WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 14, Issue 17, 161-175. Review Article ISSN 2277–7105

OVERVIEW - PHYTOCHEMICAL CONSTITUENTS & PHARMACOLOGICAL ACTIVITIES OF *HEMIDESMUS INDICUS*

Arun Kumar M.[1*], Nandhitha P.[2], Jothimanivannan C.[3], Sriganth K.[1], Gurumoorthi M.[1], Abinesh S.[1]

[1]Students, SS Institute of Pharmacy, Sankari, Salem-637301.

[2]Assistant Professor, SS Institute of Pharmacy, Sankari, Salem-637301.

[3]Professor & Principal, SS Institute of Pharmacy, Sankari, Salem-637301.

Article Received on
10 July 2025,

Revised on 01 August 2025,
Accepted on 20 August 2025

DOI: 10.20959/wjpr202517-38032

***Corresponding Author**
Arun Kumar M.
Students, SS Institute of Pharmacy, Sankari, Salem-637301.

ABSTRACT

Hemidesmus indicus (L.) R.Br., or Indian sarsaparilla, is a valued medicinal plant with deep roots in Ayurvedic, Siddha, and Unani traditions. Its roots are traditionally used to treat skin diseases, respiratory and digestive issues, venereal diseases, and general weakness. Known for its blood-purifying, anti-inflammatory, and immune-boosting properties, the plant contains bioactive compounds like flavonoids, tannins, terpenoids, and saponins. Extraction methods such as Soxhlet and cold maceration with solvents like ethanol and methanol help isolate these constituents, while HPTLC and HPLC aid in their standardization. Preclinical studies confirm various pharmacological activities, including antioxidant, anti-arthritic, anticancer, and hepatoprotective effects. Though clinical trials are limited, results are promising for conditions like psoriasis and non-ulcer dyspepsia. The plant features in many commercial formulations and is regulated globally. Future research should focus on sustainable harvesting, propagation techniques, and deeper clinical evaluations to support its use in modern medicine.

KEYWORDS: *Hemidesmus indicus, phytochemical constituents, pharmacological activity, traditional knowledge.*

1. INTRODUCTION

The resurgence of interest in traditional medicinal systems has spotlighted several botanicals with centuries-old usage, among which *Hemidesmus indicus* (L.) R.Br., commonly known as

Indian sarsaparilla, occupies a prominent position. This slender, twining, and aromatic plant belonging to the family Apocynaceae is widely distributed in the Indian subcontinent and has been an integral part of Ayurvedic, Siddha, and Unani pharmacopeias. The roots of H. indicus are primarily used for their therapeutic properties and are known for their pleasant odor and sweet taste.[1] Historically, H. indicus has been prescribed to treat a multitude of disorders such as leprosy, syphilis, bronchitis, rheumatism, skin ailments, urinary tract infections, and gastrointestinal disturbances. The roots are considered refrigerant, diuretic, demulcent, tonic, and blood-purifying. Its efficacy in restoring general health and treating chronic inflammatory and infectious conditions has been widely acknowledged in traditional literature.[2] Modern phytochemical and pharmacological evaluations have supported many of these traditional claims. The plant is found to be rich in secondary metabolites including flavonoids, phenolic acids, tannins, terpenoids, and saponins, which contribute significantly to its antioxidant, anti-inflammatory, anti-arthritic, hepatoprotective, and anticancer activities. Various in vitro and in vivo studies have documented the bioactivities of these compounds, though clinical data remain limited. The increasing demand for herbal products in the global market has led to the commercial formulation of H. indicus-based products for skincare, digestive health, immunity enhancement, and urinary tract support. At the same time, regulatory authorities in India, the USA, the EU, and WHO have recognized the plant's safety and medicinal potential, setting guidelines for its standardization and quality control.[3] Given its pharmacological richness, traditional importance, and emerging therapeutic promise, this review seeks to provide a detailed exploration of H. indicus from ethnobotanical uses and phytochemical profiles to its extraction methods, pharmacological activities, dosage forms, marketed formulations, clinical evidence, regulatory aspects, and future directions.

