REVIEW ARTICLE

Phytochemistry, pharmacology, and botanical aspects of *Stachytarpheta* species – A review

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Abstract

Introduction: Globally, the use of traditional medicines is being encouraged for the treatment of chronic disorders, as synthetic drugs may cause untoward effects. The genus *Stachytarpheta* Vahl (Verbenaceae), known as "porter weed" [English], "gervao," includes many species widely distributed in tropical and subtropical America and Africa with few members in tropical Asia and Oceania. It is valued traditionally for its different species that possess anticancer, anti-inflammatory, antidiabetic, antimicrobial, and antipyretic activities. Interestingly, current research on genus has revealed the presence of phenylethanoid with various pharmacological properties and multispectrum therapeutic applications. A relatively large number of studies cited here have adduced the possible areas where the important species of this genus can exhibit their therapeutic activities in the treatment of chronic ailments or diseases including ulcers, fever, renal disorders, and atherosclerosis. **Materials and Methods:** An extensive search in three electronic databases (Unbound Medline, PubMed, and Science Direct) and internet search engines (SciFinder and Google Scholar) was used to connote the studies on genus *Stachytarpheta.* **Results and Discussion:** This review amplifies the recent studies on phytochemical and pharmacological aspects, which alludes, these species have excogitated with noteworthy therapeutic activities. **Conclusion:** The present piece of write up will also draw the attention of scientists toward the issues and challenges associated with the probable approaches that may be reconnoitred to encourage people take the maximum benefit of these potentially useful species.

Key words: Pharmacology, Phenylethanoid glycoside, Phytochemistry, *Stachytarpheta,* Verbenaceae

INTRODUCTION

The genus *Stachytarpheta* (Family – Verbenaceae) known as "gervao" or "orgevao" includes more than 100 species distributed in tropical and subtropical parts of America, Brazil, Asia, and Australia.[1-3] The genus name originated from the Greek stachy, meaning "spike" and tarpheta, meaning "thick." Members of the genus are herbs, shrubs, and sometimes trees with leaves generally opposite or whorled, simple or palmately compound or exstipulated.[2,4,5] It is typified by small, intense blue, and pink-purple flowers brought together in dense showy inflorescences.[1] The whole plant and leaves of most species of *Stachytarpheta*, especially *Stachytarpheta jamaicensis*, *Stachytarpheta cayennensis*, *Stachytarpheta indica*, *Stachytarpheta urticifolia,* and *Stachytarpheta mutabilis* among others, have long been used in traditional medicine for the treatment of as purulent ulcers, skin lesions, and internally for inflammations, asthma, fever, renal disorders, atherosclerosis, and venereal infectious diseases.[5-7] A search through the phytochemical literature revealed presence of the phenylethanoids, iridoids, and flavonoids that possess antiulcer, anticancer, hepatoprotective, anti-inflammatory, antipyretic, antidiabetic, analgesic, antimicrobial, antioxidant, antispasmodic, and anthelmintic activities the.[1,3,8,10-15] The present effort is to systematize encyclopedic review on the species of the genus *Stachytarpheta* Vahl with focus on their distribution, identification, traditional uses, and chemical and biological studies. It also focuses on need of future research on plants of this genus for their development as potential herbal drugs.

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MATERIALS AND METHODS

A literature search was conducted using the keywords "*Stachytarpheta,*" "phenylethanoid glycoside," "Verbenaceae," "phytochemicals," and "biological activities" on electronic databases (Web of Science, PubMed, Scopus, Science Direct, Springer Link, and ACS Publications) in addition to free search in Google Scholar, to compile published research works till April 2021. The list of references of all the relevant articles was also studied and reviewed related to the subject. Inclusion criteria were papers reporting the botanical description, ethnobotanical aspects, isolated compounds, and biological activities related to the *Stachytarpheta* genus.

RESULTS AND DISCUSSION

Distribution and Habitat

Stachytarpheta Vahl is a monophyletic genus with 130 species distributed in the Americas, Africa, Asia, and Oceania, with abundant species in Brazil (81 spp.). They can be discriminated by the presence of androecium with two fertile stamens and two staminodes.[16]

Species of *Stachytarpheta* usually have four or five calyx lobes, but in *S. indica*, two of these lobes are enormously reduced giving 2-lobed appearance. Whereas other vegetative characters, along with the width of the rachis can be used to recognize introduced species of *Stachytarpheta* in Australia, *S. indica* can be discerned from these by means of its apparently bifid calyx and narrower, more lanceolate leaves. Moreover, *S. indica* can be substantiated by the presence of aborted guard cells from *S. cayennensis* which has contiguous stomata on the adaxial surface of the leaves.

