Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2018, 10(9): 55-63

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

A Comprehensive Review on the Ethnobotanical uses, Phytochemistry and Pharmacological Activities of *Smilax zeylanica L.* (Smilacaceae)

TR Prashith Kekuda[1], BK Sahana [1], GK Saema Noorain [1] and HL Raghavendra[2*]

[1]*Department of Microbiology, S.R.N.M.N College of Applied Sciences, Shivamogga, Karnataka, India*
[2]*Department of Biochemistry, School of Medicine, Wollega University, Nekemte, Ethiopia*

ABSTRACT

Since time immemorial plants have been used for various needs such as food, fodder, construction, dyes and medicine. Smilax zeylanica L., belonging to the monocotyledon family Smilacaceae, is a dioecious climbing shrub with woody stem. The plant is used as a substitute for Sarsaparilla. In this review, we present updated information on the ethnobotanical uses, phytochemistry and pharmacological activities shown by S. zeylanica by referring standard flora, journal articles and various search engines. Whole plant or certain parts of the plant (leaf, root, rhizome, fruit and stem) are used ethnobotanically in several countries for several purposes such as fodder, vegetable and in the treatment of diseases like skin diseases, piles, dysentery, venereal diseases, rheumatism, toothache, arthritis, and urinary complaints. The plant is reported to contain many chemicals and diosgenin, smilagenin, β-sitosterol, hydroxytyrosol, squalene and sarsapogenin are few among the important phytochemicals. A number of bioactivities such as antimicrobial, cytotoxic, analgesic, anti-inflammatory, antidepressant, antioxidant, antidiabetic and anticonvulsant activities have been shown by the plant. Overall, it can be concluded that S. zeylanica is a plant which is extensively utilized ethnobotanically for various therapeutic applications and is shown to exhibit a range of bioactivities, the results of which justifies the ethnobotanical uses of the plant. Further, S. zeylanica can be screened for developing bioactive phytochemicals which can be used as lifesaving drugs.

Keywords: Smilax zeylanica; Smilacaceae; Ethnobotany; Phytochemicals; Pharmacology

---

INTRODUCTION

Plants are critical to other life on earth as plants form the basis of food chains and food webs. Ethnobotany is the study of relationship between plants and humans. Since ancient time, plants have been exploited for various purposes such as food, fuel, healthcare (medicine), fodder, construction and transportation. Besides, plants are also used for beautification of body and for preparation of dyes (colors) and cosmetics. Plants are an integral part of traditional medicine. Throughout world, traditional medicinal practitioners employ plants singly or in certain formulations to treat human as well as veterinary ailments. Plant based medicines are widely used by people with low income, people living in remote areas and no access for modern medicine. Countries such as India, China, Nepal, Bangladesh, Pakistan, Bhutan and many African countries utilize plant based medicines for therapy. Plants are extensively used in various systems of medicine such as Siddha, Ayurveda, Unani, Homeopathy and traditional Chinese medicine. Several drugs for e.g., quinine, taxol, nicotine, atropine, morphine, vincristine, vinblastine, digoxin, codeine, artemisin and camptothecin are from plant origin. Drug discovery from plants plays an important role in the treatment of several dreadful diseases including cancer. It is also thought that plant based medicines are not associated with side effects [1-9].

Smilax zeylanica L.

S. zeylanica (Figure 1) is one of the important medicinal species of the genus *Smilax* (comprises of about 300-350 species) and belongs to the monocotyledon family Smilacaceae. The plant is distributed in tropical regions of India and is common in forests. The plant is known by the name Chopachinee in Sanskrit, Chobchini in

Hindi, Kaadu hambu taavare/Chennere balli in Kannada, Jangali Ushbaa in Unani and Malai-thaamara in Siddha/Tamil. The plant is used traditionally for treatment of diseases such as venereal diseases, skin diseases, abscesses, boils, psoriasis, rheumatism, swellings and dysentery. Leaves are used as vegetable. In many parts of the world the plant is used as a substitute for Sarsaparilla [10,11]. *S. zeylanica* is known to be a potential alternate source for the Ayurvedic drug Chopachinee (accepted botanical source is *S. china* L.). The plant contained chemicals such as diosgenin, smilagenin, sarsapogenin, β-sitosterol, hydroxytyrosol, trans-iso-eugenol and squalene [12-14**]**. In this review, we discuss the traditional uses, phytochemistry and various pharmacological activities of *S. zeylanica* by referring standard flora, books, articles in journals and search engines such as Google Scholar, PubMed and ScienceDirect.