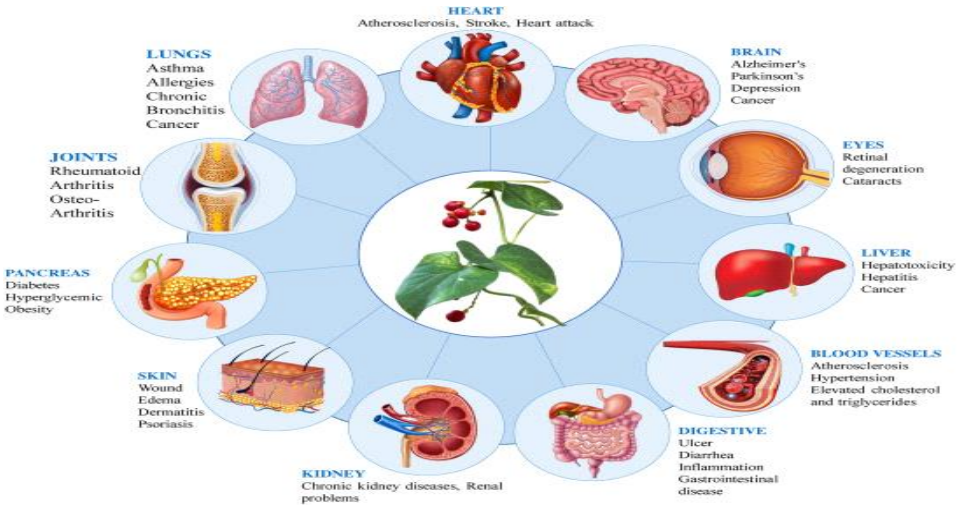

Figure. 1

DESCRIPTION

Kingdom : Plantae

Clade : Tracheophytes

Clade : Angiosperms

Clade : Eudicots

Clade : Asterids

Order : Gentianales

Family : Apocynaceae

Genus : Hemidesmus

Species : H. indicus

Binomial name : *Hemidesmus indicus* (L.) R.Br.

Synonym : Periploca indica[4]

Figure 2

Ethno-Botanical Review

While the entire plant is given to cure asthma, cough, stomach swelling, and aching limbs, Charakains recommended a decoction of the leaves of Saarivaa, or the white variety of H. indicus, to treat complexion, voice loss, coughing, menstrual problems, and dysentery. Sushruta has recommended the black variant, Krishna Saarivaa, for tiny illnesses and respiratory infections. Traditionally, *Hemidesmus indicus*-based medicinal ghee, along with a

few other plants, is used to treat chronic fever, asthma, coughing, hiccups, headaches, body burning, and digestive fire vitiation. H. indicus R. Br. has tonic, anthelmintic, refrigerant, fragrant, astringent, and bitter roots. They also helped with arthralgia, diarrhea, epileptic fits, leprosy, and burning sensations. The leaves help with leucoderma, wounds, and vomiting. The steams are laxative, bitter, and helpful for blood purification, hepatopathy, nephropathy, and inflammations. Among its many uses are anthelmintic, emollient, demulcent, expectorant, tonic, leprosy, skin disorders, and general debility.[5] When it comes to conjunctivitis, latex works. The British Pharmacopoeia (BP) of 1864 officially recognized syrup manufactured from H. indicus roots, and the Indian Pharmacopoeia followed suit. According to the Ayurvedic system, this syrup is recommended for leucorrhea, syphilis, chronic rheumatism, dyspepsia, fever, loss of appetite, and skin conditions and ulcerations. It also has diuretic and demulcent qualities. Root powder infusion has sudorific qualities and is used as a blood purifier. Children with persistent coughing and diarrhea are given this infusion together with milk and sugar as a tonic.To empty the intestines and reduce fever, Ayurvedic doctors give parts of Anantmul, the roots of Bala (Pavoniaodorata), the tubers of Mustaka (Cyperusrotundus), ginger, and kutki root (Picrorhizakurroa). The stems are laxative, bitter, and helpful for blood purification, hepatopathy, nephropathy, and inflammations. The roots are used to treat burning sensations, leprosy, epileptic fits, diarrhea, and arthralgia. They are also fragrant, astringent, refrigerant, anthelmintic, and tonic. Several cultures also employ roots to treat a variety of illnesses and ailments. In venereal illnesses, Birhore. unda: Urinating reddish. Santal: For spermatorrhea, toothache, galactagogue, skin conditions, postpartum symptoms, and impotence, Oraon: As a tonic and cooling agent for neurological disorders, indolence, and debility. Orissa (Mayurvhanj): In cases of stomachaches and diarrhea. Asur: In cases of urination. According to the antiquated Ayurvedic belief, the roots of the *Hemidesmus indicus* plant will induce deep sleep and allow the user to enter the four gates of dreaming, which Carlos Castaneda has described as the art of dreaming. It helps clarity throughout the dream or REM phase of sleep for the seasoned conscious dreamer. Men with poor libido and sexual importance were also given it by the ayurvedic doctor; it is believed that one of the active substances shaped by the roots increases male testosterone levels, which in turn increases sperm count, sexual desire, and overall sexual performance. Aphrodisiac, carminative, demulcent, expectorant, gout, epilepsy, anthelmintic, alterant, and diarrhea are some of its further uses.[6]