As claimed by some botanists, there are five species of *Stachytarpheta* currently existing in India, but none of them is comparable to *S. indica*. The Flora of Java treatment differentiates *S. indica* and *S. jamaicensis* from *S. cayennensis* by presence of four teeth in the former two species in contrast to five teeth in the latter. If *S. indica* truly possess a clearly bifid calyx, then probably those authors have misinterpreted the name, in this case to *S. jamaicensis*.

The existence of several hybrids generates problems in the correct identification of the above species. Some phytologists suggested reduction of *S. urticifolia* to the synonymy of *S. cayennensis*, even though it is documented as a different species by others. It culminates in controversy regarding the authentication of various species, signifying the need of taxonomic revision of the genus.[17]

This genus has glabrous to densely hairy annual or perennial herbs or shrubs with quadrangular, or subquadrangular stem; sessile or petiolate, linear, elliptic, ovate leaves, and terminal spikes.[18]

Taxonomy and Major *Stachytarpheta* Species

Stachytarpheta is an erect and branched half-woody plant, with slightly angled stem. Occasionally, the stem is hairy on opposite faces, while the other two faces are glabrous or hairy at the leaf nodes. Hairs can be simple, or uniseriate, and occasionally gland-tipped, and can be erect and pointing in all directions.[18] The leaves are elliptic to oblong-ovate, serrate and 2–10 cm long with decurrent base. The spikes are terminal, rather slender, 10–30 cm long and 3–4 mm thick. The calyx is small, oblique with four teeth on margin. The corolla is deep blue or blue-purple and 1 cm long. The fruit is enclosed in the calyx and oppressed to and somewhat sunk in the smooth and oblong rachis.[5] Different species of *Stachytarpheta* possess distinct pharmacognostical features depending on the geographical indication, as depicted in Table 1 and Figure 1.

S. jamaicensis (L.) Vahl: [Figure 1A]

Synonym: Abena jamaicensis, Stachytarpheta bogoriensis Zoll. and Moritzi, and Verbena jamaicensis

It is commonly known as blue porter weed, blue snake weed, bastard vervain, Brazilian tea, Jamaica vervain, and light blue snakeweed (English) and kariyartharani (Hindi). The plant has been widely used by the people throughout the world for the various medicinal purposes. It grows 0.6–1.2 m tall and has a smooth, dark green colored stem, which turns woody toward the base of the stem. This plant normally reproduces 5–7 mm long flowers in a mixture of

Table 1: Morphological comparison between different species of *Stachytarpheta*

Species	Plant height (m)	Leaf shape	Flower
Stachytarpheta jamaicensis	0.6–1.2	Ovate to elliptic, oblong	5–7 mm long mix of bluish and pinkish-purple to deep blue
Stachytarpheta cayennensis	1.5	Ovate to elliptic	4–5 mm dark blue/purple or violet-white center
Stachytarpheta indica	0.6–0.9	Lanceolate to oblong lanceolate or elliptic ovate	13 mm wide, deep blue with white center
Stachytarpheta mutabilis	0.1–0.2	Elliptic-oblong, lance shaped	13–18 mm long with bright rose-red-pink
Stachytarpheta urticifolia	0.5–1.5	Ovate to elliptic ovate	Purple-blue, or royal blue with a white throat

bluish and pinkish color or could bear flowers with a purple to deep blue color. Its leaves are grayish-green in color with smooth surface, ovate to elliptic shape, round apex, and distinct petioles.[19-22]

S. cayennensis (Rich.) Vahl: [Figure 1B]

Synonym: S. guatemalensis Moldenke

It is locally known as blue rat's tail or rough-leaved false vervian in English. It is an erect, shrubby perennial plant up to 1.5 m high. The stem is slender, branched, quadrangular, pubescent, and woody at the base. The leaves are opposite or sometimes alternate having short, winged stalks. Flowers are dark blue, purple, or violet with white centers, sessile with two large and three small petals.[9,14,23]

S. indica Vahl: [Figure 1C]

Synonym: Valerianoides indica (L.) and Verbena indica L.

