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# A BRIEF REVIEW ON GUDUCHI (*TINOSPORA CORDIFOLIA*)

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**Keywords:**

Guduchi, *Tinospora cordifolia*, Phytochemicals, Pharmacological activities

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**ABSTRACT:** Guduchi (*Tinospora cordifolia*) is an essential drug of the Ayurvedic medicine system used in different Ayurvedic formulations to treat a variety of ailments. Guduchi is a member of the *Menispermaceae* family and is widely produced in tropical and sub-tropical countries such as India, Sri Lanka, China, Myanmar, Philippines, South Africa, Thailand, Bangladesh, and several south-east Asian continents such as Indonesia, Malaysia. All parts of Guduchi have nutritional value and medicinal importance, including the roots, stem, bark, and leaves. A different class of phytochemicals like alkaloids, glycosides, aliphatic compounds, diterpenoids, sesquiterpenoids, phenolic compounds, steroid and polysaccharides, *etc.*, are found in Guduchi. Tinosporaside, tinosporine, magnosporine, berberine, choline, Jatrorrhizine, palmatine, beberine, giloin, giloinsterol, and other beneficial biomarkers are present in this herb. Guduchi is used to treat cold, fever, headache, jaundice, digestive disorder, among other things, and it shows several proven pharmacological activities such as anti-oxidant, anti-inflammatory, antidiabetic, immunomodulatory activity, anti-toxic, hepatoprotective, anticancer, cardioprotective activity, radioprotective, antimicrobial, anti-stress, anti-HIV and many more. This review article majorly highlights the phytochemical present in Guduchi, analytical works and pharmacological activities of Guduchi.

**INTRODUCTION:** Medicinal plants play an essential role in the treatment and maintenance of good health [1]. Throughout history, Guduchi has been utilized in Ayurvedic remedies to cure a variety of diseases. Scientists have recently expressed a keen interest in the development of novel medications derived from traditional medicinal herbs.

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Guduchi is a *Menispermaceae* family herbal shrub found in rich biodiversity and knowledge of ancient traditional herbs. *Gulancha*, *amrita*, *Giloya*, *gulvel*, and other names have been given to it. The plant family Menispermaceae consists of 70 genes and roughly 450 species found in tropical areas. All parts such as roots, stem, leaves, flower, fruits, and the entire plant of Guduchi have therapeutic value as it contains a variety of phytochemicals with various pharmacological properties [2].

**Vernacular Names:** ln Latin it is known as *Tinospora cordifolia*; English known as Gulancha or Indian Tinospora; Sanskrit Madhuparni; Amrita, Guduchi, *etc.;* Hindi Giloya or Guduchi; In Marathi, it is well known as Gulvel, giroli as well

as Amberveli; Assamese Amarlata; Bengali Gulancha, Giloe; Gujrati Galo, Gulo; Tamil Amridavalli; Telugu Tippatige, Guduchi [3].

**Taxonomical Classification:** Guduchi comes under the Kingdome Plantae (Plant) Division is Magnoliophyta (Flowering), Class Magnoliopsida (Dicotyledons), the order is Ranunculales, and it belongs to *Menispermaceae* family (The moonseed family), Tribe Tinosporeace, Genus Tinospora and species is cordifolia [4].

**Distribution:** Guduchi prefers to grow India's tropical a well as subtropical regions, especially areas of Maharashtra, Tamilnadu, Madhya Pradesh, Uttar Pradesh, and Kerala. It is also native to the area of Sri Lanka, China, Myanmar, Philippines, South Africa, Thailand, Bangladesh, and parts of the south-east Asian continent such as Indonesia and Malaysia [5].

**Growth Requirement:** Guduchi is growing in a variety of soils and climates, although it thrives in light to medium sandy loam soil, as well as medium black or red soil and benefits in a warm environment. It is necessary to have enough water. Cultivation is usually done in the month of July-August (during the wet season) [6].

**Morphology of Guduchi:** Root, stem, leaves, flower, fruit, and seed are all key morphological components of the Guduchi shrub, as shown in **Fig. 1.**


**FIG. 1: MORPHOLOGY OF GUDUCHI (A) AERIAL ROOT (B) STEM (C) LEAVES (D) FLOWER (E) FRUIT (F) SEED**

**Macroscopic Description:**

**Aerial Root:** The aerial root is a threadlike aerial squairshin that can develop to touch the ground. Long filiform aerial roots emerge from mature branches or cut stem portions as young aerial root.

The mature aerial roots are fleshy, which are almost similar to young aerial stem except for the presence of nodal swelling. The diameter of the dried aerial root is 3-6 cm, and the surface colour is creamy white or light grey-brown, a short fracture, a bitter taste, and they are odourless [7].

**Stem:** Guduchi stem is succulent, long, filiform, juicy and ascending in nature, with aerial roots emerging from the stem and descending towards the ground. The stem is spirally twisted, and the bark ranges in colour from pale milky to grey [8, 9].

**Leaves:** Guduchi leaves are simple, alternate, stipulate, long-petioled approximately 2.5-7.0 cm, heart-shaped twisted partly, 7-9 nerved, and deeply cordate at the base and halfway round. The lamina is oval and membranous, measuring 10-20 cm long and 8-15 cm wide. The young leaves are bright green, while the adult leaves are yellowish-green to yellow in colour, bitter, and have an unclear odour [10].

**Flowers:** Flowers are tiny, unisexual racemes that develop when the plant is leafless and are greenish-yellow in colour. Male flowers are grouped, whereas female flowers exist in solitary inflorescence. There are six sepals in each of two series of three. The outer ones are smaller, free, and membranous than the sepals. Summer is when the flowers bloom, from March to June [11].

**Fruit:** Fruits are fleshy single-seeded drupelets on a thick stalk with subterminal style scars that are aggregated in groups of [1, 3]. The fruit is ovoid with, smooth texture and orange to red colour. Fruits grow throughout the winter months [12].

Seed: This species has been known to produce seeds with a curved or hooked form. As a result, this family is known as the Moonseed family. Because seeds are white and curve or bean-shaped, the embryo turns into curve form as well [11, 12].