PHYTOCHEMICAL PROFILING

Determination of the total phenol content (TPC)

Using the Singleton and Rossi method, the phenolic content of the various H. indicus extracts was ascertained. Various extracts (0.5 mL) of H. indicus (1 mg/mL) were mixed with 2% sodium carbonate solution (2 mL) and 10% Folin–Ciocalteau's reagent (2.5 mL). Absorbance was measured at 765 nm following a 15-minute incubation period at 45 °C. The total phenol content was computed using the calibration curve made with gallic acid as the standard.[7]

Determination of total flavonoid contents (TFC)

To ascertain the total flavonoid concentration, the colorimetric technique of aluminum chloride (AlCl3) was employed. The mixture of methanol (3 mL), 10% AlCl3 (0.2 mL), potassium acetate (1 M) (0.2 mL), and distilled water (5.6 mL) was supplemented with various extracts of H. indicus (1 mL). After 30 minutes, absorbance was measured at 420 nm. The total flavonoid content was determined using a standard curve that was created using rutin as a standard.

Determination of total tannin contents (TTC)

The total tannin content was determined using the Sun (1998) method, which involved adding the Vanillin HCl reagent (6 mL) after letting a mixture of extract (1 mL) and acidic methanol (3 mL) remain for 10 minutes at room temperature. At 500 nm, absorbance was measured. Total tannin was quantified using the catechin standard curve as a reference.

Determination of total terpenoid contents (TTRC)

The total amount of terpenoid present in the various H. indicus extracts was measured. Conc. H2 SO4 was gradually added to the assay mixture of extract (160 µL) and chloroform (1.2 mL), and it was then allowed to sit at room temperature for two hours. The supernatant of reaction mixture was decanted and 95% methanol (1.5 mL) was added to dissolve the resultant reddish brown precipitate and absorbance was recorded at 538 nm. The linalool standard curve was used to calculate the total terpenoid content.[8]

Determination of total saponin contents (TSC)

For measurement of total saponin content in the extract, vanillinsulphuric acid test was incorporated. After combining extracts (0.25 mL) with 8% (w/v) vanillin in ethanol (0.25 mL) and 72% (v/v) sulfuric acid in water (2.5 mL), the mixture was incubated for 15 minutes

at 60 °C in a water bath. After cooling for five minutes at room temperature, absorbance was then measured at 560 nm.

