

## Pharmacological Importance of *Clerodendrum* Genus: A Current Review

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### Abstract

*Clerodendrum* genus l. Belongs to a family of Lamiaceae. *Clerodendrum* broadly spread in subtropical as well as in tropical areas of this world. Almost about 500 species belongings to the genus *Clerodendrum* of that are recognized till yet. More than five hundred species of *Clerodendrum* genus comprises small herbs, shrubs, and trees. Numerous species of *Clerodendrum* genus exhibited its medicinal significance that had been described in several native schemes of drugs as well as in several traditional medications. For the curing of a number of natural life menacing ailments i.e. Syphilis, typhoid, cancer, jaundice and hypertension genus *Clerodendrum* is being used as in medicines specifically in different countries like Japanese, Thai, Indian, Chinese and Korean systems of medication. *Clerodendrum* genus has also been extensively studied for various biological activities to know its potential effect towards pharmaceuticals. Several studies had been also reported the isolation as well as chemical constituents' identification and its association with the biotic activities of the *Clerodendrum* genus. Chief chemical constituents that were described in numerous reported studies of the genus are volatile oils, steroids, diterpenoids, triterpenoids, flavonoids and phenolic compounds.

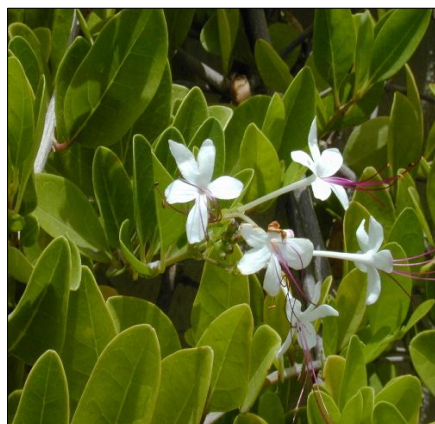
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### 1. Introduction

Human beings have depended on plants for survival since ever. Plants are not only the major source of food and shelter but also for the medicine to cure illness <sup>[1]</sup>.

Chemicals extracted from different flora have demonstrated antiseptic, anti-oxidant, anti-fungal, anti-carcinogenic, analgesic, and insecticidal properties <sup>[2]</sup>. Chemical compounds responsible for therapeutic characteristics are generally called secondary metabolites <sup>[3]</sup>. *Clerodendrum* genus belongs to the family of Lamiaceae which exhibits abundant pharmaceutical prominence. *Clerodendrum inerme* are commonly known as Indian privet, Glory Bower, Wild Jasmine and Seaside *Clerodendrum*, and Sorcerers Bush. *Clerodendrum* Genus is

extensively disseminated in subtropical regions as well as in tropical areas of the biosphere. *Clerodendrum* genus comprises of small herbs, shrubs, and trees. *Clerodendrum inerme* is an ever-popular shrub that originated inhabitation botanical gardens. It has been used as an alternative to qui-nine as well as to Chiretta <sup>[4]</sup>. Extensive use of *C. inerme* has been reported in diverse traditional medicines. In Thailand, *C. inerme* has been successfully used in traditional medicines to treat various ailments such as skin disease. In India, the distillate that is obtained from its foliage is used in Ayurvedic medicines to treat spasmodic fever. Moreover, its squash of foliage, as well as its stocks, have been cast off for the treatment of venereal ailments and scrofulous illnesses.



(a)



(b)

**Fig 1:** Species of *Clerodendrum* genus: *Clerodendrum inerme* (a), *Clerodendrom polycephalum* (b)



(c)



(d)

**Fig 2:** Species of *Clerodendrum* genus: *Clerodendrum serratum* (c), *Clerodendrum inforunatum* (d)

Several studies have also stated the valuable characteristics of *C. inerme* as an Anti-inflammatory, anti-fungal, anti-microbial and much more [5]. In Hindi, *C. inerme* is universally recognized as a Sangkupi and in Tamil as a Peechangu. To cure rheumatism, skin malady, venereal contaminations and beriberi as well as for tumors, diverse chunks of the *C. inerme* had been used in the Ayurvedic medication system [6]. Several studies reported that leaf powder of *C. inerme* and petroleum ether based extracts have the ability to hinder the development as well as the growth of *Culex pipiens larvae*, *Aedes aegypti*, and *Culex quinquefasciatus*. Its leaf Juice has the ability to cure skin infections [7].

## 2. Pharmacological potential of *Clerodendrum* genus

### 2.1 Antioxidant Activity

Chahal and Sarin [8] *et al.*, (2014) described that *Clerodendrum* genus is a valuable source of natural products such as bioactive compounds and antioxidants which are very advantageous for human health. Two conventionally valuable plants of spp. *Clerodendrum* (*C. inerme* and *C. phlomidis*) were tested for their antioxidant potential. *Clerodendrum* is found in various parts of Asia. Three solvents (Ethanol, Water, and Ethyl acetate) were used separately for extraction of dehydrated powder. The extract was separated for its prospective antioxidant potential using DPPH Radical inhibiting potential. The outcomes determined that the inhibiting potential of *C. inerme* shoot is greater than *C. phlomidis* shoot. Ethyl acetate and Ethanol both predicted the better potential for radical inhibiting activity and could be used as original parts of active antioxidant managers. Khan [7] *et al.*, (2013) stated that *Clerodendrum inerme* also has antioxidant properties. The antioxidant potential of *C. inerme* shoot was measured by calculating whole phenolic, whole flavonoid, DPPH free radical, decreasing control and proportion of linoleic acid peroxidation. Whole phenolic insides and whole flavonoid insides amount were calculated as (0.89-1.89 mg/100 g GAE) and (3.18-5.68 mg/100 g CE) correspondingly. The IC<sub>50</sub> and average self-consciousness of linoleic acid peroxidation amount of *C. inerme* remove vary from (24.1-81 µg/mL) and (41-72 %) correspondingly. Peroxide significance, free fatty acid, and *para*-anisidine amounts were also realized by using canola oil as oxidation substrate. Results showed that methanol extract of *C. inerme* shoot gives improved antioxidant activity. The cytotoxicity values were concluded from

hemolytic inactivity of plant mines and checked on the human erythrocytes (RBCs) *in vitro*.