**Microscopic Description:**

**Root:** The fundamental structure of an aerial root is tetra to the Penta-arch. The cortex is separated into two zones: the outer thick-walled zone, which represents the velamen, and the inner parenchymatous zone, which contains mucilage cells and cells that contain tannins. Starch is present throughout the parenchyma of the areal root [13].

**Stem:** Cork, cortex, and vascular bundle are visible in the transverse section of the Guduchi stem. An exterior zone of thick-walled brownish compressed cells and an inner zone of thin-walled, colourless and tangentially oriented cells make up the cork.

Because of the existence of lenticels, the cork tissue is fractured in some areas. Cortex is multilayered and broad, with 3 to 5 rows of irregularly arranged tangentially elongated chlorenchyamatous cells in the outer zone and polygonal cells loaded with numerous starch granules in the inner zone. The starch grains are ovoid and simple, with a few secretory cells dispersed across the cortex. Pericyclic fibers that have been lignified are associated with a significant number of crystal fibers, each containing a single prism [33].

The vascular zone is composed of discrete vascular strands with 10 to 12 or more wedge-shaped strips of xylem, externally surrounded by semi-circular strips of phloem alternating with wide medullary rays; phloem parenchyma contains calcium oxalate crystals, cambium is made up of 1-2 layers, xylem is made up of vessel element, tracheids, parenchyma, and fibers. Vessel elements have cylindrical shape bearing bordered pith, medullary rays 15 to 20 cells broad, and pith is primarily made up of large thin-walled cells containing starch grains [13, 14].

**Leaf:** The cross-section passing through the midrib region of Guduchi leaf reveals a small convex at the top side, a large hump on the bottom side, and a single median well-developed collateral vascular bundle. The mesophyll divides into palisade and spongy tissue in the cross-section of the lamina, which reveals a dorsiventral shape. The mesophyll is differentiated into a palisade layer, which is made up of one row of thin-walled columnar cells that take up about half of the width of the mesophyll. The palisade ratio ranges from [4, 12].

In surface view, epidermal cells are angular, with an average density of 1000-1500 $mm^{-2}$ and cellular trichomes with an average density of 1-4 $mm^{-2}$ measuring 115-145 µm length and 32-42 µm width. Anomocytic stomata range in length from 200-600mm-2 and 36-54µm long and 18-36 µm wide.

The veins are reticulate, with multiple principal veins. On the dorsal side, veins are multicostate and conspicuous. The number of vein-islet and vein-termination are 1-3 $mm^{-2}$ and 6-16 $mm^{-2,}$ respectively. The outline of the transverse section of the petiole is more or less round. It has a single-layered epidermis and a broad zone of cortex single layered endodermis as well as a wavy arrangement of 3-4 layers of fibrous pericycle and 8-10 vascular bundles grouped in a ring and broad zone of central parenchymatous pith [14].

**Nutritive Composition of Guduchi:** The nutritive value of Guduchi is 292.54 calories per 100 gm.

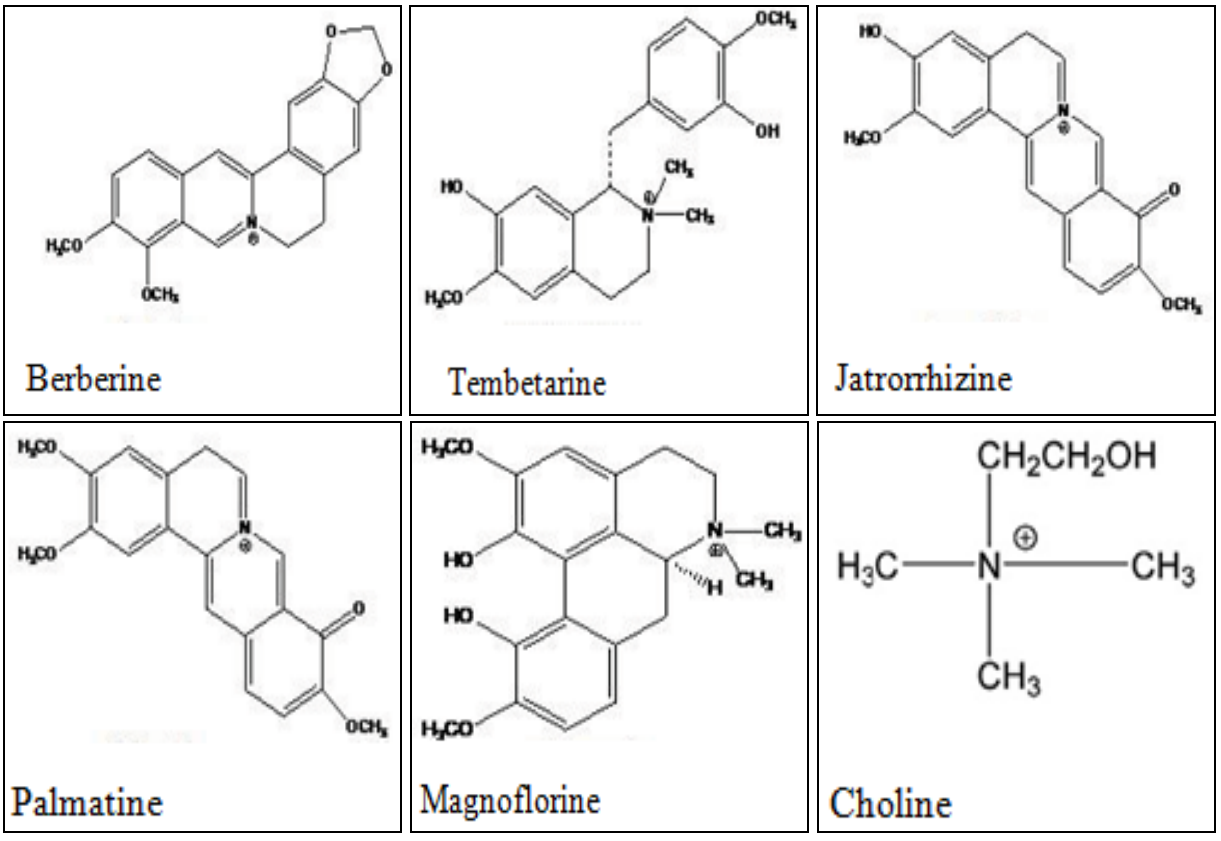
**Stem:** It is the rich source of carbohydrates (61.66%), it contains high fiber (15.9%), sufficient protein (4.5-11.2%), also contains fat (3.1%), iron (0.28%), potassium (0.845%), calcium (0.131%) and chromium (0.0060).