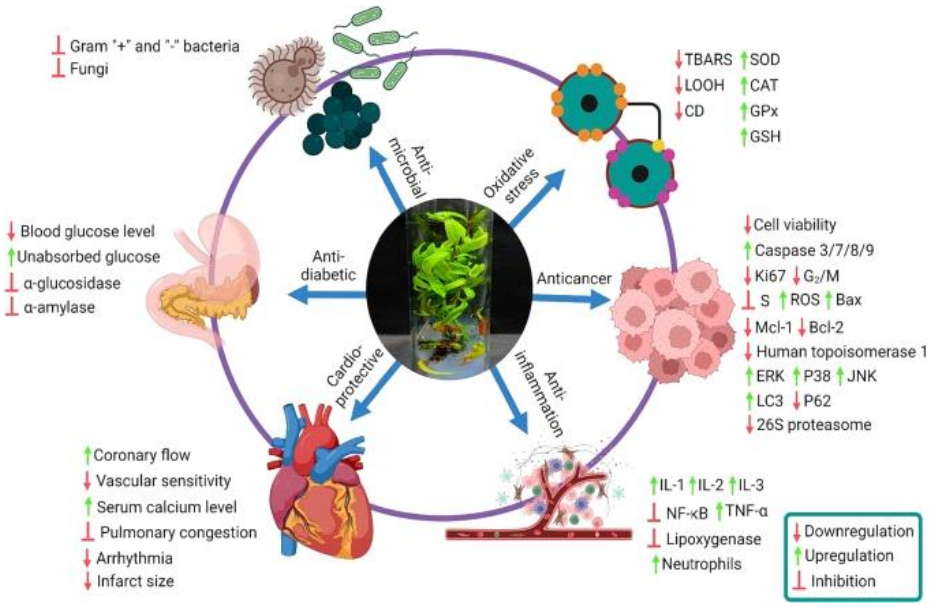

Figure 3

EXTRACTION AND ISOLATION

Bioactive chemicals from H. indicus have been extracted using a variety of methods

Ethanol, methanol, and petroleum ether extracted using

- Soxhlet
- Cold maceration
- Extraction with hydroalcoholics

Flavonoids and polyphenols are frequently found in higher concentrations in ethanolic extracts. Methods for isolation and quantification have included HPLC and column chromatography.[9]

PHARMACOLOGICAL ACTIVITIES

Pharmacological Aspects

Medicinal effects of *Hemidesmus indicus* have been mentioned in various papers from ancient to the contemporary day texts. The roots of the plant are employed as a blood purifier, antipyretic, and antidiarrheal. Blood diseases, biliousness, diarrhea and vomiting, respiratory conditions, skin conditions, leprosy, leucorrhea, leukoderma, itching, syphilis, bronchitis, asthma, eye conditions, epileptic seizures in children, lack of appetite, burning sensation, rheumatism, kidney and urinary disorders, and more are all treated with them.[10]

Anti-inflammatory activity

The substantial reduction of inflammation brought on by carrageenan, bradykinin, and S-hydroxy tryptamine in rats demonstrated the anti-inflammatory properties of ethyl acetate root extract of HI in both acute and subacute inflammation. Phenylbutazone was more active than the extract.

When HI root aqueous extract was compared to diclofenac sodium gel, it demonstrated adequate anti-inflammatory efficacy.

In the experimental rat and mouse models, the anti-inflammatory action of HI root ethanol extract (100, 200 mg/kg, p.o.) showed notable dose-dependent suppression.

Antioxidant activity

Superoxide, hydroxyl, and lipid peroxidation were all inhibited by methanol preparations of HI root bark. HI extracts shielded the liver, erythrocytes, and plasma from oxidative damage caused by free radicals.

Anti-arthritic activity

The presence of terpenes, sterols, and phenolic substances in the hydroalcoholic root extract and ethyl acetate fraction is likely what gives HI root its preventive function against arthritis. Compared to residual fraction and chloroform, these fractions exhibited stronger anti-arthritic efficacy. In rats with ovariectomies, the impact of HI root ethanolic extract on osteoporosis was assessed. It was found to decrease bone loss in dorsal ovariectomy-induced osteoporosis without causing estrogen-like adverse effects.[11]

Anti-cancerous activity

It has preventive properties against hepatocarcinogenesis and other types of cancer. Research on soxhlet HI extract's chemopreventive effects on the acute lymphoblastic leukemia cell line (CCRF-CEM) revealed a cytotoxic effect through both intrinsic and extrinsic apoptotic pathways, which inhibited the cell cycle in the S phase and reduced DNA damage. In the chorioallantoic membrane (CAM) model, aqueous extracts and fractions of Rubia cordifolia, Mimosa pudica, and HI were evaluated for their capacity to promote wound healing and were found to increase angiogenesis. In the human promyelocytic leukemia cell line, HI root decoction was shown to have cytotoxic, cytostatic, and cytodifferentiative properties.