Devi [9] *et al.*, (2012) have ascribed the comprehensive study of pharmacognostic on the foliage of *C. inerme* and have revealed its role in Ayurveda and Siddha medication systems. This study was based on its physicochemical, macroscopic and organoleptic characteristics. Polyphenols like phenolic acids, flavonoids *etC.*, triterpenoids, steroids, and sugars are found to be present in *C. inerme*. Isolation of phenolic acid had been done and marker this compound as well as also recognized as Ursolic acid. By estimating free radical scavenging potential, anti-oxidant potential of Ursolic acid, as well as alcoholic extract, had been determined by following the assay of DPPH scavenging assay. Extract of plant presented better antioxidant potential which is analogous to that of Butylated Hydroxy Toluene that had been employed as a standard.

Gokani [10] *et al.*, (2011) had been studied the essence of *Clerodendrum phlomidis* (Verbanaceae) and revealed that Arni/Agnimantha, is its vital constituent. Methanolic extract of the roots was evaluated for its *in-vitro* antioxidant potential with the anti-radical, superoxide scavenging, anti-lipid peroxidation, hydroxyl radical scavenging and nitric oxide scavenging, assesses. The active part of the plant was consistently found to have anti-oxidant potential. *C. phlomidis* is recognised as a prospective origin of ordinary antioxidant.

Amirtharaj and Saravanan [11] (2010) analyzed the antioxidant potential of aerial extracts of *Clerodendrum inerme* which belongs to the family verbenace. Anti-oxidant potential of chloroform mixture of *Clerodendrum inerme* (CI) aerial portions was examined for its free radical inhibiting possessions in different *in vitro* activities as 1, 1 diphenyl-2- picryl hydrazyl, nitric oxide, decreasing command to examine and hydrogen peroxide radical treatment activity. Various amounts of the chloroform extract of CI were extracted and examined. The IC<sub>50</sub> values of the chloroform extract of CI contended with ascorbic acid (Standard) and it was noted that the extract gives important meditation used free radical inhibiting possessions in all the methods. Examined values have chloroform extract of CI hold *in vitro* free radical inhibiting potential. The answers rationalize the presence of this plant in the controlling of antioxidant potential.

Gurudeeban [12] *et al.*, (2010) revealed that *Clerodendrum inerme* is a medicinal plant conventionally used as an

abortifacient to cure constipation, odema, bacterial infections, cancer, and diabetes. First phytochemical separation of the plant examined that the occurrence of huge quantity of phenolic compounds and flavonoids. Following quantification showed the existence of 0.74% (m/m) phenolic (calculated as gallic acid) and 0.13% (m/m) flavonoids considered as catechin per each 100 grams of new mass. The existence of phenolic compounds encouraged to lead this work to assess its antioxidant potential. Methanolic shrubberies cutting of *Clerodendrum inerme* was separated to examine its maximum antioxidant and free radical inhibiting potential of shrubberies extract. 2500 mg ml<sup>-1</sup> of antioxidants was detected.

Chourasiya <sup>[13]</sup> *et al.*, (2010) determined the antioxidant levels of methanolic and petroleum ether extract of *Clerodendron inerme*. The methods used were DPPH (1, 1-diphenyl-2-picrylhydrazyl) examine, hydroxyl inhibiting analysis and the lipid peroxidation analysis. The *Clerodendron inerme* methanol extract (CIME) was most abundant in the DPPH test with an IC50 value of 19.20 ± 0.27 µg/mL. The hydroxyl radical inhibiting potential of the petroleum ether extract disclosed the extreme potential 69.28±2.1% at 100µg/ml. In the lipid peroxidation analysis, the highest amount was that of methanolic extract *i.e.* 36.38±1.3%.

Gouthamchandra <sup>[14]</sup> *et al.*, (2010) analyzed three consecutive extracts of *Clerodendrum infortunatum* L shrubberies for their activity as antioxidant 1, 1-diphenyl 2 picrylhydrazyl (DPPH) model. The inhibiting potential of ethanol extract was examined to be maximum when analyzed with petroleum ether and chloroform extracts. So, it was chosen as a standard to test the potential candidates using in vivo and invitro methods. The antioxidant properties encouraged oxidative pressure in rats considerably high. Further, to authenticate the conventionally therapeutic claim wound healing potential of plant extract also tested. Between the three extracts used, the petroleum ether and ethanol extract showed the significant results. Due to the antioxidant and pharmacological properties compared to the total phenolic contents in the plant *Clerodendrum infortunatum* L.

Bhujbal <sup>[15]</sup> *et al.*, (2009) studied the antioxidant properties of ethanolic extract of roots of *Clerodendrum serratum* (CSR) at different concentrations in the DPPH radical inhibiting methods; FRAP method (Ferric Reducing Antioxidant Power) and the Hydrogen peroxide radical inhibiting method. In the last decade, herbal and Ayurvedic medicines were very popular due to their medicinal and economic advantages. Due to their worldwide acceptance and effectiveness, the use of plant extract throughout the world increased. Over the time, appropriate scientific methods have been developed to become the standards for recognition of herbal health rights.