Plant Description

S.zeylanica is a large, dioecious, scandent climbing shrub with woody stem which is sometimes armed with prickles and angular branches. Leaves are simple, alternate, up to 20x11 cm, variable in shape (broadly ovate or elliptic to oblong - lanceolate), acute or abruptly cuspidate at apex. The leaf base is narrow, rounded or cordate, 3-7 ribbed and reticulately veined. Petiole up to 3cm long, generally bearing a tendril on either side above the base. Flowers are greenish-white, dioecious and umbellate. Umbels 1-3 on axillary peduncle. Perianth - segments/lobes 6. Stamens 6, in male flowers, anthers introrse. Pistillode absent. Ovary superior, sessile, 3-locular, ovules 1-2 in each cell, pendulous; style short; stigmas 3, recurved; staminodes usually 3 in female flowers. Fruit is a globose berry (turning red on ripening) with 1-2 seeds, smooth, ca. 8mm across. Flowering usually occurs between November and April [15,16].

Figure 1: Smilax *zeylanica* L.

***S. zeylanica* as Food for Elephants**

Studies have shown that the plant *S. zeylanica* forms a food for Asiatic elephants. The plant *S. zeylanica* is one of the plants which are fed extensively by Asiatic elephants (*Elephas maximus*) in Satkosia tiger reserve, Odisha, India [17]. In Kuldiha wildlife sanctuary of Odisha, the Asiatic elephants feed extensively on several plant species including *S. zeylanica* [18].

EXPERIMENTAL SECTION

Ethnobotanical Uses of *S. Zeylanica*

Throughout world, indigenous medicinal systems and various ethnic communities employ plants for several purposes such as food, fodder, medicine, sources of dye and construction. Countries such as India, Bangladesh and Nepal use *S. zeylanica* traditionally. Various parts viz. tuber, stem, root and leaves of *S. zeylanica*, either singly or in combination with other plants, in certain formulations (such as paste and decoction) are used worldwide to cure several human and veterinary ailments. A brief detail on the ethnobotanical uses of *S. zeylanica* is given in Table 1.

Table 1: Ethnobotanical uses of *S. zeylanica*

Geographical area	Part	Used for	References
Thiruvananthapuram, Kerala, India	Tuber	Paste made from the tuber with coconut milk is consumed to cure piles.	Vijayan et al. [19]
Rewa district, Madhya Pradesh, India	Stem	Stems are used as toothbrush (used in toothache)	Shukla et al. [20]
Srikakulam district, Andhra Pradesh, India	Root	Root together with *Asparagus racemosus* and *Aerva lanata* is extracted with water and used to cure leucorrhea	Naidu et al. [21]
Bargarh district Western, Odisha, India	Stem	Small pieces of branches are used as toothbrush to cure toothache and pyorrhea.	Sahu and Sahu [22]
Makawanpur district, Central Nepal		The plant is used as toothbrush	Luitel et al. [23]
Gondia district, Maharashtra, India	Root	Roots used in white discharge and in male sexual disorders.	Patale et al. [24]
Tiruchirappalli district, Tamil Nadu, India	Rhizome	Rhizome is used in venereal diseases	Gritto et al. [25]
Madurai district, Tamil Nadu, India	Leaf	Leaves of *Smilax zeylanica* are mixed with leaves of *Sonchus oleraceus* and applied externally on the cuts once a day till cure.	Ignanacimuthu et al. [26]
Kasargod district, Kerala, India	Stem, leaf	Stem and leaf burnt, ash applied externally on wounds	Babu and Antony [27]
Patuakhali district, Bangladesh	Stem	Dried stem is taken orally to treat nausea, abdominal pain and acidic taste in mouth.	Pervez et al. [28]
Manas national park, Assam, India	Whole plant	Whole plant is used as medicine.	Baro and Borthakur [29]
Hazaribagh district, Jharkhand, India	Fruit	Fruit pulp is mixed with lime and consumed as remedy for dysentery	Maity et al. [30]
Vedaranyam taluk, Tamil Nadu, India	Root, leaves	Used in the treatment of leucorrhea and gonorrhea	Balamurugan et al. [31]
Tripura, India	Root, leaf	Root powder along with bark powder of *Ziziphus oenoplia* and *Streblus asper* used to cure hepatitis, nephritic and blood dysentery. Root paste is boiled with goat milk given for sexual stimulant. Fresh leaves are used as fodder for cattle for high milk production.	Deb et al. [32]
Kanyakumari, Tamil Nadu, India	Rhizome	Rhizome paste with milk is used for piles; decoction made from root and rhizome is used in venereal diseases, rheumatism, arthritis and urinary complaints.	Divya et al. [33]
Kalahandi district, Orissa, India	Root	The root is used in joint pain spermatorrhea. Root paste is administered orally to cattle in case of dysentery. Root decoction is applied externally in sores, swelling and abscess in cattle.	Nayak et al. [34]
Kadapa district, Andhra Pradesh, India	Root	Root paste is applied externally for body swellings	Reddy et al. [35]
Barind tract, Bangladesh	Root	Paste made from root is administered once daily in empty stomach for four days to cure anemia	Siddique et al. [36]
Andaman and Nicobar islands, India	Root	Roots are used to treat white discharge.	Ghosh [37]