It is popularly known as Indian snakeweed (English) and kariyartharani (Hindi). It is a well-branched annual herb about 0.6–0.9 m in height showing presence of long narrow spikes. Leaves are elliptic, obtuse or acute, coarsely serrate, glabrous with tapering and decurrent base. The flowers are deep blue with white center, 5 lobed and 1.3 cm wide.[18,24-28]

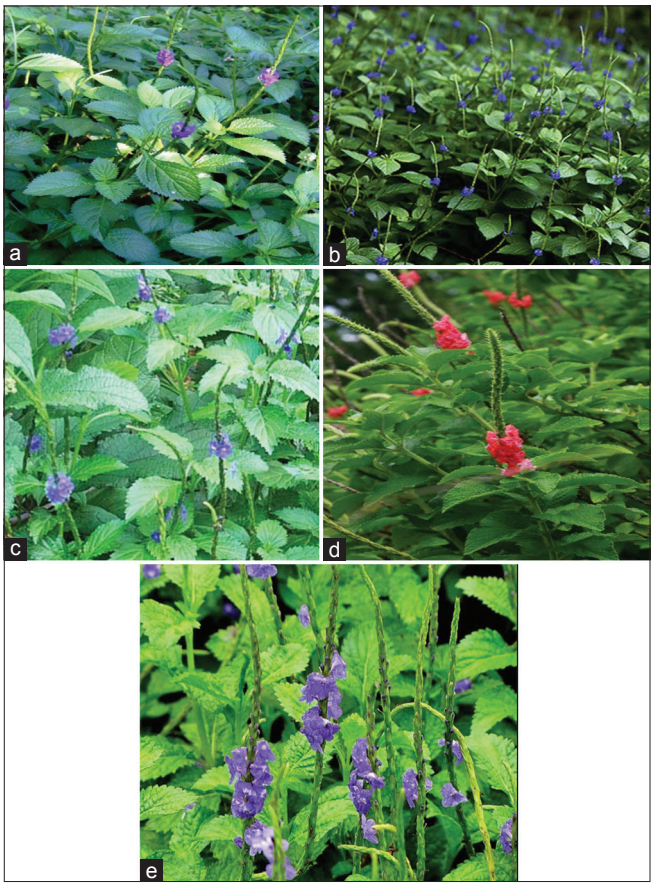

Figure 1: Different species of Stachytarpheta. (a) *Stachytarpheta jamaicensis*, (b) *Stachytarpheta cayennensis*, (c) *Stachytarpheta indica*, (d) *Stachytarpheta mutabilis*, (e) *Stachytarpheta urticifolia*

Stachytarpheta mutabilis (Jacq.) Vahl: [Figure 1D]

Synonym: Cymburus mutabilis (Jacq.) Salisb, *Verbena mutabilis Jacq., and Valerianoides mutabilis* (Jacq.) Kuntze

It is a species of flowering plant in the Verbena family usually identified as changeable velvet berry, coral port weed, pink snakeweed, red snakeweed, and pink at red tail. It is cultivated as an ornamental plant. This species is a perennial herb or subshrub generally woody at base, up to 1.8 m high with branches covered with hairs. Leaves are 5–6 cm long, 4 cm wide, elliptic-oblong and lance-shaped, scabrous. Corolla is rose, slender, with pale pink stripes, bright rose-red-pink, whitish inside at mouth and bottom. The spike inflorescence is up to 60 cm long.[29-32]

S. urticifolia Vahl: [Figure 1E]

Synonym: Cymburus urticifolia (Salisb) and Zappania urticifolia (Salisb)

It is frequently named as blue snakeweed and nettle leaf velvet berry**.** It is a perennial herb growing wild in the Sylhet and Chittagong districts of Bangladesh and also cultivated as an ornamental weed. It is 0.5–1.5 m tall with ovate to elliptic ovate, or oblong, serrate leaves and 4 angled softly pubescent stems. Calyx lobes are shortly 5 toothed and corolla dark purple-blue, mauve or royal blue with a light or white throat.[33-36]

Traditional Uses

Stachytarpheta has been traditionally used as antibacterial, antispasmodic, antidiabetic, analgesic, anti-inflammatory, antipyretic, antifungal, anticancer, hepatoprotective, anxiolytic, hemolytic, laxative, larvicidal, anthelmintic, etc. Various parts of the plants of *Stachytarpheta* are used in Indian traditional medicine for the treatment of aforementioned conditions as well as for inhibition of gastric secretion and immunopathological diseases related to oxidative stress.

