum ether, ethanol and aqueous extracts of *Dichrostachys cinerea* on some bacteria associated with diarrhoea revealed the plant's antidiarrhoeal activity in a dose depended manner[47].

6. Anti-malarial activity:

An in vitro and in vivo study was carried out to investigate the anti-malarial activity of dichloromethane(DCM) and methanol extracts of *Commiphora africana* (stem bark and whole stem)and *Dichrostachys cinerea*(stem bark and whole stem)against chloroquine resistant (Dd2) and chloroquine Balb/c mice sensitive (D6) strains of *Plasmodium falciparum*. Lactate dehydrogenase method (pLDH) was used to assess the anti-malarial property (in vitro) and Peter's 4-day suppressive test in *Plasmodium berghei*in Balb/c mice was carried out for the in vivo anti-malarial study. In the in vitro anti-plasmodial study, DCM extract of *D.cinerea* whole stem and *C.africana* stem bark showed higher anti-plasmodial activity (IC_{50}= 11.47±2.17 µg/mL and 4.54±1.80 µg/Ml respectively) against D6 strain of *P.falciparum* and the DCM extract of *D.cinerea* stem bark showed good activity against both Dd2 and D6 strains of *P.falciparum*(IC_{50}= 11.92±7.43 µg/mL and 2.37± 0.86 µg/Ml respectively). In the in vivo mouse model,

the DCM extracts of *D.cinerea*(stem bark) and *C.africana*(stem bark) equally showed significant anti-malarial activity with the parasite suppression rates of 53.12% and 64.24% respectively[71].

7. Antioxidant activity:

A study investigating the anti-oxidant activity of *D.cinerea* bark different extracts (aqueous, ethyl acetate, butanol, dichloromethane and methanol) revealed a positive correlation between total phenolic levels and anti-radical activity, between total phenolics and antioxidant activity. Among all the extracts, dichloromethane and ethyl acetate extracts showed significant antioxidant activity with the higher value of polyphenolic compounds, 49,72±0,55 mg EAG / g and 52,27±0,66 mg EAG / g respectively[72].

8. Facilitate Childbirth:

A study was conducted to analyse the childbirth facilitating property of the methanolic extract of *D.cinerea* bark on isolated uterine muscle from the pregnant rats and its effect was compared to the oxytocin generally used by the obstetricians to facilitate childbirth. Treatment of the isolated strips of the uteri of pregnant rats with methanol extract of *D.cinerea* of different concentrations (3.2 µg/ml, 16 µg/ml, 80 µg/ml, 400 µg/ml, and 2 mg/ml)caused an increase in contractile force of the uterine fragments like that of oxytocin concentrations ($8.4x10^{-5}$µg/ml, $8.4x10^{-4}$µg/ml, $8.4x10^{-3}$µg/ml, $8.4x10^{-2}$µg/ml).The maximum contraction amplitude of *D.cinerea* and oxytocin was found to be 39.68mN at 400µg/ml and 55.82mN at $8.4x10^{-2}$ µg/ml respectively[73].

9. Anti-proliferative activity:

Water and methanolic extracts from four plant species namely *D.cinerea, Aloe secundiflora, Vernonia zanzibarebsis* and *Maytenus obscura* were investigated for the anti-proliferative activity by MTT assay, using cervical cancer cells (HeLa), prostate cancer cells (DU145 and 22Rv1) and African green monkey cells (Vero) cell lines. At the concentrations of 1.37µg/ml to 1000µg/ml, all the extracts suppressed the growth of cancer cells in a dose-dependent manner. Among the plant extracts studied, *D.cinerea* stem bark methanol extract showed a low cytotoxic effect against the Vero cells with a CC50 of 812.1 ± 12.72 µg/ml and the highest anti-proliferative activity with an IC_{50} of IC50 of 8.04 ± 2.02 µg/ml against the 22Rv1 cells[74].

In another study, apoptosis in CCRF-CEM cells were induced by the crude extract of *Dichrostachys cinerea* bark, mediated mostly by increased production of Reactive Oxygen Species(ROS) and through alteration in Mitochondrial Membrane Potential (MMP).The isolated constituents Triterpenoid and flavone with an IC_{50} values below 50µM showed good cytotoxic effect against the 9 tested Multifactorial Drug-Resistant Cancer Cell lines. The recorded IC50 values varied from ,18.90μM (CCRF-CEM leukemia cells) to 88.86 μM (against HCT116p53+/+ colon adenocarcinoma cells) for flavone**,** 7.65 μM (towards multidrug-resistant CEM-ADR5000 leukemia cells) to 44.17 μM (against HepG2 hepatocarcinoma cells) for triterpenoid and 0.02 μM (against CCRF-CEM cells) to 122.96 μM (against CEM/ADR5000 cells) for doxorubicin. Apoptosis was induced by the compound triterpenoid through MMP alteration, enhanced ROS production and through activation of the caspases[75].