Chemical Compounds/Groups in *S. Zeylanica*

The chemical compounds present in plants are broadly known by the name phytochemicals. Plants produce a number of primary and secondary metabolites. These chemical substances are the important components in vegetables, fruits, nuts, legumes, whole grains etc. and are known to exhibit beneficial effects on consumption. Compounds such as polyphenolic compounds including flavonoids, alkaloids, and terpenes are few among the important plant secondary metabolites and many of these compounds have no direct function in the growth and development of plants. However, many of plant secondary metabolites have certain ecological functions such as protection against herbivores and insects and attracting pollinators and seed-dispersing animals. Pathways such as shikimic acid pathway, malonic acid pathway and mevalonic acid pathway are involved in the synthesis of plant metabolites. Several plant metabolites have found commercial applications such as drugs, dyes and insecticides. Plant secondary metabolites are shown to exhibit a variety of pharmacological activities including antimicrobial, anti-inflammatory and anticancer activity. Advancements in chromatographic and spectral analyses have been used in the rapid identification of phytochemicals [38-46]. Studies have identified a myriad of chemicals/phytochemical groups present in various parts of *S. zeylanica*. Phytochemicals such as alkaloids, tannins, triterpenoids, sterols, flavonoids and compounds such as diosgenin and β-sitosterol (Figure 2) have been identified in the plant by a range of methods such as standard phytochemical tests, HPTLC and GC-MS analyses. A list of phytochemicals detected in various parts of *S. zeylanica* is shown in Table 2.

Table 2: Phytochemical groups/compounds detected in *S. zeylanica*

Part	Chemicals/phytochemical group detected	References
Leaf	Glycosides, alkaloids, tannin, triterpenoids, sterols	Jena et al. [47]
Leaf	Glycosides, flavonoids and saponins	Murali et al. [48]
Leaf	Glycosides, alkaloids, tannins, flavonoids	Rajesh and Perumal [49]
Root and rhizome	Glycosides, phytosterols, tannins, saponins	Murali et al. [13]
Root	Steroids, phenols, flavonoids and saponins	Ahemad et al. [50]
Root and rhizome	Glycosides, saponins, phytosterols, tannins, diosgenin	Madhavan et al. [12]
Stem	Steroids, tannins, flavonoids and glycosides	Uddin et al. [51]
Leaf	Tannin, saponins, steroids, alkaloids and flavonoids	Hossain et al. [52]
Leaf	Glycosides, alkaloids, tannin, triterpenoids and steroids	Jena et al. [53]
Leaf	Hydroxytyrosol, trans-iso-eugenol and squalene	Rajesh and Perumal [14]

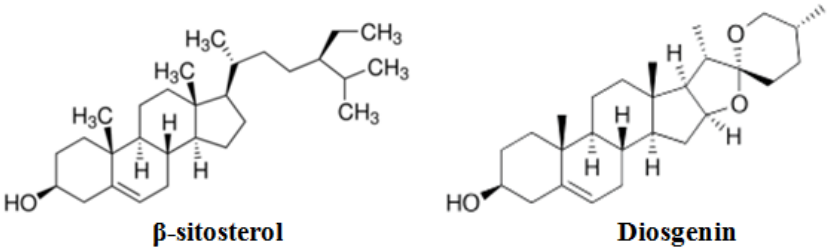

Figure 2: Structures of β-sitosterol and diosgenin

RESULT AND DISCUSSION

Pharmacological Activities of *S. Zeylanica*

A number of studies carried out on *S. zeylanica* have revealed the potential of the plant to exhibit various pharmacological activities such as antimicrobial, analgesic, anticonvulsant, anti-inflammatory, cytotoxic, antioxidant, anthelmintic and hepatoprotective activities. A brief description on various pharmacological properties of the plant is described below.

Analgesic activity: Jena et al. screened analgesic activity of solvent extracts of *S. zeylanica* leaves by tail immersion method using Swiss albino mice. Administration of extracts showed significant analgesia and the result was comparable with aspirin (standard drug). Overall, methanolic extract displayed marked analgesic effect. Nithyamala et al. [54] investigated analgesic activity of root powder of *S. zeylanica* by hot plate method and acetic acid induced writhing method in albino mice. The oral administration of root has significantly increased the reaction time in a dose dependent manner in hot plate method. The root powder also caused inhibitory effect on writhing induced by acetic acid. Hossain et al. evaluated analgesic potential of ethanolic extract of leaves of *S. zeylanica* by acetic acid-induced writhing test in Swiss albino mice. The extract administration caused a dose dependent inhibition of number of writhing in mice suggesting analgesic activity of leaf extract.