S. jamaicensis is utilized as medicine in Southeastern Asia and West Tropical Africa, it is considered to be aperient, as an important medicinal plant with great medicinal properties in the elderly as a cure for allergies and respiratory conditions, cough, cold, fever, constipation, digestive complications, and others. In Nigeria, the leaves are used for birth control, abortion, treatment of menstrual disorders, and as a galactagog. Whole plant of *S. jamaicensis* has been known to demonstrate antioxidant, hypoglycemic, antacid, analgesic, anti-inflammatory, hypotensive, anthelminthic, diuretic, laxative, purgative, sedative, spasmogenic, vasodilator

properties, and its infusion which have been used as a remedy for a headache it is used to treat sores in children's ears, heart trouble, and as anti-asthmatic, sedative, and anti-hypertensive.[7,8,19,37,38]

S. cayennensis is employed in traditional medicine for the management of mental illness and as an anti-inflammatory, analgesic, antipyretic, hepatoprotective, laxative agent, and in the treatment of gastric disorders. Ethnomedicinally in Nigeria and other parts of the world, the leaves are used for the management of insomnia and anxiety. Crushed leaves and roots have also been applied in the treatment of skin lesions and are used as folk medicine in Brazil and other countries to treat inflammation, varicose ulcers, fever, hepatic and renal disorders, hypertension, and diabetes.[6,37]

S. indica is being extensively used in the Indian traditional system of medicine for diabetes and liver liver complaints, and has been used as a folk medicine for the cure of allergies, respiratory conditions, cough, cold, fever, constipation, digestive complications, and dysentery and also reported to promote menstruation. Stem bark is valued in traditional medicine as analgesic, anti-inflammatory, and antipyretic drug.[38]

S. mutabilis leaves are used for adulterating tea. They are pounded with lime and applied to swollen wounds and sours. Plant is useful for the treatment of tumors also besides an ornamental, mainly in Amravati, India.[30]

S. urticifolia folklorically used as cure for fever, rheumatic inflammations, venereal diseases, dropsy, ulcer, and other stomach troubles. Infusion of the bark is advocated in the treatment of diarrhea and dysentery. It is used as an abortifacient agent by the tribal people of Bangladesh.[10]

Phytochemistry

Preliminary phytochemical screening of the genus *Stachytarpheta* revealed the presence of alkaloids, flavonoids, tannins, saponins, glycosides, steroids, and phenols [Table 2 and Figure 2].

S. jamaicensis

The active phytoconstituents from the leaves of *S. jamaicensis* are reported to have aforesaid major groups of secondary metabolites. Iridoid ipolamiide, phenylethanoid glycoside, and verbascoside are found to present in aqueous extract of leaves. The flavonoid, scutellarin has been isolated, with cardioprotective, anti-inflammatory, and antiviral actions and hispidulin to be bronchodilator, antispasmodic and anti-asthmatic. Study of leaves showed a new lanostane triterpenoid 16*β*-(*β*-D-glycopyramosyl-3-8, dihydroxylanstan-5, 22-diene-11- methroxy-1*β*-yl-6-0-(2,3-dimethoxybenzoyl)-*β*-d-glycopyranoside. Some secondary metabolites that have been found include lanostane phenylacetate (1,3,16*β*-yl-phenypropylacetate-lanostan-5,11,14,16,23,25-hexen-22-one), two steroidal glucosides 16 *β*-(glucopyranosyl *β*-D, 3,8,22-trihydroxy) cholestan-1 *β*-yl-6-O-(3,4,5-trimethoxy benzoyl) *β*-D and 16-*β* (*β*-D-glucopyranosyl

Table 2: Phytochemistry of genus *Stachytarpheta*

Component	Sub-type	References
Phenyl propanoid glycoside	Acetoside	[9,14,41,46]
	Iso-acetoside	[9,41,46]
	Leucosceptoside A	[9]
	Martynoside	[9,46]
	Jinoside D	[9]
Steroidal glycosides	Spinasterol	[10,11]
	α-spinasterol	[8,10,11]
	16*β*-(*β*-D-glucopyranosyl-3,8,22–trihydroxy)-cholestan–1*β*-yl–6–O-(3,4,5–trimethoxy benzoyl) *β*-D-glucopyranoside	[8,36,40,41]
	16-*β*(*β*-D–glucopyranosyl 2) 3,8,22–tri-hydroxy cholest 5, 14, 16,23 tetraiene-1 *β*-yl–6–O-(3, 4, 5–trimethoxybenzoyl) *β*-D, glucopyranoside	[8,36,40,41]
Flavonoids	Scutellarin	[36,41]
	Hispidulin	[36,41,42]
Phenylethanoid glycosides	Verbascoside	[41,46]
	Isoverbascoside	[43,46]
Iridoid glycosides	Ipolamiide	[3,10,14,44]
	Ipolamiide	[14,44]
	6*β*-hydroxy ipolamide	[40]
	Betulinic acid	[46]
	Tarphetalin	[8]
Terpene glycoside	Lanostane terpenoids	[36,40,41,42]
	Lanostane phenylacetate	[36,40,41,42]
	Ursolic acid	[41]
Phenolic acid	Chlorogenic acid	[8]
	Catechin tannins	[8]
	6-Hydroxy luteolin 7-glucuronide	[8]
	Luteolin 7-glucuronide	[8]
	Apigenin	[41]
Alkaloids	N-nenoside B	[23]