Sannigrahi <sup>[16]</sup> *et al.*, (2009) evaluated the antioxidant potential of methanolic extract *Clerodendrum infortunatum* Linn. (MECI), used in the Indian native medicine for wide uses, was examined. The antioxidant activity was calculated using various organized in vitro antioxidant tests. MECI was found to have a lot of polyphenolics and it holds important free radical inhibiting potential. The greater potential was probably due to the highest quantity of polyphenolics and flavonoids in it.

Chae <sup>[17]</sup> *et al.*, (2007) studied the antioxidant potential of isoacteoside, separated from *Clerodendron trichotomum* (Verbenaceae), This compound inhibited intracellular sensitive oxygen species (ROS) and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical, and prohibited lipid peroxidation. This radical

inhibiting potential of isoacteoside sheltered cell viability of Chinese hamster lung fibroblast (V79-4) cells exposed to hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>). Furthermore, isoacteoside decreased the cell apoptosis caused by H<sub>2</sub>O<sub>2</sub>. However, isoacteoside amplified the cellular antioxidant enzyme action including superoxide dismutase (SOD) and catalase (CAT). Altogether these results examined that isoacteoside, separated from *C. trichotomum*, have antioxidant potentials.

## 2.2 Antidiabetic activity

Panigrahi <sup>[18]</sup> *et al.*, (2015) estimated the anti-hyperglycemic potential of aerial separations of *Clerodendrum inerme* (L) Gaertn. Toxicity of this plant extract was very low. The methanolic extract of the plant caused a significant reduction in fasting blood glucose (FBG) level by 54.32% as compared to initial FBG level, after 10 hours of treatment. The dose used was 400 mg/kg body weight. In the glucose tolerance test, this extract also reduced hyperglycemia at the same dose. These results confirmed the effective anti-hyperglycemic potential of the extract of *Clerodendrum inerme*.

Kar <sup>[19]</sup> *et al.*, (2014) evaluated the antidiabetic potential of *Clerodendrum serratum* shrubberies. The shrubberies were collected from Khandagiri hills of Khurda district in the state of Odessa, India. The extract dose used was 400 mg/kg. Glucose-loaded and streptozotocin (STZ)-induced diabetic rats were used for the experiment and glucose consumption activity in rat hemi-diaphragm was monitored. The test extracts reduced blood glucose level in, glucose-loaded, and STZ-induced diabetic rats and also showed improved glucose utilization in separated rat hemi-diaphragm. Methanol extract established supreme blood glucose lowering activity as compared to the other extracts.

## 2.3 Antibacterial Activity

Sathish <sup>[20]</sup> *et al.*, (2013) made an attempt to assess the in-vitro antimicrobial activity of the extracts and isolated compounds from roots of *Clerodendrum phlomidis* of family Verbenaceae against *Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida albicans*, and *Aspergillus niger*. Root extracts (Pet ether, Chloroform, Ethyl acetate and Ethanol) of *Clerodendrum phlomidis* were organized by using Soxhlet apparatus. 30gms of ethanol extract was subjected to column chromatography. Three compounds, Phenylacetic acid, Ethyl- 2- hydroxy -4- methyl benzoate, 3,6,7-trihydroxy-2-(3-methoxyphenyl)-4H-chromen-4-one, were isolated and characterized by IR, NMR and Mass Spectroscopy. Different dilutions of extracts (106.66µg/ml, 200 µg/ml, 320 µg/ml and 400µg/ml) and isolated compounds (20, 40, 60 µg/ml) were prepared and their antimicrobial screening was carried out by disc diffusion method. The MIC of the extracts and isolated compounds was determined by broth dilution method of NCCLS. The selected microorganisms were also tested against standard drugs like (Amikacin 30µg/disc and Ketoconazole 20µg/disc). Ethanol extract at the concentration of 106.66µg/ml showed a significant against *Escherichia coli*. Chloroform extract also showed antimicrobial activity against *Staphylococcus aureus* with a zone of inhibition of (14.67mm). Among the isolated compounds, Ethyl- 2- hydroxy -4- methyl benzoate showed better antimicrobial activity as compared to the other two compounds against *Staphylococcus pyogenes*, and *Candida albicans*. Three compounds were isolated by column chromatography such as Phenylacetic acid, Ethyl- 2- hydroxy -

4- methyl benzoate, 3,6,7-trihydroxy-2-(3-methoxyphenyl)-4H-chromen-4-one. Ethyl- 2- hydroxy -4- methyl benzoate shows the novel antimicrobial activity.

Kutty <sup>[21]</sup> *et al.*, (2011) realized the few of feature mechanism strictures of the stocks of *Clerodendron infortunatum* belonging to Verbenaceae family. Plants are used as local medicines and provide ingredients for the pharmaceutical products and contribute to the worldwide drug marketplace. So, there is a need for the internationally accepted standard tests for the analysis of their quality control. Few parameters to be taken care of include essence fine particles types, water amount found by LOD method, FOM determination, Rf significance detection by TLC, using different solvents, Ash values, the pure content of plant values. The essence rations of *Clerodendron infortunatum* Linn mixed with ethanol, chloroform by the cold soaking process was used. The extracts were vacuum dried and subjected to antibacterial (*Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli* and *Klebsiella pneumoniae*) returning by Agar disc diffusion method. Smallest Inhibitory value of microbial nutrition was also measured. The value of chemicals present in the plant extracts was used and many phytocomponents existing in the extracts were recognized.