Hepatoprotective activity: The study carried out by Murali et al. revealed the hepatoprotective potential of leaf extract of *S. zeylanica* by CCl_4 induced hepatotoxicity in Wistar rats. The administration of methanolic extract of leaf significantly reduced the elevated levels of SGOT, SGPT, ALP and total bilirubin. The treatment of extracts revealed regeneration of hepatocytes and normalization of fatty changes in the hepatocytes indicating hepatoprotective activity of extract. In another study, Murali et al. [55] carried out hepatoprotective activity of roots and rhizomes of *S. zeylanica* in paracetamol induced hepatotoxicity model in Wister rats. The extract administration had a protective effect against hepatotoxicity as evidenced by the significant reduction in the elevated levels of ALT, AST, ALP, total bilirubin and an increased level of total protein and albumin with a significant reduction in liver weight, when compared with the paracetamol control.

***In vitro* antioxidant activity:** The study of Thirugnanasampandan et al. [56] revealed the free radical scavenging and antioxidant effect of ethanol, ethyl acetate and chloroform extracts of leaves and stems of *S. zeylanica*. Overall, ethanol extracts of leaf and stem displayed marked antioxidant activity. Hossain et al. screened the potential of ethanol extract of *S. zeylanica* leaves to scavenge DPPH radicals. The extract exhibited concentration dependent scavenging of DPPH radicals with an IC_{50} value of 30.93µg/ml. Daffodil and Mohan [57] investigated antioxidant potential of various solvent extracts of aerial parts of *S. zeylanica* by DPPH, ABTS, hydroxyl and superoxide radical scavenging assays and reducing power assay. Among extracts, methanol extract displayed marked scavenging of radicals as indicated by low IC_{50} values. The study carried out by Uddin et al. revealed the in vitro antioxidant nature of petroleum ether and methanol extract of stems of *S.*

zeylanica. In all assays performed, methanol extract displayed marked activity as evidenced by low IC_{50} values. A direct correlation between antioxidant activity and the phenolic and flavonoid content was observed.

***In vivo* antioxidant activity:** Ahemad et al. investigated in vivo antioxidant activity of root extract of *S. zeylanica* in male rats induced with catalepsy by haloperidol. The administration of haloperidol increased generation of TBARS and significantly reduced glutathione (GSH), superoxide dismutase (SOD) and catalase levels. Treatment with extract considerably restored these changes to almost near to normal level. Rajesh and Perumal revealed in vivo antioxidant activity of methanolic extract of leaves of *S. zeylanica* in diabetic rats. Administration of streptozotocin to rats resulted in an increase in levels of lipid peroxidation in liver and kidney tissues with concomitant decrease in activities of antioxidant enzymes viz., SOD, catalase, glutathione peroxidase, glutathione reductase, glutathione-S-transferase and non-enzymatic antioxidants GSH, vitamin C and vitamin E in liver and kidney tissues. However, rats treated with the leaf extract revealed a significant ameliorative effect. The extract treatment lowered the extent of lipid peroxidation and normalized the activities of enzymatic and non-enzymatic antioxidants in both liver and kidney tissues indicating potent in vivo antioxidant activity. In another study, Rajesh and Perumal [58] evaluated the in vivo antioxidant potential of leaf extract of *S. zeylanica* leaves in N-nitrosodiethylamine induced hepatocarcinogenesis in wistar albino male rats. Administration of extracts to rats resulted in significant decrease in lipid peroxidation and considerable increase in the enzymatic and non-enzymatic antioxidants which have been impaired drastically in animals induced with hepatocarcinoma. The study of Rajesh and Perumal [59] also revealed the potent in vivo antioxidant activity displayed by *S. zeylanica* leaf extract in terms of reducing the extent of lipid peroxidation and increasing the activities of enzymatic and non-enzymatic defense system in mice treated with benzo(a)pyrene. The study carried out by Murali et al. [60] indicated the potential of methanol extract from roots and rhizomes of *S. zeylanica* to exhibit in vivo antioxidant activity in terms of suppression of lipid peroxidation and increasing the activity of enzymatic antioxidants in albino rats administered with carbon tetrachloride.