Anti-hepatocarcinogenic effect

By measuring the expression of the p53 and p21 genes in human hepatoma cells (HepG2) and mouse liver with chemically-induced hepatocarcinogenesis, the decoction made from HI root, Smilax glabra rhizome, and Nigella sativa seed was assessed for its potential as a cancer treatment. They discovered that the decoction boosted the expression of both genes in mice and HepG2 cells, most likely by modifying the functions of genes involved in cell cycle arrest and tumor suppression. The decoction's mechanism of antihepatocarcinogenic effect showed that it activates caspase-3 and caspase-9, up-regulates pro-apoptotic Bax, and down-regulates anti-apoptotic Bcl-2 genes to cause apoptosis in human hepatocellular carcinoma HepG2 cells [12]

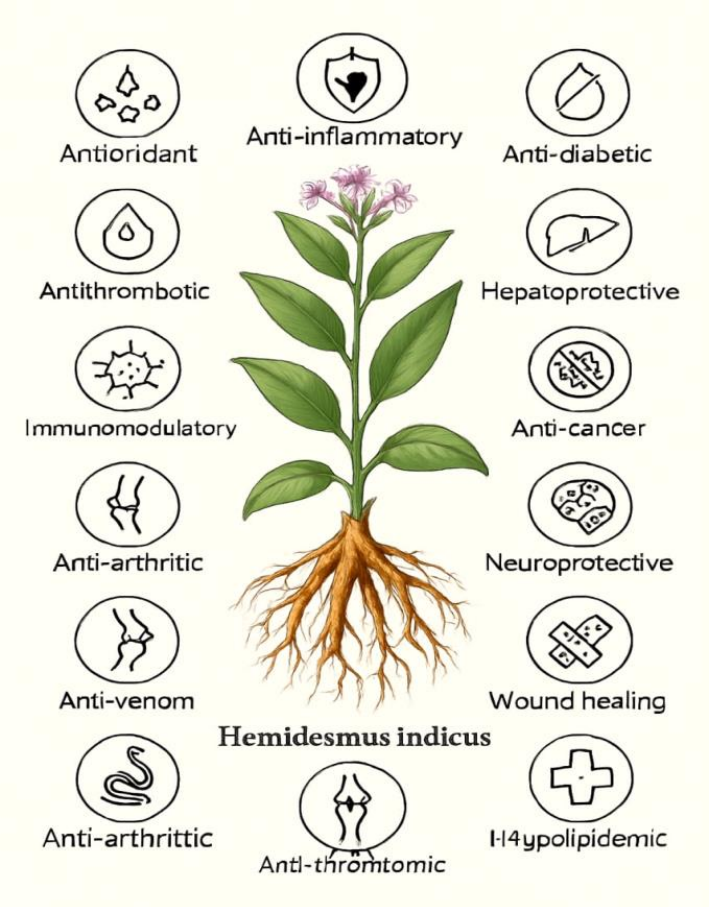

Figure: 7

Toxicity and Safety Studies

Research indicates that in animal models, H. indicus root extract is safe at up to 2000 mg/kg. Studies that were both acute and sub-chronic found no evidence of severe behavioral or physiological damage. There aren't enough human clinical trials, though.[13]

DOSAGE FORMS:

Dosage Forms for Indian Sarsaparilla (*Hemidesmus indicus*)

In Ayurvedic, Siddha, and Unani medicine, *Hemidesmus indicus* is a traditional medicinal herb. The plant's many parts mostly the root are utilized. It comes in a variety of dose forms, both conventional and contemporary.