Oly <sup>[22]</sup> *et al.*, (2011) tested the rough extracts of *Clerodendrum viscosum* Vent. (Verbenaceae) in various solvents with six gram positive bacterial stresses, *Staphylococcus aureus*, *Sercinia lutea*, *Bacillus subtilis*, *B. megaterium*, *B. cereus* and *Streptococcus-β-haemolyticus*, Nine gram negative bacterial stresses, *Salmonellae typhi*, *Shigella dysenteriae*, *Escherichia coli*, *S. shiga*, *S. boydii*, *S. sonnei*, *Proteus sp.*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* and seven fungal strains, *Aspergillus niger*, *A. fumigatus*, *A. flavus*, *Candida albicans*, *Vasin factum*, *Mucor sp.* and *Fusarium oxysporum* by applying disc diffusion and micro broth dilution methods. Every plant solution has antimicrobial potential with corresponding strength with different microbes pathogenic to organisms. Few plant solutions were bacteriostatic and fungistatic and all the other solutions have bactericidal and fungicidal activity. The MIC figures (64-128 µg/mL) of ethyl alcohol and plant solution were examined with every gram positive and gram negative bacterial stresses; *S. aureus*, *B. subtilis*, *S. β-haemolyticus*, *S. typhi*, *E. coli* and *Klebsiella sp.* For cytotoxic activity, ethyl alcohol root solution was highly poisonous (LC50 20.845 ppm) as compared to other plant solutions investigated in Brine shrimp test.

Garima <sup>[4]</sup> *et al.*, (2011) studied the antimicrobial potential of *Clerodendrum inerme*. *Clerodendrum inerme* L. amiaceae (Verbenaceae). This plant belongs to the family 'alihar' and it is perennial mangrove plant. Due to its stiffness and complex branches and leaves, it is used for ornamental purposes. Tribals use *C. inerme* as cure harmful effects of eating fish, crabs and toads. Anti-malarial activity of this plant has also been reported. Mostly it is used for the treatment of elephantiasis, asthma, topical burns. The in-vitro antimicrobial properties of shoot of *Clerodendrum inerme* were revealed by estimating the area of scavenging appeared around the well for gm +ve, gm -ve bacteria and fungi i.e. *Escherichia coli*, *Bacillus subtilis*, *Staphylococcos aureus*, *Pseudomonas auregenosa*, *Micrococcus leuteus*, *Aspergellius niger*. Anti-microbial potential was evaluated using various extracts i.e. Pet- ether, chloroform, ethyl acetate, ethanol in various concentrations.

Jayalakshmi <sup>[23]</sup> *et al.*, (2011) evaluated the antibacterial potential of different solvent extracts of medicinal plants for the

diseases caused by microbes *Escherichia coli*, *Klebsiella pneumonia*, *Bacillus subtilis* *Bacillus cereus*, *Salmonella typhi*, *Enterobacter aerogenes* and *Staphylococcus aureus* by the agar cup diffusion method. Methanol extracts of *Clerodendrum inerme* L., *Terminalia chebula* Retz. *Curcuma amada* Roxb, *Anacardium occidentale* L., *Duranta repens* L., *Eucalyptus camaldulenis* Dehnh and *Euphorbia cotinifolia* L. have significant antibacterial potential. The antibacterial activity of this plant's active ingredients, when compared to the standard drugs streptomycin and gentamycin, shows good scavenging. Phytochemical studies of the various extracts of the separated plants showed the existence of flavonoids, terpenoids, tannins, steroids, alkaloids, and glycosides. The optimistic activity of separating of medicinal plants for antibacterial potential forms basic way for more phytochemical and pharmacological uses.

Chahal <sup>[24]</sup> *et al.*, (2010) investigated the in vitro antimicrobial perspective of various extracts (ethanol, benzene and aqueous) of *Clerodendrum inerme* plant parts. In vitro antimicrobial efficiency of various extracts of *C. inerme* was assessed by disc diffusion method against Gram positive - *Bacillus subtilis* (ATCC 6633), *Staphylococcus aureus* (ATCC 25923) Gram negative- *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853) and fungal strains *Aspergillus niger* (ATCC 16404), *Aspergillus flavus* (ATCC 9807), *Candida albicans* (ATCC5027) and *Candida glabrata* (ATCC 66032). The methanol leaves extract exhibited a highest zone of inhibition against *S. aureus* and *A. niger* (16.67 ± 0.47 and 15.0 ± 0.01 mm, respectively) with low MIC values (0.78 mg/ml for each). It was concluded that *Clerodendrum inerme* possess compounds with antimicrobial properties and hence can be exploited for future natural plant based antimicrobial agents.

Vidya <sup>[25]</sup> *et al.*, (2010) screened the ethanol extract of roots of *Clerodendrum serratum* for their antibacterial potential. The extract (7.5mg/disc) examined the broad-spectrum antibacterial potential for gram positive and gram negative bacteria. The results were in sync with the regularly used drug streptomycin (10µg/disc).

Habila <sup>[26]</sup> *et al.* (2009) studied the bark of the root of *Clerodendrum aculeatum* that uses as traditional Medicinal. The phytochemical study showed the existence of carbohydrates, saponins tannins, and alkaloids. A polyphenolic compound with IR-SpeC. the signal at 3869.47 and 3738.93 cm<sup>-1</sup> (O-H) gives growth scavenging properties on *Escherichia coli* *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis*, *proteus sp.*, *Samonella typhi* and *Candida albicans*. The lowest scavenging concentration for the polyphenolic compound was from 31.25 to 500 mg/ml on the test species. The smallest bactericidal concentration (MBC) determination gives a concentration of 62.5 mg/ml of the polyphenolic compound. It could entirely destroy *Staphylococcus aureus* and 125 mg/ml *Escherichia coli*.