Cytotoxic anticancer activity: The study carried out by Rajesh and Perumal highlighted the protective efficacy of methanol extract of *S. zeylanica* leaves against lung cancer in Swiss albino mice. Administration of extract to animals with lung cancer (induced by benzo(a)pyrene) resulted in effective suppression of the lung cancer as indicated by the significant decrease in number of nodules in lung and also a significant weight gain. Rajesh and Perumal investigated the potential of leaf extract of *S. zeylanica* leaves to protect against N-nitrosodiethylamine induced hepatocarcinogenesis in wistar albino male rats. Administration of N-nitrosodiethylamine resulted in body weight loss with a significant increase in relative liver weight, and an increase in levels of liver injury and liver cancer markers such as alanine transaminase, aspartate transaminase, alkaline phosphatase, gamma-glutamyl transferase, α-feto protein and carcinoembryonic antigen. However, extract treated animals showed marked improvement in body weight gain and a significant decrease in relative liver weight with reduced levels of liver injury and liver cancer markers in serum. Uddin et al. evaluated cytotoxic activity of methanol and petroleum ether extracts of *S. zeylanica* stem by brine shrimp lethality assay and MTT cell viability assay. Petroleum ether extract displayed marked cytotoxicity in both the assays. In MTT assay, the petroleum ether and methanol extracts exhibited cytotoxicity against MCF7 cells (human breast cancer cell line) with an IC_{50} value of 15.49 and 19.19µg/ml respectively.

Cytoprotective activity: Rajesh and Perumal evaluated cytoprotective potential of solvent extracts of *S. zeylanica* leaves against hydrogen peroxide induced oxidative stress in L132 pulmonary cells and BRL 3A liver cells by cell viability assay, lipid peroxidation assay, lactate dehydrogenase leakage into culture medium, catalase activity and the levels of reduced glutathione (GSH) in the cells. It was observed that pretreatment of cultured cells with methanol extract of leaves revealed a significant cytoprotection in terms of increasing cell viability, decreasing lipid peroxidation and LDH leakage and an increase in the catalase and reduced glutathione content indicating marked cytoprotective activity against oxidative damage.

Antidiabetic activity: Various extracts of leaves of *S. zeylanica* were screened for antidiabetic activity by streptozotocin induced diabetic model in Wister rats. It was observed that all extracts displayed antidiabetic activity at 250 mg/kg concentration and the activities were well comparable with glibenclamide, the standard drug. The extract administration resulted in significant reduction in blood sugar level in diabetic rats. Among extracts, ethanolic extract exhibited marked antidiabetic activity [61]. Rajesh and Perumal investigated antidiabetic activity of methanolic extract of leaves of *S. zeylanica* by streptozotocin-induced diabetis in rats. A significant decrease in serum insulin levels and a considerable increase in the plasma glucose levels were observed in rats administered with streptozotocin. Administration of leaf extract caused a dose dependent decrease in the glucose levels and a dose dependent increase in the insulin level in the serum of treated animals. Extract administration also resulted in considerable decrease in the levels of blood urea and creatinine.

Antibacterial activity: The potential of ethanol extract of *S. zeylanica* leaves to exhibit antibacterial activity was investigated by disc diffusion assay. The extract exhibited a concentration dependent inhibition of test bacteria with highest and least activity being observed against *Salmonella paratyphi* and *Escherichia coli* respectively. Sarbadhikary et al. [62] determined antibacterial activity of leaf extract of *S. zeylanica* by disc diffusion method against a panel of gram positive and gram negative bacteria. The extract was effective in inhibiting *E. coli* with zone of inhibition of 10mm while other bacteria were not inhibited by extract.

Antifungal activity: Saha et al. **[**63] investigated antifungal activity of ethanol and aqueous extract of leaves of *S. zeylanica* by spore germination technique against fungal pathogens of tea viz. *Pestalotiopsis theae*, *Colletotrichum camelliae*, *Curvularia eragrostridis* and *Botryodiplodia theobrome*. Both extracts were effective in causing inhibition of spore germination of test fungi. Ethanol extract caused 100% inhibition of *P. theae*.

Antipyretic activity: In a study, Jena et al. investigated antipyretic activity of various solvent extracts of *S. zeylanica* leaves by brewer's yeast-induced pyrexia in rats. It was observed that petroleum ether extract exhibited marked antipyretic potential when compared to other extracts.

Anticonvulsant activity: Various solvent extracts of *S. zeylanica* leaves were screened for anticonvulsant activity in mice by strychnine induced tonic convulsions in Swiss albino mice. Administration of extracts resulted in reduction of convulsions in mice. Among extracts, marked activity was shown by ethyl acetate extract.

Thrombolytic activity: Hossen et al. [64] determined thrombolytic activity of petroleum ether and ethanol extract of leaves of *S. zeylanica* in terms of inhibition of clot lysis. Ethanol extract displayed significant clot lysis (43.35%) when compared to petroleum ether extract (19.59%).

Antidepressant activity: Ahemad et al. [65] evaluated antidepressant activity of dried roots of *S. zeylanica* by forced swimming test and tail suspension test in mice. After two weeks of administration, the extract caused anti-depressive like effect and caused significant reduction in immobility time of mice in both tests. The mechanism of action seemed to involve a rise in the monoamines level.

Pesticidal activity: Bari et al. [66] screened pesticidal activity of chloroform and methanolic extract of leaf, stem and root of *S. zeylanica* against the adult flat grain beetle *Cryptolestes pusillus* by surface film method. Among extracts, methanol extracts caused marked mortalities than chloroform extracts. The contact toxicity of extracts was in the order: root > stem > leaf.