**Leaves:** It contains high carbohydrates (65.31%), Sufficient protein (8.74%), fiber (8.25%) fat (2.80%), iron (1.53%), calcium (0.11%), and it is a good source of vitamin C (1.24%) [15].

**Phytochemical Composition of Guduchi:** The chemical constituents of Guduchi belong to different classes such as Alkaloids, Glycosides, steroids, phenolic compounds, aliphatic compounds, polysaccharides, lignans, terpenoids, *etc*. as shown in **Table 1** with their active constituents and their chemical structures as shown in **Fig. 2** [14, 16].

**TABLE 1: Guduchi-MAJOR CHEMICAL CLASSES AND THEIR ACTIVE CONSTITUENTS**

| Chemical class | Active constituents | References |
|---|---|---|
| Alkaloids | Berberine, tembetarine, choline, magnoflorine, tinosporin, palmatine, isocolumbin, aporphine alkaloids, jatrorrhizine, tetrahydropalmatine | 16, 19 |
| Glycosides | Tinocordioside, Tinocordifolioside, Cordioside, 18-norclerodane glucoside, Furanoid diterpene glucoside, Cordifolioside Syringin, Syringinapiosyglycoside, Pregnane glycoside, Palmatosides, Cordifolioside A, B, C, D and E, 2-Methyl-1,2-pyrrolidine, N- Formylannonai | 20, 24 |
| Steroids | Beta-sitosterol, 20 beta – hydroxyecdysone, Makisterone A, Giloinsterol | 25, 28 |
| Sesquiterpenoids | Tinocordifolin | 29 |
| Diterpenoid Lactones | Furanolactone, Tinosporon, Tinosporides, Jateorine, Clerodane derivatives [(5R,10R)-4R-8R- dihydroxy-2S-3R:15,16-diepoxy-cleroda-13(16),14-dieno-17, 12S:18,1S-dilactone] | 30, 38 |
| Aliphatic compounds | Octacosanol, Heptacosanol, Nonacosan-15-one dichloromethane | 26, 30 |
| Other compounds | Nonscosan-15-one 3, (a,4-di hydroxyl -3 methoxy-benzyl)-4-(4 compounds hydroxy-3 methoxy-benzyl)-Tetrahydrofuran, Jatrorrhizine, Tinosporidine, Cordifol, Cordifelone, Giloinin, Giloin, N transferuloyltyramine as diacetate, Tinosporic acid. | 35, 36 |



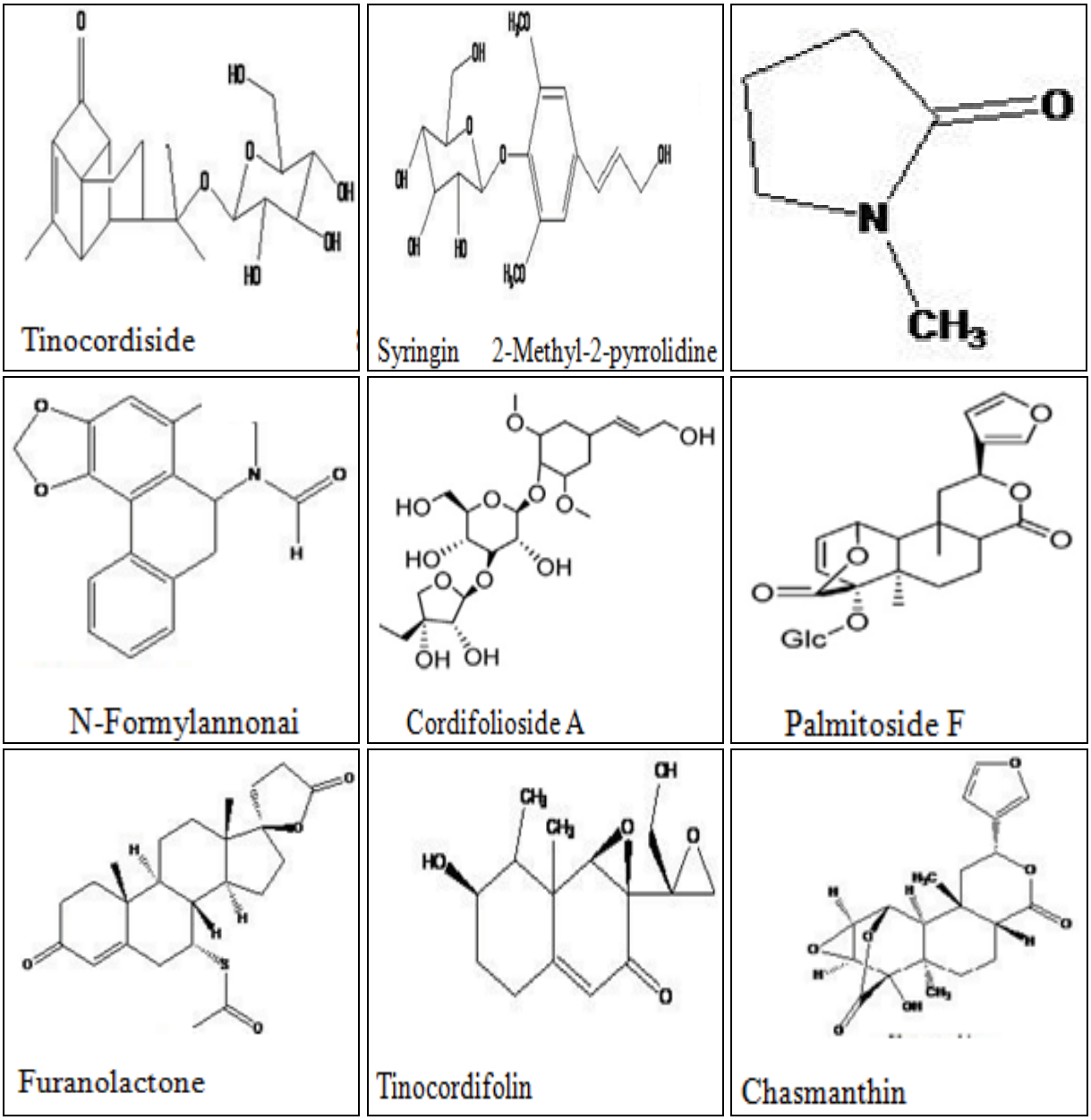



**FIG. 2: STRUCTURE OF THE CHEMICAL CONSTITUENTS OF GUDUCHI**

**Medicinal Part and Their Therapeutic Uses of Guduchi:** Roots, stem, leaves, fruits, bark as well as the entire plant of Guduchi is useful for medicinal purposes. **Table 2** lists the medicinal parts and their therapeutic uses.