Deji-agboola <sup>[27]</sup> *et al.*, (2009) investigated the antimicrobial potential of *C. polycephalum* as well as also studied the phytochemical mechanisms that are present in this herb. *Clerodendron polycephalum* Baker (known as Ewe Agbosa in Yoruba land) is used by the old people in South West Nigeria to cure bleeding and bacterial infections particularly wound infection. However, there is no scientific proof of its efficiency. The antimicrobial potential of aqueous and ethanol extracts of the herb was examined for clinical bacterial separations using agar diffusion method, the MIC and MBC were found for *S. aureus* using two-fold dilution of the herbal extract. The

phytochemical constituents were found using standard procedures. The plant extracts demonstrated broad-spectrum antimicrobial potential, which was more in ethanol extract as compared to aqueous extract. The herbal extracts scavenging *Staphylococcus aureus*, *Enterococcus faecalis*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Klebsiella pneumoniae* and some *Escherichia coli* were tested. The maximum scavenging potential was for *S. aureus* (26mm) at a concentration of 50 mg/ml. The extract was bacteriostatic at 1.57mg/ml and bactericidal at 3.13mg/ml. The shrubberies extract of *C. polycephalum* decreased a number of practicable cells of *S. aureus* by 2log unit in 1 hour of development, and total slaying in 4 hours. The antimicrobial importance of the herb can be recognized by the existence of saponins, flavonoids, anthraquinones and tannins in the extracts. The antimicrobial potential showed by this medicinal herb justifies its use in the cure of infected wounds.

Hamid <sup>[28]</sup> *et al.*, (2008) evaluated the anti-microbial and antifungal potential of plant *Clerodendrum inerme*. The herb also called as Dedonia is really an ornamental one, but traditionally being used to cure the infections like skin outbreaks, eye infection, and umbilical cord infection by local people. The first attempt to explore the activity of this herb as antibacterial and antifungal was investigated. The dehydrated shrubberies of the herb were separated with water, ethanol, and chloroform using saturation technique. The subsequent extract was assessed for bacteria *E. coli* (gram-negative), *Staphylococcus* (gram positive) and fungi aspergillus. All the extract was exposed to the scavenging potential for all examined microorganisms. The ethanolic extract has the maximum potential among all extract and chloroform extract has the least potential.

#### 2.4 Antimalarial Activity

Lamiaceae was assayed for their toxicity by Muthu <sup>[29]</sup> *et al.*, (2012). Against the early fourth-instar larvae of the filarial vector *Culex quinquefasciatus*, Say and dengue vector *Aedes aegypti* L. The portions used were at 100, 50, 25 and 12.5 ppm concentrations. The compound pectolinarigenin was used at 5, 2.5, 1.0 and 0.5 ppm concentrations. Between the various portions, portion 5 recorded the least LC<sub>50</sub> and LC<sub>90</sub> values of 5.02, 61.63 ppm and 32.86, 73.62 ppm for *C. quinquefasciatus* and *A. aegypti*, correspondingly. The compound pectolinarigenin had the least LC<sub>50</sub> and LC<sub>90</sub> values of 0.62, 2.87 ppm and 0.79, 5.31 ppm for *C. quinquefasciatus* and *A. aegypti*, respectively. The novel mosquito larvicidal potential of the separated compound pectolinarigenin from *C. Phlomidis* was reported. This study also concluded that the chloroform extract of *C. phlomidis* can be used as a strong source and pectolinarigenin as a new regular mosquito larvicidal mediator.

#### 2.5 Antifungal Activity

Gong <sup>[30]</sup> *et al.*, (2015) reported that fungal endophytes live in the inner tissues of *Clerodendrum inerme* and it may be a significant resource for the new chemicals in drug discovery. 242 endophytic fungi were recovered from 602 sample segments of *C. inerme*; 66 were purified. The 66 fungi belonging to 16 taxa and 11 genera (*Alternaria*, *Nigrospora*, *Bartalinia*, *Pestalotiopsis*, *Fusarium*, *Mycoleptodiscus*, *Trichoderma*, *Phomopsis*, *Diaporthe*, *Lasioidiplodia*, and *Curvularia*) were identified by morphological characteristics

and fungal internal transcribed spacer sequences. The most abundant genera were *Alternaria* and *Lasioidiplodia*. Some of the endophytes exhibited tissue specificity. The colonization frequencies of endophytes in the stems were evidently higher than those in the roots and leaves. The crude ethyl acetate extracts were tested against 6 endophytes isolated from *C. inerme*. Three out of 10 (33.3%) endophytes, which were identified as *Phomopsis* sp, *Curvularia* sp, and *Mycoleptodiscus* sp, displayed distinct antifungal activity against  $\geq 3$  tested fungi. This was the novel report on an endophytic community associated with *C. inerme* in China and its antifungal activity *in vitro*.

Anitha and Kannan <sup>[31]</sup> *et al.*, (2006) screened the antifungal potential of ethyl acetate and hexane extracts of leaves and stems of *Clerodendrum inerme* and *Clerodendrum phlomidis* (Verbenaceae). Both ethyl acetate and hexane extracts of *C. phlomidis* stem and leaf presented considerable scavenging on all the studied herb and human pathogenic fungi. However, leaf hexane extract (1 mg/ml) of *C. inerme* inhibited the herb pathogenic fungi well then the human dermatophytes.