Anti-inflammatory activity: Anti-inflammatory activity of root powder of *S. zeylanica* was investigated by formalin-induced paw edema and cotton pellet granuloma method. Administration of extract caused a significant reduction in the formalin-induced paw oedema and the weight of cotton pellet granuloma dose dependently**.** Divya [67] screened anti-inflammatory effect of aqueous, ethanol and chloroform extracts of roots and rhizomes of *S. zeylanica* in reducing inflammation by three different models of inflammation viz., carrageenan induced acute inflammation, formalin induced sub-acute inflammation and cotton pellet induced chronic inflammation. The ethanol and aqueous extracts exhibited a significant anti-inflammatory activity.

Immunomodulatory activity: Babu et al. [68] conducted study on immunomodulatory potential of root extract of *S. zeylanica* by NBT reduction test. The extract was shown to exhibit a significant effect on both humoral and cell mediated immunity and suppressed stimulated immune responses in the NBT reduction test.

Antiarthritic activity: The ethanol and aqueous extracts of roots and rhizomes of *S. zeylanica* were subjected for anti-arthritic studies in the Wistar albino rats by using Freund's complete adjuvant which induces arthritis. Both extracts caused a significant dose dependent anti-arthritic activity when compared to arthritic control rats.The methanolic extract prepared from the roots of *S. zeylanica* was investigated for antiarthritic activity by in vitro protein denaturation and in vivo complete Freunds adjuvant induced arthritis in rats. The extract was shown to cause inhibition of protein denaturation in vitro. The extract caused significant inhibition of the edema formation in the in vivo assay which is supported by findings from histopathological studies **.**

Anti-cataleptic activity: Ahemad et al. evaluated anti-cataleptic activity of ethanolic extract of dried roots of *S. zeylanica* against haloperidol induced catalepsy in male Wistar rats by block method. Extract administration caused a significant reduction in the cataleptic scores in all the drug-treated groups as compared to the

haloperidol-treated group with maximum reduction observed in animals administered with 500 mg extract/kg body weight.

Anti-epileptic activity: Madhavan et al. [69] determined antiepileptic activity of alcohol and aqueous extracts of roots and rhizomes of *S. zeylanica* by Pentylenetetrazole and Maximal electro shock induced convulsion models in swiss albino mice. In maximal electro shock induced seizures, both extracts reduced the duration of extensor phase and time taken for recovery. In Pentylenetetrazole induced seizures, both extracts at the dose of 600 mg/kg, significantly delayed the onset of convulsions.

Anthelmintic activity: Various solvent extracts of *S. zeylanica* leaves were evaluated for anthelmintic activity using adult Indian earthworm *Pheretima posthuma*. Among extracts, marked and least anthelmintic activity was shown by petroleum ether extract and benzene extract respectively. The activity displayed by petroleum ether extract was higher than that of Albendazole, standard anthelmintic drug [70]. Jena et al. carried out anthelmintic activity of various solvent extracts of leaves of *S. zeylanica* against adult Indian earthworms *Pheretima posthuma* in terms of time taken for paralysis and death of worms. It was observed that all extracts revealed anthelmintic activity concentration of 10mg/ml concentration and the activities were comparable with the standard drug, piperazine citrate.

CONCLUSIONS

The data gathered by an extensive literature survey on *S. zeylanica* shows that the plant is extensively used ethnobotanically and is shown to exhibit a wide range of pharmacological activities. The plant is traditionally used in the treatment of diseases such as piles, wounds, venereal diseases, toothache and dysentery. Studies have shown that several parts of the plant exhibit a number of pharmacological activities such as antimicrobial, antioxidant, analgesic, anti-inflammatory, antipyretic, cytotoxic, hepatoprotective and antidiabetic activity. The presence of various phytochemicals, for e.g., alkaloids, terpenoids, flavonoids and other phenolic compounds in the plant might have been responsible for the observed pharmacological activities and therapeutic potential of the plant. Overall, the plant appears to be a promising candidate for developing therapeutic agents that can be used for disease therapy. More studies are to be conducted in order to recover active principles from the plant and to investigate their biological activities.