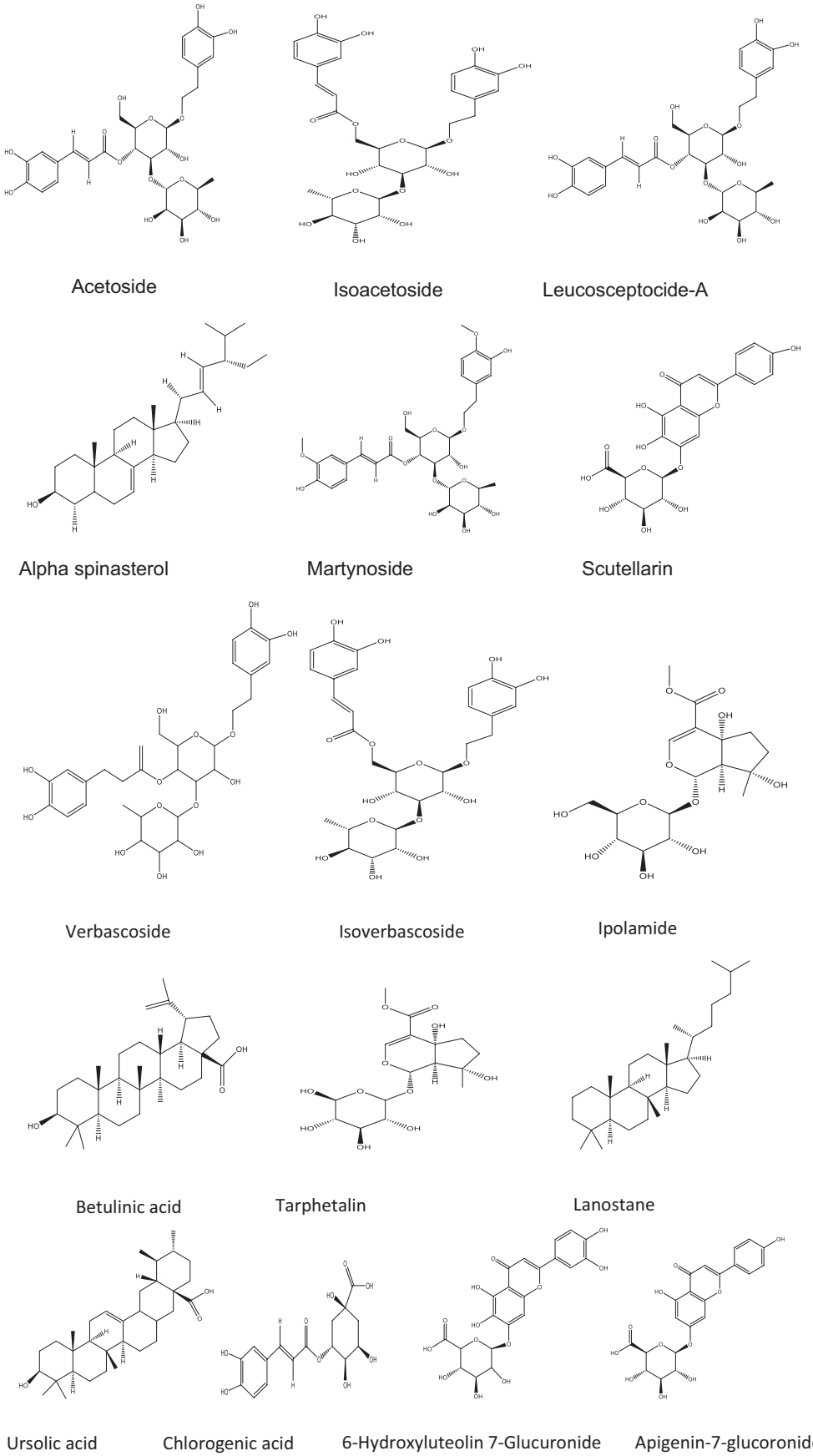

Figure 2: Chemical structures of some important constituents of *Stachytarpheta*

3,8,22-trihydroxy-cholest-5,14,16,23tetraiene, 1β-yl,6-O-(3,4,5-trimethoxybenzonyl) *β*-D-glucopyranoside.[8,36,39-42]