#### 2.6 Erectogenic Potential

Abdelwahab <sup>[32]</sup> *et al.*, (2012) studied the erotogenic potential of *C. capitatum*. *Clerodendrum capitatum* (family: Verbenaceae) is generally known as Gung and used conventionally to cure erectile dysfunction. The property of relaxation of this plant was revealed on phenylephrine precontracted rabbit corpus cavernous flat weight (CCSM). The appearance of *C. capitatum* was also calculated on separated Guinea pig atria only, in the home of calcium chloride (Ca<sup>2+</sup> channel blocker), atropine (cholinergic blocker), and glibenclamide (ATP-sensitive K<sup>+</sup> channel blocker). These potentials were definite on separated rabbit aortic strips. The extract, when examined calorimetrically for its scavenging potential on phosphodiesterase-5 (PDE-5) *in vitro* for p-nitrophenyl phenyl phosphate (PNPPP), was noted to encourage important dose-dependent scavenging of PDE-5, with an ID<sub>50</sub> of 0.161  $\mu$ g/ml (P<.05). Finally, these results recommended that *C. capitatum* has a relaxant effect on CCSM, which is similar to the scavenging of PDE-5, but not facilitated by the relief calcium, initiation of adrenergic or cholinergic receptors, or the initiation of potassium passages.

#### 2.7 Hepatoprotective Potential

Sannigrahi <sup>[33]</sup> *et al.*, (2009) studied the Hepatoprotective potential of methanolic extract of *Clerodendrum infortunatum* Linn. (MECI), which was extensively used in Indian indigenous system of medicine, against carbon tetrachloride induced hepatotoxicity in rats. Methanol extract at the dose of 100 and 200 mg/kg was administered daily along with carbon tetrachloride once in 72 hours for 14 days. The study was evaluated by assaying the serum biochemical parameters glutamate pyruvate transaminase (ALT), glutamate oxaloacetate transaminase (AST), alkaline phosphatase (ALP), bilirubin and total protein. Malondialdehyde (MDA) level, as well as reduced glutathione (GSH) content and catalase activity (CAT), was determined to explain the possible mechanism of the activity. The substantially elevated serum enzymatic levels of AST, ALT, ALP and total bilirubin were restored towards normalization significantly by the extract. Silymarin was used as a standard reference and exhibited significant hepatoprotective activity against carbon tetrachloride induced

hepatotoxicity in rats. MDA concentration was decreased, while the liver antioxidative enzyme activity was elevated in all the MECI treated rats. All the results were compared with standard drug silymarin. In addition, histopathology of liver tissue was investigated to observe the morphological changes, showing the reduction of fatty degeneration and liver necrosis. The results of this study exposed that methanol extract of *C. infortunatum* has moderate hepatoprotective activity. This effect may be due to the ability of the extract to inhibit lipid peroxidation and increase in the anti-oxidant enzymatic activity.

Gopal and Sengottuvelu<sup>[34]</sup> *et al.*, (2008) screened the ethanol extracts of *Clerodendrum inerme* leaves for its hepaprotective activity in  $\text{CCl}_4$  (0.5 ml/kg, IP), it induced liver damage in Swiss albino rats at a dose of 200 mg/kg BW. The ethanolic extract of *Clerodendrum inerme* significantly ( $p < .001$ ) decreases the serum enzyme aniline aminotransferase (ATL), aspartate aminotransferase (AST), alkaline phosphate (ALP) and triglyceride (TGL). The total cholesterol and significantly increased the glutathione level. Silymarin (25mg/kg) a known hepaprotective drug used for comparison exhibited significantly activity ( $p < .001$ ). The extract did not show any motility up to a dose of 2000g/kg BW.

George<sup>[35]</sup> *et al.*, (2008) observed that about twenty-four rats were divided into four equal groups. The control group established distilled water intraperitoneally. The second group was mixed in carbon tetrachloride 0.5 ml/kg for seven days whereas the third group was also used with carbon tetrachloride 0.5 ml/kg and simultaneously managed with *Clerodendrum inerme* extract 200 mg/kg orally for seven days. The fourth group received carbon tetrachloride 0.5 ml/kg intraperitoneally collected with silymarin 200 mg/kg orally for seven days. At the end blood samples separated by direct cardiac puncture and serum were used against the marker enzymes aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, similarly cholesterol and triglyceride content. Rats treated with the ethanolic extract of *C. inerme* displayed an important decrease in the worth of the indicators. The results suggest that *C. inerme* protects the liver however carbon tetrachloride produce hepatotoxicity.

Vidya<sup>[36]</sup> *et al.*, (2007) evaluated the ethanol extract of *C. serratum* roots and ursolic acid isolated from it for the hepaprotective potential of carbon tetrachloride produced poisonousness in male Wistar staining rats. The parameters planned were to assess the liver function serum indicators such as serum entire bilirubin, entire protein, alanine transaminase, aspartate transaminase and alkaline phosphatase potentials. The ursolic acid exposed more important hepatoprotective action than crude extract. The histological profile of the liver tissue of the root extract and ursolic acid cured animal exposed to normal hepatic cords, lack of necrosis and fatty infiltration as same to the panels. The results when equated with the regular drug silymarin, discovered that the hepatoprotective potential of the constituent ursolic acid is important as similar to the standard drug.

## 2.8 Insecticidal Activity

Morya<sup>[37]</sup> *et al.*, (2010) tested the powder leaves of *Lantana camara* (L.) (Lamiales Verbenaceae), *Clerodendrum inerme* (L.) (Lamiales Verbenaceae) and *Citrus limon* (L.) (Sapindales Rutaceae) for their effectiveness, in treating the stored grain insect pest *Corcyra cephalonica* (Stainton) (Lepidoptera Pyralidae). Seven different doses alternating from 0.05 to 2.0 g

(0.05, 0.1, 0.15, 0.5, 1.0, 1.5, and 2.0 g) per 20.0 g of rice were tested against this common insect pest of rice to evaluate their effect on its life cycle and mortality. Three higher doses were further tested for their effect on physiological parameters like Total Haemocyte Count (THC), total protein content and glycogen level along with starved insects. *L. camara* and *C. inerme* exhibited biopesticidal activity as evident by the high mortality rate in treated insects while *C. limon* was ineffective for *C. cephalonica* in the tested conditions. There was also an important decrease in the THC (39-53%), protein (30-38%) and glycogen (40-61%) content in *L. camara* and *C. inerme* treated larvae with respect to their controls. This was, however, analogous to the results which were detected in starved groups (52.0, 39.0 and 82.0% respectively for THC, protein, and glycogen) which mimic a physiological circumstance similar to them.