**TABLE 2: GUDUCHI-MEDICINAL PARTS AND THERE THERAPEUTIC USES**

| S. no. | Plant part | Medicinal uses | References |
|---|---|---|---|
| 1 | Roots | The roots of Guduchi are a powerful emetic it having anti-oxidant activity it reduces tissue cholesterol, free fatty acid and phospholipid. Roots are used for visceral obstruction. Water extract is used in leprosy, and it prevents diabetic cataracts and weight loss in a diabetic patient | 39, 41 |
| 2 | Stem | The stem is a bitter stomachic it stimulates bile secretion it cures jaundice, fever, burning sensation, vomiting, is useful in skin diseases, its juice is useful in diabetes. Stem used for intestinal problems and improved digestion | 14, 40 |
| 3 | Stem and root | Combinable it is used as an antidote to scorpion sting and snakebite | 42 |
| 4 | Bark | The Bark is used as an antipyretic, anti-leprotic, anti-spasmodic, anti-allergic | 43 |
| 5 | | Leaves are useful in the treatment of urinary tract disorder, fever, asthma, | 14, 44 |

| | | | |
|---|---|---|---|
| | | bacterial infection, anaemia, cardiac disorder. The leaves are beaten with honey and use to treat ulcers; it is also useful for the treatment of erysipelas (bacterial skin infection) and goat | |
| 6 | Fruit | Dried fruit powder of Guduchi mix with honey or ghee and it is used as a tonic. It is also used to treat jaundice and rheumatism | 14, 45 |
| 7 | Whole plant | The whole plant is used to stimulate the body's immune system, used to treat diarrhoea, scabies in swine, stomach problems, skin disorder, urinary diseases, *etc* | 45, 47 |

Using the various chemical compounds from Guduchi, various pharmaceutical market products have been produced by different industries as shown in **Table 3** [48].

**TABLE 3: GUDUCHI PHARMACEUTICAL MARKETED PRODUCTS AND THEIR BIOLOGICAL ROLES**

| Name of the market product | Biological role |
|---|---|
| Safe herb | Use to cure Anemia and sexual disabilities |
| Mussaffen | Blood purifier and anti-allergic |
| Rebuild | Anti-stress and Anti-toxic |
| Tonplex | Increase immunity |
| Guduchi | Increase immune system and body's resistance to infections. |
| *Tinospora cordifolia* pellets | Use to treat a number of diseases |
| Braveheart capsules | Use as a diuretic, It lowers the cholesterol (Lipid level) and LDL- cholesterol in the body. |
| Abhaibhubejhr | Anti-stress |
| Madhu mehari | The urinary problem, fatigue, maintain blood sugar |
| Cirrholiv capsules | Hepatoprotective |
| Cirrholiv-ds syrup | Hepatoprotective |

**Qualitative Analysis:**

**Physicochemical Analysis:** Raina M. *et al.,* (2013), performed a physicochemical analysis of Guduchi stem by different parameters such as foreign matter, total ash, acid insoluble ash, water-soluble ash, loss on drying, extractive values like water soluble and acid soluble extractive values were determined as per Indian Pharmacopoeia and results were reported [37]. Namrta C. *et al.,* (2014), performed physicochemical analysis for leaf, stem, and aerial root of Guduchi. Air-dried powdered leaf, stem, and aerial roots were subjected to physicochemical analysis *viz*, ash, and extractive values which were noted [13].

**Preliminary Phytochemical Analysis:** Manish K. *et al.,* (2015), Performed Qualitative Preliminary Phytochemical analysis of Guduchi by using its leaves and stem.

The extract was obtained with five different solvents *viz;* water, ethanol, methanol, chloroform and petroleum ether by maceration process. This phytochemical screening of Guduchi leaves and stem extract indicates the presence of alkaloids, cardiac glycosides, tannins, phenols, carbohydrates, and flavonoids. By this research, the researcher concluded that most phytochemical components were found in methanolic extract due to the high solubility of the active compound of Guduchi as compared to other solvents [38]. Gagandeep K. *et al.*, (2016), performed a preliminary phytochemical analysis of Guduchi. The extract of the stem was successively extracted by Soxhlet assembly using various solvents such as hexane, chloroform, ethyl acetate, and methanol. Results showed the presence of carbohydrates, glycosides, flavonoids, phenols, tannins, and amino acids. Methanolic stem extract shows the presence of more phytochemicals than other solvents [49].

Acharya B. *et al.,* (2016), carried out preliminary phytochemical screening on four different powdered samples (fresh aqueous extract, freeze-drying powder, aqueous freeze-drying powder, and dry powder) of Guduchi stem. Results revealed the presence of a wide range of phytochemicals such as alkaloids, glycosides, flavonoids, phenolic compounds, fixed oil, tannin, carbohydrates, and steroids.

The fresh aqueous extract shows the presence of more phytochemicals AS compared to other samples [50]. Garg *et al.,* (2018), carried out preliminary phytochemical screening of chloroform, methanolic, ethanolic extract of leaves and stem. Guduchi expressed the presence of several phytochemicals *viz.,* flavonoids, amino acids, diterpenes, protein, saponins, and carbohydrates. Methanolic stem extract shows the presence of most phytochemical than other extracts of leaves and stems [51].