Traditional Dosage Forms

Kashaya, or decoction

To extract the active ingredients, roots are cooked in water.

Dosage: based on formulation and concentration, 50-100 ml, 1-2 times per day.

Phanta infusion

Which involves soaking roots in hot water.

Dosage: 1-2 times per day, 50-100 ml.

Powdered dried root (churna)

which can be eaten on its own or mixed with milk, honey, or water.

3–6 g per day is the dosage.

Paste (Kalka)

A paste produced from dried or fresh roots that is applied externally to skin conditions.[14]

MARKETED HERBAL FORMULATION & THEIR INDICATORS

No.	Formulation	Marketed by	Indications
1	Praas	Komal Herbals, Inc., United States	Used as tonic, as restorative agents, prevent health stresses; helps enhance memory power, prolongation of antioxidant capabilities.
2	Skinelle Tablets	Charak Pharma, India	Used for treatment of Acne vulgaris and premenstrual acne.
3	ELGER	Healing Power, Inc., New York	To provide resistance against all airborne allergies.
4	Renalka Syrup	Himalaya Herbal Healthcare, India	Used in variety of urinary disorders viz. burning micturition, recurrent urinary tract infection and dysuria.
5	Psorcure Oil and ointment	Clinic Psoriasis, Canada	Treatment of Psoriasis.
6	Urilow	Merazon Health Products, Inc., USA	Used in kidney stone.
7	Pressure Control	Vadik Herbs, California	In regulating the blood pressure.

REGULATORY STATUS AND QUALITY CONTROL PARAMETERS

Regulatory status

India

Ayurvedic Medicine

The Indian Ayurvedic Pharmacopoeia (API) formally recognizes *Hemidesmus indicus*.

For a variety of formulations (such as Sariva Arishta and Sarivadyasava), roots are employed in accordance with the monographs.

Controlled by the 1940 Drugs and Cosmetics Act and the 1945 Drugs and Cosmetics Regulations.

It can be used in polyherbal formulations, as an extract, or as a raw medication by authorized Ayurvedic producers.[15]

United States

Dietary Supplement

The Dietary Supplement Health and Education Act (DSHEA) of 1994 classified it as a dietary supplement.

Although it is not an FDA-approved medication, it may be sold as long as it is properly labeled and makes no claims to cure, treat, or prevent illness.

Good Manufacturing Practices (GMP) and safety must be guaranteed by manufacturers.

European Union

Regarded as a conventional herbal product.

governed by the Traditional Herbal Medicinal Products Directive (THMPD) and the European Medicines Agency (EMA).

Evidence of traditional usage (at least 30 years, including 15 years within the EU) is necessary for market authorization.

In certain member nations, it is frequently sold as a food supplement.[16]

WHO Guidelines

Hemidesmus indicus is included as a traditional medicinal plant with proven safety in traditional usage in WHO monographs on selected medicinal plants.

It is not listed as a controlled substance on the schedule.

Other Countries

In Canada, it is governed by the Natural and Non-prescription Health Products Directorate (NNHPD) and is classified as a Natural Health Product (NHP).

Australia: If it satisfies safety requirements, it may be utilized as an ingredient in specified medications that are subject to Therapeutic Goods Administration (TGA) regulation.[17]

QUALITY CONTROL PARAMETERS

To ensure the safety, purity, and efficacy of *Hemidesmus indicus*, the following quality control parameters are recommended (as per the Ayurvedic Pharmacopoeia of India and WHO guidelines):

Macroscopic and Microscopic Evaluation

Macroscopic:

Roots: Cylindrical, thin, brittle, aromatic with a sweetish taste.

Microscopic:

Presence of parenchymatous cells, xylem vessels, and stone cells characteristic of the species.[18]

Standards for Physicochemicals

Foreign subject: No more than 2%

Total amount of ash: No more than 6%

Ash that is insoluble in acid: No more than one percent

Extractive that dissolves in alcohol: At least 15%

Water-soluble extractive: At least 20%

Drying loss at 105°C: No more than ten percent.[19]

Phytochemical Tests

These tests look for distinctive markers such as saponins, tannins, flavonoids, glycosides, and essential oils.