## 2.9 Antihypertensive Activity

Guessan<sup>[38]</sup> *et al.*, (2010) analyzed that in spite of advances in modern medicine, hypertension remains a disease which is difficult to eliminate. The leaves of *Clerodendrum inerme* (Verbenaceae) were tested to lower hypertension. Dried leaves of the plant were pulverized; with the powder, maceration was made, herbal extract (*C. inerme*), was prepared at 100mg/mL. Rabbits were injected with 10 mL of ethylurethane, intraperitoneally. The saphenous vein was intubated with a catheter attached to a syringe allowing the injection of different doses of *C. inerme* and Acetylcholine. The physiological records made on rabbits revealed that *C. inerme* has no effect on the blood pressure, at low doses ( $\leq 10$ -4 mg/ml). For doses ranging from 10-3 mg/ml to 10 mg/ml, it developed a gradual and reversible hypotension. At 20 mg/ml, the hypotension remains steady. *C. inerme* has no influence at doses  $\leq 10$ -4 mg/ml on blood pressure. At higher doses ( $\geq 10$ -3 mg/ml), it lowers blood pressure. Hence, it can be concluded that *Clerodendrum inerme* leaves aqueous extract exerts a hypertensives effect.

## 2.10 Anti-inflammatory Activity

Yankanchi and Koli<sup>[39]</sup> *et al.*, (2010) investigated that *Clerodendrum inerme* is a hedge plant that belongs to the Verbenaceae family, conventionally used for decorative purpose in domestic gardens. In the present study, anti-inflammatory and analgesic influence of methanol extract of *Clerodendrum inerme* (MECI) was evaluated in animal models. The anti-inflammatory potential of MECI was found to be significant. In addition, the extract also presented the important analgesic potential in acetic acid persuaded writhing. Therefore, the anti-inflammatory and analgesic potential observed with MECI could be attributed mainly to its antioxidant and lysosomal membrane stabilizing properties.

Yadav and Gupta<sup>[40]</sup> *et al.*, (2014) developed a validated high-performance thin-layer chromatographic (HPTLC) method for the simultaneous determination of anti-inflammatory compounds betulinic acid (BA, 1), 24 $\beta$ -ethylcholesta-5,22E, 25-triene-3 $\beta$ -ol (ECTO, 2), and lupeol (LU, 3) in the roots of *Clerodendrum phlomidis*. The extraction efficiency of marker compounds was studied using normal (cold and hot), ultrasonic, as well as microwave-assisted extraction techniques with various solvents. Well-resolved separation of marker compounds was achieved on silica gel 60F<sub>254</sub> plates using the mobile phase consisting of chloroform-methanol (98:2, 1/2<sup>1/2</sup>).

Marker compounds were scanned using the densitometric reflection-absorption mode after post-chromatographic derivatization with the vanillin-sulfuric acid reagent. Validation of method was performed as per the International Conference on Harmonization (ICH) guidelines. Novel report on the occurrence of betulinic acid in *C. phlomidis* is of chemotaxonomic importance. In addition, the anti-inflammatory potential of the rare sterol ECTO (2) on lipopolysaccharide (LPS)-stimulated production of pro-inflammatory cytokines (tumor necrosis factor- $\alpha$  [TNF- $\alpha$ ] and interleukin-6 [IL-6]) was also evaluated as it was not reported earlier.

### 3. Green synthesis of silver nanoparticles with *Clerodendrum inerme*

Farooqui <sup>[5]</sup> *et al.*, (2010) first reported the synthesis of silver nanoparticles using extracts of a medicinal leaf *Clerodendrum inerme*. Nanoparticles were synthesized from three altered leaf conditions; fresh leaves, sun-dried leaves, and hot-air oven dried leaves. Atomic force microscopy (AFM) analysis of the nanoparticles exposed differences in sizes for the nanoparticles manufactured from different leaf conditions. Nanoparticles manufactured using fresh leaves have the smallest sizes. It is anticipated that optimization of the current synthesis method would yield highly monodispersed silver nanoparticles that have countless activity in treating skin illnesses.

#### 3.1 Schistosomiasis Activity

Jatsa <sup>[41]</sup> *et al.*, (2009) presented their report on the study which was undertaken to assess the in vivo antischistosomal activity of its leaves aqueous extract on a *Schistosoma mansoni* mice model and to determine the most effective dose of this extract. *Clerodendrum umbellatum* Poir (Verbenaceae) is traditionally used in Cameroon for the treatment of many diseases including intestinal helminthiasis. Mice showing a patent infection of *S. mansoni* were daily treated with *C. umbellatum* leaves aqueous extract at the doses of 40, 80 or 160 mg/kg body weight for 14 days. Seven days after administration of the extract, schistosomiasis activity was evaluated on the liver and spleen weights, fecal eggs releasing, and liver egg count and worm burden. Treatment using *C. umbellatum* leaves aqueous extract resulted in an important reduction in faecal egg output by 75.49 % and 85.14 % for 80 mg/kg and 160 mg/kg of the extract respectively. These reduction rates did not differ significantly from the 100 % obtained in the group of infected mice treated with 100 mg/kg of praziquantel. *C. umbellatum* leaves aqueous extract was lethal to *S. mansoni* worm. A 100 % reduction rate was recorded in the group of infected mice treated with 160 mg/kg of the extract, as well as in praziquantel-treated mice. An amelioration of the hepatosplenomegaly was noticed in both the extract-treated mice and the praziquantel-treated mice. From these results, we can conclude that *C. umbellatum* leaves aqueous extract demonstrated schistosomiasis properties in *S. mansoni* model at doses of at least 80 mg/kg body weight.