10. Analgesic and Anti-inflammatory activities:

The chloroform extract of *D.cinerea* leaves (15mg/kg, 30mg/kg) showed a significant analgesic activity in the Swiss albino mice (acetic acid- induced writhing method). At a dose of 30mg/kg body weight, the extract revealed a good reduction in the number of induced writhes when compared to standard aspirin given at a dose of (100mg/kg)[76]. An in vitro study was conducted to determine the analgesic and anti-inflammatory activity of the ethanolic extracts of *D.cinerea'*s stem bark (EDCB), root

(EDCR) and leaf (EDCL). Among all the extracts, EDCL showed good analgesic activity in centrally mediated analgesia (Eddy's hot plate method) and EDCR showed good analgesic activity in both centrally and peripherally mediated analgesia when compared to the standard carboxymethyl cellulose(Acetic acid-induced writhing method)[77] .

In a study conducted, chronic and acute model (cotton pellet granuloma and carrageenan-induced paw edema model, respectively) were used to investigate the anti-inflammatory activity of EDCL, EDCR and EDCB. Among the extracts studied(at a dose of 200mg/kg and 400mg/kg)EDCR showed a better reduction in granuloma formation at both doses (32.84% and 33.84% respectively) and EDCL showed a significant reduction in volume of paw edema at both doses (63.64% and 69.97% respectively)[77].

11. Antimicrobial activity:

Petroleum ether, ethanol and aqueous extracts of *D.cinerea* leaves showed antibacterial activity against *Salmonella typhi, Escherchia coli and Shigella dysenteriae* in a dose dependent manner[47]. The chloroform extract of the leaves was found to be active against the bacterial strains *Pseudomonas, Vibrio cholera, Staphylococcus aureus, Bacillus brevis, Shigella flexneri* and *Salmonella typhi*[76]. Aqueous and methanolic extracts of various *D.cinerea* explants possessed anti-bacterial activity against all the tested bacteria[78]. Tannins isolated from the ethanolic extract of the *D.cinerea* root exhibited significant antibacterial activity against the pathogens *S.aureus, E.coli, Sh.fleneri, Sh.boydii and P.aeruginosa*[49].

The effect of ethanol and aqueous extracts of *D.cinerea* stems and roots on the oral pathogens *Staphylococcus saprophyticus, Candida albicans*and *Streptococcus mutans* showed a significant inhibitory activity[79]. Ethyl acetate and methanol extracts of *D.cinerea* leaves showed a better antimicrobial activity against gram positive bacteria *(S.aureus)* than the gram negative bacteria *(Sh.soneii)*[80].

At a concentration of 20µg/µl, the isolated clovamide and the crude extract of the *D.cinerea leaves* exhibited a significant antiviral activity against influenza A virus (H5N1) infection (74% and 73% respectively). Clovamide showed a potential antitrypanosomal effect with an IC_{50} value of 3.27µg/ml against *Trypanosoma evansi* when compared to the standard drug diminazene aceturate (IC_{50} = 0.72µg/ml)[81].

12. Toxicity:

Varied lethal concentration potential was exhibited by the methanolic extracts of *D.cinerea* root, stem-bark and leaves through Brine shrimps test. Higher lethal effect was found in leaf than the root and stem-bark. At a concentration of 2000ppm, the extracts showed ≤50% lethal effect and at concentrations above 2000ppm, had high lethal potential[78].

13. Anti-venom activity:

The methanol extract of *Dichrostachys cinerea* root (200mg/kg) showed significant anti-venom activity against Russell's viper venom induced mice than the aqueous and ethereal extracts[82].

Conclusion:

Several studies on *Dichrostachys cinerea* have revealed its high medicinal Importance. It has been widely used as folk medicine or traditional medicine due to its different pharmacological properties. The plant extracts showed significant therapeutic activities including hepatoprotective, anti-diabetic, broncho-relaxation, nephro-protective, ant-diarrheal, anti-malarial, anti-oxidant, facilitate childbirth, anti-proliferative, analgesic, anti-inflammatory, anti-microbial and toxicity properties. These activities may be

due to the phytoconstituents present in various parts of the plant. Thus, further extensive studies needs to be done for its better use in pharmaceutical sector.

Acknowledgement:

The authors are grateful to Bharathidasan College of Arts and Science, Ellispettai, Erode-638116.

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