Chromatographic fingerprinting using High-Performance Thin Layer Chromatography (HPTLC) and Thin Layer Chromatography (TLC) for standardization based on marker substances such as coumarinolignoids and hemidesmin.[20]

Heavy Metals and Contaminants

Mercury <1 ppm, cadmium <0.3 ppm, arsenic <3 ppm, and lead <10 ppm are the acceptable limits for heavy metals.

Pesticide residues: Need to adhere to national safety regulations and WHO guidelines.

Microbial load: Both the fungal and total bacterial counts need to fall under pharmacopoeial bounds.

Hemidesmus indicus: Human Studies and Clinical Evidence.[21]

CLINICAL EVIDENCE AND HUMAN STUDIES

Overview

Hemidesmus indicus, commonly referred to as Indian Sarsaparilla, is widely utilized in Ayurveda and traditional medicine due to its blood-purifying, anti-inflammatory, hepatoprotective, anti-ulcer, and immunomodulatory properties. There are fewer clinical studies and human trials compared to preclinical research. Most of the clinical evidence is based on its use in polyherbal formulations.[22]

Document Clinical Studies

a) Anti-psoriatic activity

Open-label clinical research is the design.

Patients with mild-to-moderate psoriasis make up the population.

Hemidesmus indicus, was taken orally.

Result: A decrease in scaling, itching, and Psoriasis Area Severity Index (PASI) scores.

Conclusion: Although the formulation exhibited improvement, it was impossible to separate the precise function of *Hemidesmus indicus* due to the usage of several herbs.

b) Blood purification and skin disorders

Design: Observational clinical trial for patients with urticaria, acne, and eczema, which are chronic skin disorders.

Intervention: 50 cc of *Hemidesmus indicus* root decoction taken twice a day for six weeks.

Results: Pruritus and lesion healing improved; two patients experienced slight stomach pain.

Conclusion: Lacks a big sample size and a control group, but suggests efficacy in chronic skin conditions.

c) Anti-ulcer and gastroprotective effects

Design: Pilot study (randomized controlled trial).

Population: Individuals suffering from non-ulcer dyspepsia.

Intervention: 3 g of powdered *Hemidesmus indicus* root twice a day for 4 weeks, compared to a placebo.

Result: The treatment group saw a noticeable improvement in bloating, acidity, and epigastric discomfort as compared to the placebo group.

Conclusion: Its gastroprotective function is supported by preliminary data.[23]

Safety and Toxicity in Humans

Clinical trials and conventional use have not revealed any significant side effects.

High dosages may cause mild gastrointestinal problems (diarrhea, bloating).

When taken within the suggested dosage range, it is regarded as safe.[24]

FUTURE PERSPECTIVES

Hemidesmus indicus (Indian sarsaparilla) conservation through in vitro propagation, synthetic seed synthesis, and genetic engineering to preserve and sustainably use the plant in light of overharvesting threats are the main areas of focus for future views. biotechnological developments to increase the production of its valuable bioactive chemicals, including as tissue culture and molecular methods.continuing research into individual active chemicals and expanding medicinal applications, especially hepatoprotective, immunomodulatory, antidiabetic, and anticancer purposes.Its usage in drinks, nutraceuticals, cosmetics, and green nanotechnology is driven by the growing industrial demand for natural products. emphasis on community participation in sustainable farming and trading, as well as the preservation of ethnobotanical knowledge.[25]

CONCLUSION

Hemidesmus indicus (Indian sarsaparilla) is a valued medicinal plant with deep roots in traditional medicine and growing scientific support. Traditionally used in Ayurveda for skin disorders, venereal diseases, and blood purification, its therapeutic relevance is backed by studies showing anti-inflammatory, antioxidant, hepatoprotective, and anticancer properties. Phytochemical analyses reveal bioactive compounds like flavonoids, tannins, terpenoids, and saponins, which contribute to its wide-ranging pharmacological effects, including immune modulation and cancer cell apoptosis. However, clinical trials on humans remain limited, often involving polyherbal mixtures, making it hard to isolate *H. indicus*'s specific effects. Its inclusion in herbal products globally and recognition by bodies like the Indian Pharmacopoeia, FDA, EMA, and WHO reflect its commercial and therapeutic potential.