**TLC Analysis:** Namrta C. *et al.,* (2014), Studied TLC on methanolic extracts of leaf, stem, and aerial root that were obtained by simple reflux method. Berberine and tinosporaside were used as a standard this; both biomarkers were observed in all three parts of extract in the mobile phase they were used and observed at UV 254 nm and 366 nm [13]. Gagandeep K. *et al.,* (2016), performed TLC of hexane, chloroform, ethyl acetate, and methanolic extract of Guduchi stem, which was obtained by the Soxhlet extraction method. Detection of spots was done in visible light as well as by derivatizing agents like Natural Product (NP) reagent at 366 nm. The result reveals that the hexane extract gives three spots, chloroform, as well as ethyl acetate, gives seven spots, and methanol gives eight spots having $R_f$ in the range of 0.14-0.51, 0.19-0.78, 0.06-0.81, and 0.05-0.87, respectively [49].

Acharya B. *et al.,* (2016), performed TLC for four different powdered sample extracts (fresh aqueous extract, freeze-drying powder, aqueous freeze-drying powder, and dry powder) of Guduchi stem. Two different solvent systems were used as mobile phase, anisaldehyde used as spray reagent, and bands were observed at UV 366 nm. The first three samples show a maximum number of bands with similar Rf values in both solvent systems, and the last sample shows a lesser band with different $R_f$ values than other sample extracts. All $R_f$ values were reported; one major constituent was found in this research at Rf 0.58, tinosporaside [50].

**HPTLC Analysis:** Puratchimani V.*et al.,* (2007), a simple and reproducible HPTLC method for the determination of tinosporaside in Guduchi was developed. This method involves separating tinosporaside by TLC on pre-coated silica gel 60F 254 plates with a solvent system of toluene: acetone: water (5:15:1) and scanned using the densitometric scanner in UV reflectance photomode at 220 nm. Using the proposed HPTLC method the Rf of tinosporaside was found to be 0.58 and the content of tinosporaside in the test sample was found to be 0.40% w/w [52]. Sivakumar V. *et al.,* (2011), developed the HPTLC method for the determination of berberine in methanolic stem extract of Guduchi, which was obtained by the Soxhlet extraction method. This HPTLC method involved the separation of compounds by TLC on pre-coated silica gel 60F 254 plates with a solvent system of butanol: ethyl acetate: acetic acid: water (3: 5: 1: 1) and scanned using the densitometric scanner in UV reflectance photo mode at 366 nm. The $R_f$ of berberine found to 0.23 and berberine content in methanolic stem extract of Guduchi test sample was found to be 0.23% w/w [53]. Raina M. *et al.,* (2013), HPTLC Fingerprinting analysis was carried out on Soxhlet methanolic extract of Guduchi stem with solvent system Toluene: ethyl acetate: formic acid (5:4:1) using CAMAG HPTLC system consisting of Linomat-V spotting and scanner 3. The chromatogram obtained was studied under 254 nm and 366 nm. Fingerprint analysis of Guduchi at 254 nm gives 7 spots, and 366 nm gives 10 spots that were reported [37].

Saurabh S. *et al.,* (2015), The HPTLC analysis of methanolic extract of Guduchi was performed to estimate berberine content in the test sample obtained by different extraction methods such as MAE, soxhlation, and maceration. Methanol: acetic acid: water (8:1:1 v/v/v) was used as the mobile phase for this study. Densitometric scanning was performed on a CAMAG TLC scanner 3in the absorbance mode at 366nm. The $\lambda_{max}$ value of berberine was found to be 348 nm. In this study, MAE was found to be more potent for berberine than other methods of extraction [54]. Acharya B. *et al.,* (2016), carried out HPTLC analysis on four powdered extracts of Guduchi stem with the solvent system such as chloroform: methanol: ethyl acetate (9.5: 0.5: 0.1 v/v/v) using CAMAG HPTLC system. The Rf value of different compounds at 254 nm and after derivatization with anisaldehyde at 366 nm was reported [50].

**Total Phenolic Content:** Gagandeep K. *et al.,* (2016), studied total phenolic content in the hexane, chloroform, ethyl acetate, and methanol extract of Guduchi stem. This was evaluated by the modified Folin-Ciocalteu method using tannic acid as a standard. The absorbance was measured at 765 nm using a UV- VIS spectrophotometer. The result shows that the hexane extract has low phenolic content (4.8 µg/g) and ethyl acetate extract has high phenolic content (9.8 µg/g.) of Guduchi [49].

**Total Flavonoid Content:** Gagandeep K. *et al.,* (2016), the total flavonoid content in hexane, chloroform, ethyl acetate, and methanol extract of Guduchi stem was calculated by aluminum chloride

colorimetric method using quercetin as a standard, and the absorbance was measured at 415 nm. This investigation has shown that hexane extract has low flavonoid content (3.6 µg/g) while methanolic stem extract has high flavonoid content (10.8 µg/g) of Guduchi [49].

**Pharmacological Activity:**

**Activity in SARS-CoV-2 (Covid-19):** Priya *et al.,* (2020), performed a molecular docking and molecular dynamics (MD) simulation study on the Ayurvedic medicinal plant such as ashwagandha, tulsi, and Guduchi against COVID-19. This study discovered six possible inhibitors against SARS-CoV-2 main protease, Tinocordiside, which comes from Guduchi. ADMET profile prediction showed that the phytochemicals from these plants were safe and possessed drug-like properties with no toxicity [55].

Vasanthkumar *et al.,* (2020), natural compounds from Guduchi were tested for antiviral activity against SARS-CoV-2 targets involved in virus attachment and replication. Isocolumbin, magnoflorine, berberine, and tinocordiside, all Guduchi chemicals shown excellent binding efficacy against all four key SARS CoV-2 targets (surface glycoprotein, receptor binding domain, RNA dependent RNA polymerase, and main protease). Tinocordiside and isocolumbin have an $IC_{50}$ value of < 1µM against both surface glycoprotein and main protease, which can inhibit attachment and replication of the virus to the host cell. This study was designed to prove the efficacy of Guduchi in the treatment of SARS-CoV-2 infection [56].