#### 3.2 Pharmacological Study

Wahab <sup>[42]</sup> *et al.*, (2008) investigated the pharmacological effects of the methanolic extract of *Clerodendron capitatum*, belonging to family Verbenaceae. These investigations were carried out on isolated frog rectus abdomens muscle and rabbit aortic strips and jejunum and non-pregnant rat uterus pre-treated with oestradiol. Results showed that *Clerodendron capitatum*

did not reveal any contracting, relaxant or blocking effects on frog rectus abdomens muscle and rat aortic strip preparations. The extract produced a concentration-dependent ( $p < 0.05$ , t-test,  $n = 6$ ) decrease of the normal rhythmic contraction of rabbit jejunum, however, this effect was reversed by prior addition of cyproheptadine (non-specific 5-HT antagonist). In addition, *Clerodendron capitatum* also produced a stimulant activity on rat uterus which was blocked by cyproheptadine. Future study is recommended to study the specificity of *Clerodendron capitatum* to different 5-HT receptors by using different isolated animal tissues and specific 5-HT antagonists.

#### 3.3 Chemopreventive Potential

Manoharan <sup>[6]</sup> *et al.*, (2006) illustrated that Oral cancer is the fifth most frequent cancer worldwide and India has recorded the highest incidence (40-50 percent) of oral malignancy. *Clerodendrom inerme* is used by Indian alternative medicine for the treatment of various ailments including cancer. Chemopreventive potential of the aqueous leaf extract of *Clerodendrom inerme* (CiAet) was tested in 7, 12-dimethylbenz (a) anthracene (DMBA) - induced hamster buccal pouch carcinogenesis. Oral squamous cell carcinoma in the buccal pouch of male Syrian golden hamsters was induced by painting them with 0.5% DMBA in liquid paraffin thrice a week for 14 weeks. The tumor incidence, tumor volume and tumor burden that were formed in the hamster buccal pouches were determined. Oral administration of CiAet at a dose of 500 mg/kg body weight to DMBA-painted animals on days alternate to DMBA painting for 14 weeks significantly prevented the tumor incidence, tumor volume, and tumor burden. CiAet also exerts potent anti-lipid peroxidative effect and improved the antioxidant defense system in DMBA-painted animals. The chemopreventive efficacy of CiAet was evident by inhibition of tumor formation (80%) in DMBA painted animals. The chemopreventive potential of CiAet is probably due to its anti-lipid peroxidative effect or the presence of some potent bioactive chemopreventive principles in the leaves of *Clerodendrom inerme*.

Avani <sup>[43]</sup> *et al.*, (2006) studied the *Clerodendrom inerme* L. (Verbenaceae), commonly known as vanajai or garden quinine, it is a perennial shrub. They analyzed that leaves and roots of the plant are used in rheumatism and skin diseases. In Indian classical literature, the plant *Clerodendrom inerme* is also reported as a substitute of quinine. Since the root of the plant is used as a drug, the whole plant has to be destroyed; this has resulted in the reduction of the plant population. The present investigation was taken up to establish a protocol for mass production of better quality plant material, using auxiliary bud multiplication. The protocol will help in ex situ conservation of the plant. A maximum number of multiplied auxiliary bud was observed in 16 M 6-benzyladenine (BA) with 3% sucrose. After elongation, regenerated micro-shoots were rooted in MS medium in absence of plant growth regulators (PGR). The rooted plantlets showed 100% field survival. The regenerated plants showed a similar phytochemical profile as mother plant when compared.

#### 4. Isolation activity of naturally occurring compounds

Apigenin-7-glucoside,  $C_{21}H_{20}O_{10}$  (7-( $\beta$ -D-glucopyranosyloxy)-5-hydroxy-2-(4-hydroxyphenyl)-4H-1-benzopyran-4-one), was firstly separated by Bhujbal<sup>[44]</sup> *et al.*, (2010) from the roots of *Clerodendrom serratum* (L.) Moon, Lamiaceae. Structure

interpretation of the compound was approved out by <sup>1</sup>HNMR and FAB-MS techniques. Pandey <sup>[45]</sup> *et al.*, (2005) isolated the three neo-clerodane diterpenoids, *inermes* A, B and 14, 15-dihydro-15b-methoxy-3-epicaryoptin, from the hexane extract of the leaves of *Clerodendrum inerme* in addition to an epimeric mixture of 14, 15-dihydro-15-hydroxy-3-epicaryoptin. Structures of these compounds have been elucidated on the basis of spectral studies.

Kanchanapoom <sup>[46]</sup> *et al.*, (2001) isolated 15 known compounds from the aerial parts of *Clerodendrum inerme*, two megastigmane glycosides (sammangaosides A and B) and an iridoid glucoside (sammangaoside C). The structural elucidations were based on analyses of physical and spectroscopic data.

## 5. Conclusion

It can be concluded that precise miniature exertion had been conceded out for the investigation of pharmaceuticals potential of the plant species. As a result, this review would resolve the inquiries of investigators and will emphasis on the exact activities that are associated with the plant. All over the world, herbal medication embodies its utmost significance as well as reveals its vibrant role in the arena of traditional medication system. Because of request escalation of herbal medicines day by day due to its operative rectification, plants are employed broadly for the production of new-fangled medicines that are usually less harmful as compared to the other medication systems.

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