REFERENCES

[1] S Rajan, M Sethuraman, PK Mukherjee. *Phytother Res*. **2002**, 16, 98-116.
[2] M Ayyanar, S Ignacimuthu. *Indian J Tradit Know*. **2005**, 4(3), 229-236.
[3] MJ Balunas, DA Kinghorn. *Life Sciences*. **2005**, 78, 431-441.
[4] NCC Silva, FA Junior. *J Venom Anim Toxins Incl Trop Dis*. **2010**, 16(3), 402-413.
[5] AA Abdullahi. *Afr J Tradit Complement Altern Med*. **2011**, 8(51), 115-123.
[6] S Sharma, A Kumar. *Int J Life Sci Pharma Res*. **2012**, 2(3), 293-303.
[7] MK Hasan, P Gatto, PK Jha. *Int J Med Arom Plants*. **2013**, 3(1), 102-112.
[8] Lakey, K Dorji. *BMC Ecol*. **2016**, 16, 45.
[9] PGM Kumar, S Nagayya. *Int J Pharm Pharm Sci*. **2017**, 9(4), 107-112.
[10] BV Shetty, KM Kaveriappa, GK Bhat. Plant resources of Western Ghats and lowlands of Dakshina Kannada and Udupi districts. Pilikula Nisarga Dhama Society, Mangalore, India, **2002**,58-211.
[11] CP Khare. Indian medicinal plants: An illustrated dictionary. Springer-Verlag Berlin, Heidelberg, **2007**, 609.
[12] V Madhavan, HT Hemalatha, MR Gurudeva, SN Yoganarasimhan. *Indian J Nat Prod Resour*. **2010**, 1(3), 328-337.
[13] A Murali, P Ashok, V Madhavan. *Int J Pharm Pharm Sci*. **2011**, 3(1), 192-195.
[14] V Rajesh, P Perumal. *Orient Pharm Exp Med*. **2014**, 14(3), 255-268.
[15] SA Punekar, P Lakshminarasimhan. Flora of Anshi national park: Western Ghats-Karnataka. Biospheres Publication, Pune, India, **2011**, 501.
[16] GK Bhat. Flora of South Kanara (Dakshina Kannada and Udupi districts of Karnataka). Aakriti Prints, Mangalore, India, **2014**, 90-91.
[17] RN Pradhan, AR Chorghe, AK Nayak. *Natural Resources and Conservation*. **2015**, 3(3), 45-49.
[18] KK Mohapatra, AK Patra, DS Paramanik. *J Environ Biol*. **2013**, 34(1), 87-92.
[19] A Vijayan, VB Liju, RJV John, B Parthipan, C Renuka. *Indian J Tradit Know.* **2007**, 7(1), 589-594.
[20] AN Shukla, S Srivastava, AKS Rawat. *Indian J Tradit Know*. **2010**, 9(1), 191-202.
[21] RBVA Naidu, KJ Rao, STVV Reddy. *International Multidisciplinary Research Journal*. **2011**, 1/6, 14-16.