Sampark *et al.,* (2021), in this study,in silico technique was used to dock the numerous various secondary metabolites derived from Guduchi (ligands) to the SARS-CoV-2 main protease (target) and compared their efficacy to standard drugs such as chloroquine, hydroxychloroquine, favipiravir, azithromycin, remdesivir. This method demonstrates that the screened compounds might cause efficient SARS-CoV-2 inhibitors. Columbine, tinosporide, amritoside A, amritoside B, amritoside C, palmatoside G, Tinocordifolin and other molecules considered to be the key molecules based on their docking score that was ranged between -5.02 to -5.7257. Sushovan *et al.,* (2021), the chemical ingredients of the Guduchi extract were assessed for their potential against viral spike protein and human receptor ACE2 using computational molecular modeling (auto dock), along with their ADME/T characteristics. The results of molecular docking and ADME/T studies have revealed six constituents that can inhibit the binding of SARS-CoV-2 spike protein with the human receptorACE2 protein. Guduchi can inhibit COVID-19 by modifying the chemical structures and employing computational geometry optimization and molecule docking method [58].

Antioxidant activity: Premnath *et al.,* (2010), reported antioxidant activity; they dried the leave of Guduchi, powdered it, and extracted it with solvents such as chloroform, methanol, ethanol, hexane and water. Antioxidant assay was done by different *in-vitro* models, lipid peroxidation inhibitory activity, DPPH radical scavenged, and superoxide radical scavenging activity. Other solvent extracts had low antioxidant activity, whereas ethanol extract had high antioxidant activity. The results suggested that the antioxidant compounds are better in ethanol extract, and there is a direct correlation between the total polyphenols extracted and its anti-oxidant activity [59].

Goerge *et al.,* (2016), performed antioxidant activity by in-vitro method with methanolic, ethanolic, and water extract of Guduchi; it shows that the ethanolic stem extract increased the erythrocytes membrane lipid peroxide, catalase activity and decreased the superoxide dismulate, glutathione peroxidase in alloxan-induced diabetic rats. Methanolic extract of leaves, partitioned in water with ethyl acetate and butanol at 250 mg/ml, showed their antioxidant activity and concluded that the methanol phosphor molybdenum extract and metal chelating activity high followed by ethyl acetate, butanol, and water extract [60].

**Anti-inflammatory Activity:** Jana *et al.,* (1999), reported the anti-inflammatory activity by the *in-vitro* method in acute and sub-acute models of inflammation. According to the researcher, Guduchi induced odema arthritis and human arthritis. The dried leaves of Guduchi produced an anti-inflammatory effect that was more effective and useful than acetylsalicylic acid and effective in joint inflammation. The aqueous stem extract of

Guduchi also exerted a significant anti-inflammatory effect on cotton pellet granuloma and formalin-induced arthritis models; its result was comparable with Indomethacin. Guduchi shows a significant anti-inflammatory effect in both acute and sub-acute models of inflammation [61].

**Anticancer Activity:** Singh *et al.,* (2006), reported the anticancer activity by *In-vitro* method, alcoholic extract of Guduchi inhibited cell proliferation which leads to cell death in a dose-dependent that is 25-75 µg/ml and time-dependent that is 24-120 h, in oral squamous cell carcinoma cell line with a significant cytostatic effect [62]. Thippeswamy *et al.,* (2007), investigated that the effect of (in-vitro) administration of alcoholic extract of Guduchi (whole plant) leads to proliferation and myeloid differentiation of bone marrow hematopoietic precursor cells in mice bearing a transplantable T cell lymphoma of spontaneous origin designated as Dalton's lymphoma (DL). The study has shown that the plant extract has influenced the myeloid differentiation of bone marrow progenitor cells, and the macrophages are recruited in response to tumor growth in-situ [63].

**Immunomodulatory Activity:** Manjreker *et al.,* (2000), reported that the water and ethanol extract of stem of Guduchi inhibit immunosuppression produced by cyclophosphamide and also inhibit cyclophosphamide-induced anemia by *in-vitro* model. According to the researcher water extract of Guduchi is found to be more potent than the other extract [64].

Kalikar *et al.,* (2008), in human immunodeficiency virus (HIV) positive patients, the immunomodulatory impact of Guduchi extract was examined. In a randomized, double-blind placebo-controlled experiment, they evaluated the efficacy of Guduchi extract in HIV-positive patients. For six months, 48 HIV positive volunteers are randomly assigned to one of two groups, either Guduchi extract or placebo. DLC, TLC, ESR, platelet count, haemoglobin and CD4 count were performed after the clinical examination. The results showed that Guduchi extract therapy reduced eosinophil count and haemoglobin percentage significantly. 60% of Guduchi extract receiving patients and 20% of placebo receiving patients reported a reduction in the occurrence of various illness symptoms. Their findings indicate that Guduchi extract, a plant-based immunomodulant, has a significant impact on HIV symptoms. Clinical evaluation backed up this claim. However, not all of the objective factors that they looked at supported this. Guduchi could be used to supplements HIV/AIDS management65.

**Antidiabetic Activity:** Sudha *et al.,* (2011), reported the antidiabetic activity by using in- Vivo method in which crude extract of the stem in ethyl acetate, dichloromethane (CDM), chloroform and hexane was studied for inhibition of the α-glucosidase enzyme. The activity of the enzyme inhibited hypoglycemic action in diabetic animals and normal animals. The aqueous extract was studied in the rats, without the addition of Guduchi extract increase in glucose by 21.3%, insulin by 51.5%, triglycerides by 54.12%, and glucose-insulin index by 59.8 when plant containing extract was given. The fructose-induced abnormalities in the liver involving lipid peroxidation, protein carbonyl groups, GSH levels, and enzymatic antioxidants decreased [66].

Methew *et al.,* (2009), *in-vivo* studies of different extracts of the plants on a diabetic patient were done, and it shows that sedimental extract of Guduchi on the subject was studied at 30 days. Different doses (200 and 400 mg/kg b.w.) of Ethanolic extract of Guduchi leaves were prepared. The doses were administered orally for 10 days and 30 days in streptozotocin-diabetic albino rats, and it shows the antidiabetic activity in diabetic animals, efficacy 50%-70% compared to insulin [67].