S. cayennensis

The Nnenoside-B isolated from the leaves of *S. cayennensis* showed absorption peaks characteristic bands at V_{max} 2980 cm^{-1} and 2750 cm^{-1}. It is also considered to be most rich in iridoids glycosides, mainly ipolamiide, lamiide; phenylethanoid glycosides such as, jinoside-D, martinoside (martynoside), acetoside, iso-acetoside, leucosceptoside-A. Arylpropanoid glycosides found are verbascoside and isoverbascoside.[9,23,37,43]

S. indica

The active constituents include sterols, *β*-sitosterol, lupeol, and stigmasterol together with triterpenic acid, ursolic acid, and flavone apigenin, iridoids ipolamide, phenylethanoid glycosides, and verbascoside in entire plant of *S. indica*. Sulfurous acid, 2-ethylhexyl hexyl ester, N-t-butylpyrrole, pantanoic acid, 5-decyne 11,14,17-eicosatrienoic acid, methyl ester, phytol 2-methylheptanoic acid, norpipanone, 1,5,9-undecatriene, 2,6,10-trimethyl-, vitamin E, 1,3-benzenediol, o-(2-methoxybenzoyl)-o'-ethoxycarbonyl- 4-methyl-2,4-bis (4'-trimethylsilyloxyphenyl) pentene-1, phthalic acid, and di (2,3-dimethylphenyl) ester are found to be present in the leaves.[1,38,44]

S. mutabilis

S. mutabilis showed the presence of iridoid glycoside, 6 *β*-hydroxy ipolamide, lamiide, and saponin. Essential oil of *S. mutabilis* analyzed by GC/MS demonstrated major components 1-octen-3-ol, (Z)-3-hexen-1-ol, (Z)-4-hexen-1-ol, linolenic acid, palmitic acid, octan-3-ol, and rosifoliol.[29]

S. urticifolia

Phytochemical analysis of *S. urticifolia* revealed the presence of saponins, flavonoids, terpenoids, steroids, glycosides, quinines, alkaloids, tannins, and phenols in various extracts of root, stem, leaf, and inflorescence. The methanolic extract of the leaves is found to contain iridoid glycoside, ipolamiide whereas the n-hexane extract of the root yielded the sterol, *α*-spinasterol.[11,45]

Pharmacological Activities

A variety of species of *Stachytarpheta* is prescribed since a longer time for their medicinal use in treatment of ulcers, skin lesions, allergies, cough, cold, insomnia, anxiety, internally for inflammations, fever, renal disorders, atherosclerosis, also as antimicrobial, antispasmodic, antidiabetic, analgesic, anticancer, and hepatoprotective and many of these claims have been proved through scientific studies [Table 3].

Antibacterial and Antimicrobial Activity

In a study, targeting antimicrobial activity mixture of verbascoside, martynoside, and iso-verbascoside of the ethyl acetate fraction is shown to exhibit greater antibacterial inhibition when compared to other fractions of *S. cayennensis*. The aqueous extract of *S. indica* root and methanolic extract of *S. urticifolia* leaf showed significant activity against various species of bacteria which is comparable with standard antibiotic streptomycin and ampicillin, respectively. Several studies have demonstrated the antimicrobial potential of *S. jamaicensis* extracts toward pathogenic microorganisms, including bacteria and fungi.[8,10,46-48]

Antioxidant Activity

The methanol and ethyl acetate extract of *S. jamaicensis* leaf showed 59.53 and 60.20% percentage free radical scavenging activity at 100 µg/mL. The IC_{50} for the methanol extract (16.95 µg/mL) was lower than the ethyl acetate extract (33.12 µg/mL). The 75% methanolic extract of *S. indica* leaf was found to have the highest antioxidant activity in both fresh and dry samples compared to the aqueous and 50% methanolic extract. Verbascoside and betulinic acid isolated from *S. cayennensis* increased the tolerance and decreased the lipid peroxidation of *S. cerevisiae* to reactive oxygen species. Moreover, the methanolic leaf and inflorescence extracts of *S. urticifolia* also showed significant antioxidant activity.[8,42,47,49-51]

Hypoglycemic Activity

The ethanolic extract of *S. jamaicensis* leaf as well as *S. indica* plant when used continuously for a period of 15 days, they produced a significant reduction in the blood glucose level in streptozotocin-induced diabetic rats. The effect of the extract at 600 was almost equal to that of the standard metformin (500 mg/kg) used for the control of diabetes.[49,52]