[22] M Sahu, AR Sahu. *Journal of Medicinal Plants Studies*. **2017**, 5(5), 120-125.
[23] DR Luitel, MB Rokaya, B Timsina, Z Munzbergova. *J Ethnobiol Ethnomed*. **2014**, 10, 5.
[24] C Patale, P Nasare, S Narkhede. *International Journal of Research in Plant Science*. **2015**, 5(1), 10-16.
[25] MJ Gritto, A Aslam, V Nandagopalan. *Int J Res Ayurveda Pharm*. **2012**, 3(6), 844-846.
[26] S Ignacimuthu, M Ayyanar, SK Sivaraman. *J Ethnobiol Ethnomed*. **2006**, 2, 25.
[27] AVB Babu, VT Antony. *Advances in Biology , BioMedicine*, **2017**, 4(1), 1-6.
[28] MN Pervez, MIH Nahid, P Das, Z Islam, RA Islam, RJ Priya, A Chakraborty, M Rahmatullah. *J Chem Pharm Res*. **2014**, 6(12), 118-122.
[29] D Baro, SK Borthakur. *Bioscience Discovery.* **2017**, 8(2), 158-165.
[30] D Maity, SK Dey, S Chatterjee, GG Maiti. *Explor Anim Med Res.* **2015**, 5(1), 44-61.
[31] S Balamurugan, S Vijayakumar, S Prabhu, MJE Yabesh. *J Tradit Complement Med*. **2017**.
[32] D Deb, BK Datta, J Debbarma, S Deb. *Biodiversitas.* **2016**, 17(1), 256-259.
[33] VV Divya, N Karthick, S Umamaheswari. *Int J Adv Biol Res*. **2013**, 3(3), 384-393.
[34] S Nayak, SK Behera, MK Misra. *Indian J Tradit Know*. **2004**, 3(1), 72-79.
[35] RS Reddy, MA Reddy, SMV Babu. *Am J Ethnomed*. **2015**, 2(6), 379-391.
[36] NA Siddique, MA Bari, ATM Naderuzzaman, N Khatun, MH Rahman, RS Sultana, MN Matin, S Shahnewaz, MM Rahman. *J Biol Sci*. **2004**, 4(1), 72-80.
[37] A Ghosh. *Int J Pharm Life Sci*. **2014**, 5(5), 3531-3533.
[38] MM Cowan. *Clin Microbiol Rev*. **1999**, 12(4), 564-582.
[39] CJ Dillard, BJ German. *J Sci Food Agric*. **2000**, 80, 1744-1756.
[40] GGF Nascimento, J Locatelli, PC Freitas, GL Silva. *Braz J Microbiol*. **2000**, 31, 247-256.
[41] R Verpoorte, A Contin, J Memelink. *Phytochem Rev*. **2002**, 1(1), 13-25.
[42] S Karuppusamy. *J Med Plants Res*. **2009**, 3(13), 1222-1239.
[43] C Bothiraja, PP Joshi, GY Dama, AP Pawar. *Eur J Integr Med*. **2011**, 3(1), 39-42.
[44] P Paul, MK Unnikrishnan, AN Nagappa. *Indian J Nat Prod Resour*. **2011**, 2(2), 137-150.
[45] MU Kabir, SM Abdulkarim, R Son, AH Azizah, NB Saari. *Int Food Res J*. **2013**, 20(1), 35-41.
[46] W Li, Y Guo, C Zhang, R Wu, AY Yang, J Gaspar, AT Kong. *Chem Res Toxicol*. **2016**, 29(12), 2071-2095.
[47] PK Jena, BS Nayak, SC Dinda, P Ellaiah. *Asian J Chem*. **2011**, 23(10), 4307-4310.
[48] A Murali, P Ashok, V Madhavan. *MSRUAS-SASTech Journal*. **2014**, 13(2), 25-28.
[49] V Rajesh, P Perumal. *Orient Pharm Exp Med*. **2014**, 14(2), 127-144.
[50] RS Ahemad, S Venkataraman, FA Mohammed, KN Jayveera. *Int J Pharm Pharm Sci*. **2012**, 4(3), 323-327.
[51] MN Uddin, T Ahmed, S Pathan, MM Al-Amin, MS Rana. *J Basic Clin Physiol Pharmacol*. **2015**, 26(5), 453-463.
[52] AM Hossain, S Saha, M Asadujjaman, AS Kahan. *Pharmacologyonline*. **2013**, 1, 244-250.
[53] PK Jena, SC Dinda, P Ellaiah. *Orient Pharm Exp Med*. **2012**, 12, 123-127.
[54] I Nithyamala, S Ayyasamy, M Pitchiahkumar, A Kumar, V Velapandian. *IOSR Journal of Pharmacy and Biological Sciences*. **2013**, 6(1), 6-11.
[55] A Murali, P Ashok, V Madhavan. *J Complement Integr Med*. **2012**, 9.
[56] R Thirugnanasampandan, VN Mutharaiah, NV Bai. *Afr J Biotechnol*. **2009**, 8(3), 395-400.
[57] ED Daffodil, VR Mohan. *Int J Pharm Sci Rev Res*. **2017**, 42(1), 85-90.
[58] V Rajesh, P Perumal. *Orient Pharm Exp Med*. **2014**, 14(2), 111-126.
[59] V Rajesh, P Perumal. *Orient Pharm Exp Med*. **2013**, 13, 267-277.
[60] A Murali, P Ashok, V Madhavan. *International Journal of Pharmacy and Technology*. **2010**, 2(4), 862-875.
[61] PK Jena, SC Dinda, P Ellaiah. *Asian J Chem*. **2012**, 24(10), 4825-4826.
[62] SB Sarbadhikary, S Bhowmik, BK Datta, NC Mandal. *Int J Curr Microbiol App Sci.* **2015**, 4(8), 643-655
[63] D Saha, S Dasgupta, A Saha. *Pharm Biol*. **2005**, 43(1), 87-91.
[64] MSM Hossen, IN Khan, MMI Sarkar, MA Jahid. *International Blood Research and Reviews*. **2014**, 2(6), 262-269.
[65] RS Ahemad, S Venkataraman, F Ahmad, M Ibrahim. *Eur J Pharm Med Res.* **2016**, 3(12), 335-341.
[66] MA Bari, W Islam, AR Khan. *J Bangladesh Acad Sci*. **2010**, 34(2), 205-208.
[67] VV Divya. Anti-inflammatory and anti-arthritic activity of different extracts of *Smilax zeylanica* (L.) and *Smilax ovalifolia* (Roxb.). Ph.D thesis, Manonmaniam Sundaranar University, Tamil Nadu, India, **2014**.
[68] VP Babu, T Ashwini, VM Krishna, GM Raju. *Int J Phytomed.* **2017**, 8, 123-131.
[69] V Madhavan, HT Hemalatha, A Murali, SN Yoganarasimhan. *Pharmacologyonline*. **2008**, 3, 263-272.

[70] V Rajesh, P Perumal, V Chinthakindhi, S Prabhakaran, G Hymavathi, T Guntupalli. *Internet Journal of Pharmacology*. **2009**, 9(1).