**Cognition (Learning and Memory) Activity:** Agrawal *el al.,* (2009), investigated the cognition activity of Guduchi in rats using an in-vivo method in which aqueous and alcoholic whole plant extracts of Guduchi were administered orally to two different groups of rats for 15 days. In two different groups of rats, cyclosporine 15, 25 mg/kg, i.p. for 10 days, alcoholic Guduchi 200 mg/kg, and aqueous extract of Guduchi 100 mg/kg were administered. Both Guduchi extracts reduced learning scores in the Hebb William maze and improved retention memory, indicating improved learning and memory. Cyclosporine increased learning in the Hebb William maze and decreased retention time in the passive avoidance test at both

doses, indicating memory impairment. The combination of cyclosporine and Guduchi produced a decrease in learning score in the Hebb William maze and increase latency in passive avoidance task compared to cyclosporine alone treated rats. Their result shows that Guduchi extract improves learning and memory in normal rats and that Guduchi successfully overcomes the memory impairment caused by cyclosporine [68].

**Antimicrobial Activity:** Guduchi shows good antibacterial and antifungal activity with different solvents on different microorganisms. Jayachandran *et al.,* (2003), studied the methanolic extract of stem shown good antimicrobial activity by in-vitro analysis against both gram-positive and gram-negative bacteria such as *Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Salmonella typhi, Proteus vulgaris, Shigella flexniri, Salmonella tryphimurium, Enterobacter aerogene, Enterobacter aeruginosa, Pseudomonas aeruginosa, Salmonella paratyphi* and it is shown excellent therapeutical activity on the infectious disease [69].

Shanthi *et al.,* (2013), showing that the aqueous, acetone and ethanol extract of Guduchi inhibited the activity on clinical isolates of urinary pathogens Klebsiella pneumonia and Pseudomonas aeruginosa 69. Allemailen *et al.,* (2019), reported that the aqueous extract on Guduchi has potent antifungal activity against *A. fumigatus, Aspergillus flavus,* and *Aspergilles Niger* which was determined by agar well plate diffusion method [70].

**Anti-allergic Rhinitis activity:** Bousquet *et al.,* (1994), reported the Anti-allergic Rhinitis activity by the *in-vivo* method. The efficacy of Guduchi extract in patients of allergic rhinitis in a randomized double-blindplacebo-controlled trial is reported. For these, seventy-five patients were randomly given either Guduchi extract or placebo for 8 weeks. After treatment with plant extract 100% relief was reported from sneezing in 83% of patients, 71% from nasal pruritus, 69% from nasal discharge, and 61% from nasal obstruction. In the placebo group, there was no relief in 79% from sneezing, 88% from nasal pruritus, 84.85 from nasal discharge, and 83% from nasal obstruction. The difference between Guduchi and the placebo group was highly significant. After treatment with Guduchi extract, neutrophil and eosinophil count decreased and goblet cells were absent in nasal smear. Placebo drug was decreased in eosinophil and neutrophil count was marginal and goblet cells were present. As per this study, Guduchi significantly decreased all symptoms of allergic rhinitis [71].

**Anti-angiogenic Activity:** Layon *et al.,* (2004), studied the anti-angiogenic activity of Guduchi in both *in-vivo* and in-vitro models. *An in-vitro* study done using B16F10 melanoma cell-induced capillary formation in animals. Intraperitoneal administration of the Guduchi extract at a 20 mg/kg concentration significantly inhibited the tumor-directed capillary formation induced by melanoma cells. The serum cytokine profile analysis showed a drastic increase of proinflammatory cytokines such as IL-6, IL-1b, TNF-a, granulocyte monocyte-colony stimulating factor (GM-CSF) and the direct endothelial cell proliferating agent vascular endothelial cell growth factor (VEGF) in the angiogenesis-induced control animals. The administration of Guduchi could differentially regulate these cytokine's elevation. The differential regulation is further evidenced by the increased production of antiangiogenic agents IL-2 and tissue inhibitor of metalloprotease-1 (TIMP-1) in the B16F10-injected, Guduchi extract-treated animals. Moreover, using an *in-vitro* rat aortic ring assay, it is observed that the extract at nontoxic concentrations inhibited the production of proangiogenic factors from B16F10 melanoma cells. Direct treatment of the extract also inhibits the microvessel outgrowth from the aortic ring. Hence, the observed antiangiogenic activity of the plant Guduchi is related, at least in part, to the regulation of the levels of these cytokines and growth factors in the blood of the angiogenesis-induced animal [72].

**Anti-osteoporotic Activity:** Kapur *et al.,* (2008) evaluated the Anti osteoporotic potential of ethanolic extract of stem of Guduchi in an ovariectomized rat model of osteoporosis. Rat treated with the alcoholic extract of concentration (10 mg/kg b.w.) showed an osteoprotective effect. It has been found that it significantly reduces and cross laps serum osteocalcin levels and it caused a significant rise in alkaline phosphatase activity in the Guduchi treated groups [73].

Abiramasundari *et al.,* (2012), investigated that the alcoholic extract of Guduchi on the proliferation, differentiation and mineralization of bone-like matrix on osteoblast model systems *in-vitro* and the result showed that the alcoholic extract of Guduchi at a dosage 25 µg/ ml stimulated the growth of osteoblasts, increased the differentiation of cells, increase the cell numbers into the osteoblastic lineage and increased the osteoblast model systems. Their finding suggests that Guduchi extract has a potential influence on osteogenesis, and hence its use could be explored as a potential anti-osteoporotic agent [74].

**Hepatoprotective Activity:** Adhvaryu *et al.* (2007), reports that the crude extract of Guduchi showed a protective effect on drug-induced liver injury and immunosuppression by Anti-tubercular drugs like rifampicin, isoniazid, and pyrazinamide. The aerial root extract of Guduchi has a protective action against liver injury induced by these anti-tubercular drugs, and it prevents immunosuppression. Consumption of hepato-protective drug-like Guduchi with these anti-tubercular drugs could minimize liver toxicity [75].