Antihypertensive Activity

The aqueous leaf extract of *S. jamaicensis* demonstrated a significant dose-dependent antihypertensive effect. The extract reduced blood pressure and heart rates of anesthetized rabbits, gradually in increasing doses, and the maximum effect was observed at 80 mg/kg dose.[53]

Sedative and Anxiolytic Activity

The methanolic leaf extract of *S. cayennensis*, its butanol and aqueous fractions, inhibited rearing and spontaneous locomotion and prolonged pentobarbitone-induced sleep time in mice. The

anxiolytic effect was observed in both the aqueous and n butanol fraction at dose 20 and 5 mg/kg, by elevated plus maze test.[6]

Anti-inflammatory and antinociceptive activity

The ethanolic leaf extract of *S. jamaicensis* exhibited antinociceptive activity against chemically and thermally induced nociception and against both inflammation and non-inflammation-mediated nociception through suppression of both peripheral and central levels. It also showed anti-inflammatory activity through inhibition of arachidonate COX. The alcoholic and *n*-butanolic extracts of dried leaves of *S. cayennensis* significantly inhibited carrageenan induced edema formation at doses ranging from 100 to 200 mg/kg. The iridoid ipolamiide and the phenylethanoid glycoside acetoside isolated from the active fraction, demonstrated inhibitory effect on histamine and bradykinin-induced contractions of guinea-pig ileum. These compounds also found to have *in vivo* anti-inflammatory activity when administered orally to rats mainly in the 4th h after the administration of the phlogistic agent (70.22% and 93.99%, respectively). The extracts also exhibited antinociceptive activity measured by the hot plate test in doses ranging from 100 to 300 mg/kg. An infusion of the methanol leaf extract of *S. indica* showed significant anti-inflammatory activity in a dose-dependent manner comparable to that of standard indomethacin.[8,24,54]

Hepatoprotective Activity

The alcoholic extract of *S. indica* whole plant significantly improved the biochemical profiles in various liver functions tests at the dose 600 mg/kg in rats. The protective action was further confirmed by histopathological study and found to be equal to that of silymarin (100 mg/kg).[55]

Wound healing Activity

The ethanolic leaf extract of *S. jamaicensis* exhibited significant wound healing in albino rats when applied externally. It showed better wound contraction and promoted faster wound closure.[56,57]

Immunomodulatory Activity

Methanolic extract of *S. cayennensis* exhibited 64.21% inhibition of determination of delayed type hypersensitivity response at 500 mg/kg and evoked 139.64% of phagocytic stimulation at 100 µg/ml dose. It also showed dose-related stimulation of humoral immunity and leucocyte mobilization of 10.15% at 250 mg/kg dose.[58]

Antimalarial Activity

The methanolic extract of *S. cayennensis* leaf (90–270 mg/kg/day) showed significant ($P < 0.05$) blood schizonticidal activity against chloroquine sensitive *Plasmodium berghei berghei* in mice with a considerable mean survival time comparable to that of the standard drug, chloroquine, 5 mg/kg/day. The extract also showed anti-plasmodium activity against chloroquine sensitive strain poW and multiresistant clone Dd2 of *Plasmodium falciparum*.[58,59]

Gastric Acid Secretion and Antiulcer Activity

The aqueous extract of *S. cayennensis* the whole at dose 2 g/kg increased the intestinal motility and protected mice against ulcers induced by ethanol, indomethacin and stress (cold restrained). It also inhibited the basal acid secretion as well as that induced by histamine and bethanechol in pylorus-ligated mice when injected into the duodenal lumen. The purified active fraction (benzene fraction of the butanolic phase of water extract and its ethanol fraction) reduced gastric acid secretion 5–10 times higher compared to the original extract.[3,60]

Cytotoxic Activity

The dichloromethane extract of *S. jamaicensis* aerial parts exhibited a potent cytotoxicity against human oral squamous cell carcinoma cell lines CLS-354/WT and CLS-354/DX. In another study, the dichloro from same plant was found to have cytotoxic activities in HeLa and T47D cell line with IC_{50} values of 84,198 µg/ml and 64,167 µg/ml respectively. Furthermore, the *n*-hexane and the methanol extract of *S. urticifolia* leaf and root bark as well as isolated compounds ipolamiide and α-spinasterol also demonstrated moderate cytotoxic activities against brine shrimp nauplii (*Artemia salina*) where vincristine sulfate was taken as a standard.[10,61,62]