Sharma *et al.,* (2010), investigated hepatoprotective activity in rats by the *in-vitro* method. The whole plant extract showed protection against $CCl_4$ because it causes hepato-cellular changes after forming proteins or by forming bioaction of $CCl_4$ and accelerated toxification. It helps in increasing the level of alanine aminotransferase (ALT), aspartate aminotransferase (AST), an acid phosphatase (ACP) alkaline phosphatase (ALP), and reducing the level of enzymes catalase and superoxide dismutase (SOD) in lead-induced liver injury in rats, therefore, Guduchi is considering as hepatoprotective agent [76].

**Cardioprotective Activity:** Mary *et al.,* (2003), reported cardioprotective activity *in-vivo*; the ethanolic extract of Guduchi at various dose levels showed dose-dependent reduction in infarct size and in lipid peroxide levels of serum and heart tissue. The cardioprotective activity of the herbal formulation "Caps HT2", which contains methanol extract of Guduchi, has anticoagulant, platelet antiaggregatory, anti-inflammatory, lipoprotein lipase releasing, antioxidant and hypolipidaemic activity in rats [77].

**Radioprotective:** Subramanium *et al.,* (2003), shown *in-vitro* radioprotective activity of Guduchi aqueous stem extract. The endogenous antioxidant enzymes like superoxide dismutase (SOD) and catalase act as an endogenous defense mechanism against the reactive oxygen species (ROS)-mediated biological damages. Polysaccharide compound such as arabinogalactan preventing radiation-induced damages to biomacromolecules and organism has been studied [78].

**Antituberculosis:** Vedavathy *et al.,* (1991), reported that the ether extract of the stem distillate of the aerial part of Guduchi had inhibited the *in-vitro* growth of Mycobacterium tuberculosis at 1:50,000 dilutions. Its ethanolic extract has exhibited significant antipyretic activity in experimental rats. 'Septilin' syrup, a compound preparation containing Guduchi (7.82% in 5 ml of syrup) has been found to elicit a good clinical response in children suffering from upper respiratory tract infection and chronic otitis media [79].

**Wound Healing:** Shanbhag *et al.,* (2005), evaluated the *in-vitro* wound healing activity of Guduchi. The alcoholic extract of Guduchi effect on dexamethasone suppressed healing. Excision, Incision, and dead space of the wound models were employed to investigate the wound healing potential of the plant; increased tensile strength extract of Guduchi may be attributed to the promotion of collagen synthesis. This extract did not reverse dexamethasone suppressed wound healing 80.

**Mental Disorder:** Kulkarni *et al.,* (1993), state that the Guduchi was one of the best psychotropic drugs and juice of Guduchi (whole plant or leaves) was used in various medicines to treat mental disorders. A herbal psychotropic preparation BR-16A containing Guduchi was investigated in short-term memory paradigms in mice, and it resulted in cholinergic and GABAergic modulation involved by BR-16A nootropic action [81].

**Anti Toxic Effect:** Gupta *et al.,* (2011), reported the Guduchi extracts to scavenge free radicals' generation during Aflatoxicosis. It showed a protective effect of Guduchi on thiobarbituric acid reactive substances (TBARS) level and increased

the level of GSH, ascorbic acid, protein, and the activities of anti-oxidant enzymes such as catalase (CAT), Dismutase (SOD), GPs enzyme, glutathione reductase (GR) and Glutathione S-transferase (GST) in the kidney. Phytochemicals in Guduchi, such as tinosporin, palmatine, choline, isocolumbin, etc., show protection against nephrotoxicity induced by aflatoxins [82].

**Anti-malaria (HMS) Activity:** Singh *et al.,* (2005), described that hyper-reactive malarious splenomegaly (HMS) is thought to be the result of immunological dysfunction due to recurrent episodes of malaria. HMS is treated by chloroquine (CQ)/pyrimethamine prophylaxis/ proguanil by *in-vivo* and *in-vitro* models. The aqueous extract of Guduchi and chloroquine in treating three cases of hyper-reactive malarious splenomegaly (HMS) was studied.

The plant extract (500 mg/kg b.w.) added to chloroquine (CQ) base (300 mg/kg b.w.) was administered weekly, and the results showed regression of spleen by 37-50% after six weeks and 45- 69% after six months. Likewise Decrease in IgM and an increase in Hb were observed. Their finding required a large-scale trial to confirm the beneficial effect of Guduchi extract in combination with chloroquine [83].

**Toxicity and Side Effects:** As per ayurvedic literature reports, Guduchi can because constipation if taken regularly in high doses, it has no toxicity and side effect. When stem extract of the plant was administered to rabbits up to the highest oral doses of 1.6 g/kg b.w. and in rats, at doses of 1,000 mg/kg b.w. of whole plant extract, there is no adverse reaction was noted.

The $LD_{50}$ value is greater than 1g/kg b.w. for oral administration. Acute toxicity study with the dose of 3 g/kg b.w. demonstrated that it does not have any side effects and not reported any death of the treated rats. Aqueous extract dosing 400 mg/kg for Long term (60 days) shows no effect on RBC, WBC, HCT, HB, MCH, MCV values [84].

**Interactions with Other Drugs:**

**The antidiabetic drug Interacts with Guduchi:** Guduchi acts as an antidiabetic it might decrease the blood sugar. Taking Guduchi with antidiabetic medications might cause blood sugar too low.

**Immunosuppressants Interact with Guduchi:** Guduchi causes the immune system more active and could increase the symptoms of autoimmune disease. Taking Guduchi with some medications decreases the immune system and decreases the effectiveness of the medicine.

**CONCLUSION:** It is quite evident from this review that Guduchi is a significant herbal shrub that plays a valuable role in health care management. Its parts or whole plant is used to treat various disorders in human beings, such as cold, fever, mouth ulcer, digestive disorders, etc. It contains different bioactive compounds, including alkaloids, glycosides, and steroids, sesquiterpenoids, aliphatic compounds, etc. have been discussed. Present revive mentioned the pharmacognosy, analytical works, and various pharmacological activities such as anti-oxidant, anti-inflammatory, antidiabetic, anti-toxic, anti-HIV, antimicrobial, anti-allergic rhinitis, anti-tubercular, anti-angiogenic, and many more. Now people are beginning to recognize the value of this amazing plant in this pandemic crisis as they begin to use Guduchi in various forms. In this area, more research is needed to see how effective Guduchi is at preventing and treating diseases like COVID-19.

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