Antidyslipidemia Activity

The aqueous infusion (tea) of *S. jamaicensis* significantly reduced the plasma levels of triglycerides, total cholesterol, low-density lipoprotein (LDL), and and VLDL but but increased high-density lipoprotein cholesterol levels in the treated animal models.[63]

Miscellaneous

Zinc oxide (ZnO) and Cu-doped ZnO nanoparticles synthesized from aqueous leaf extract of *S. jamaicensis* showed antibacterial activity against *Bacillus subtilis* and *Staphylococcus aureus* at the concentration 500 mg/mL. Its silver nanoparticles demonstrated highest activity against *Escherichia coli*, *S. epidermis,* and fungal strain *Candida*. pH-Sensitive biopolymeric hydrogel based on indole-3-acetic acid extracted from *S. jamaicensis* leaf showed good surface morphology and thermal stability, and is proposed for wound healing and anti-cancer applications. *S. cayennensis*-mediated copper nanoparticles showed anticancer effect in

Table 3: Pharmacological activity of different species of *Stachytarpheta*

Plant part	Component responsible	Mechanism of action	Activity	References
Leaves (*Stachytarpheta jamaicensis*)	Scutellarin	Protein-protein interaction	Cardioprotective	[64]
Leaves (*Stachytarpheta jamaicensis*)	Hispidulin	Targeting β-2 receptor	Antiasthamatic, bronchiodilator	[36,41]
Leaves (*Stachytarpheta jamaicensis*)	Verbascoside, acetoside	-	Antioxidant, neuroprotective, antibacterial	[41]
Whole plant (*Stachytarpheta indica*)	Flavonoids scutellarin	Ability to moderate some cell signaling	Antidiabetic, and hypolipidemic	[52,65]
Leaves (*Stachytarpheta urticifolia*)	Polyphenols	1,1-diphenyl-2-picrylhydrazyl radical scavenging activity	Antioxidant activity	[15]
Whole plant (*Stachytarpheta indica*)	Ipolamiide	Locally	Anti-inflammatory	[44,54]
Leaves (*Stachytarpheta indica*)	-	Agar well diffusion method	Antibacterial and antifungal activity	[1,27]
Leaves (*Stachytarpheta cayennensis*)	Ipolamiide and verbascoside	Inhibition of leukocyte accumulation, neutrophil, and mononuclear cell influx	Gastric acid secretion and antiulcer activity	[3,48,66]
Leaves (*Stachytarpheta cayennensis*)	Ipolamiide and verbascoside	-	Anti-inflammatory activity	[66]
Leaves (*Stachytarpheta indica*)	Flavonoids and tannins	-	Hypoglycemic activity	[67]
Leaves (*Stachytarpheta jamaicensis*)	Flavonoids, triterpenes, and sterols	Excision and dead space model	Wound healing activity	[56,57]
Whole plant (*Stachytarpheta jamaicensis*)	Ipolamiide, acetoside	Inhibition of histamine, and bradykinin receptor	Antihistamine, other respiratory conditions	[8,30,33]
Whole plant (*Stachytarpheta jamaicensis*)	-	-	Antimicrobial activity	[68]
Leaves (*Stachytarpheta cayennensis*)	-	Delayed-type hypersensitivity response, humoral immune responses, and in the *in vivo* leukocyte immobilization tests	Immunomodulatory effects	[58]
Leaves (*Stachytarpheta indica*)	-	CCl4-induced toxicity with standard drug Liv-52	Hepatoprotective activity	[52]
Leaves (*Stachytarpheta cayennensis*)	-	GABAergic and opioid	Sedative and anxiolytic	[6]
Whole plant (*Stachytarpheta mutabilis*)	-	-	Treatment of tumor	[30]

skin melanoma cancer. Silver nanoparticles of this species moderately inhibited the denaturation of egg albumin, suggesting their anti-inflammatory and moderate pro-regenerative action.[69-73]

CONCLUSION

The present piece of writing is a result of in-depth studies of the documented literature on the genus *Stachytarpheta*. It highlights the knowledge about botanical description that would be useful in identification, phytochemistry, and pharmacology acknowledging the traditional medicinal uses. Further, it also has been noted that the majority of the species remain unknown or scantily studied for the chemical composition and biological activities. The combined efforts of ethnobotanists, pharmacognosists, and pharmacologist could be a practical approach to evaluate and validate the usage of the species of the genus *Stachytarpheta* with the modern scientific methods and innovative techniques.

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