Moving forward, sustainable cultivation, genetic research, and advanced clinical studies are essential to unlock its full potential in modern medicine, while maintaining a balance between traditional knowledge and scientific validation.

REFERENCE

1. Anonymous. The Wealth of India. Raw materials, Vol. III, V and X, CSIR, New Delhi, India, 1997.
2. Anonymous. Indian Pharmacopoeia. Indian Pharmacopoeia Committee, Ministry of Health and Family Welfare, Government of India, New Delhi, 1996.
3. Jagtap A, Sing NP. Fascicles of Flora of India. Botanical Survey of India, Government of India, India, 1999.
4. Sasidharan N. Biodiversity Documentation for Kerala. Kerala Forest Research Institute, Peechi, Kerala, India, 2004.
5. Siddique NA, Bari MA, Naderuzzaman ATM, Khatun N, Rahman MH. Collection of indigenous knowledge and identification of endangered medicinal plants by questionnair survey in Barind Tract of Bangladesh. J Biological Sci., 2004; 4: 72-80.
6. Anonymous. Quality Standards of Indian Medicinal Plants. Indian Council of Medical Research, New Delhi, 2005; 2: 119-128.
7. Nayar TS, Beegam AR, Mohanan N, Rajkumar G. Flowering Plants of Kerala, A Handbook. Tropical Botanic Garden and Research Institute, Thiruvanathapuram, Kerala, India, 2006.
8. Patnaik J, Debata BK. Micropropagation of *Hemidesmus indicus* (L.). R. Br. through axillary bud culture. Plant cell Rep., 1997; 15: 427-430.
9. Misra N, Misra P, Datta SK, Mehrotra S. Improvement in clonal propagation of *Hemidesmus indicus* R.Br. through adenine sulphate. J Plant Biotechnol., 2003; 5: 239 244.
10. Malathy S, Pai JS. Studies on tissue culture of *Hemidesmus indicus*, Abstract. International Seminar on Latest Trends in Pharmaceutical Sciences, Ootacamund,South India, 1995.
11. Sharma Yelne. Observation on in vitro propagation of Sariva (Hemidesmus indicus R. Br.), proceeding Seminar on research in Ayurveda and Siddha, New Delhi, 1995.
12. Saha S, Mukhopadhyay MJ, Mukhopadhyay S. In vitro clonal propagation througbud culture of *Hemidesmus indicus* (L.) R. Br. – an important medicinal herb. J Plant Biochem. and Biotechnol., 2003; 12: 61-64.

13. Cheruvathur MK, Najeeb N, Thomas DT. In vitro propagation and conservation of Indian sarsaparilla, *Hemidesmus indicus* L. R. Br. through somatic embryogenesis and synthetic seed production. Acta Physiol. Plant., 2013; 35: 771-779.
14. Shanks JV, Morgan J. Plant hairy root culture. Curr Opin Biotechnology, 1999; 10: 151-155.
15. Giri A, Narasu ML. Transgenic hairy roots: recent trends and applications Biotechnology Adv., 2000; 18: 1-22.
16. Christy MC, Braun RH. Production of hairy root cultures and transgenic plants by Agrobacterium rhizogenes- [mediated transformation. Methods Molecular Biology, 2005; 286: 47-60.
17. Srivastava S, Srivastava AK. Hairy root culture for mass production of high-value secondary metabolites. Crit Rev Biotechnology Pharmacotherapy, 2007; 56: 200-207.
18. Flores HE, Vivanco 004AM, Loyola-Vargas LM. Trends Plant Sci., 1999; 4: 220-226.
19. Sreekumar S, Seeni S, Pushpagandhan P.Micropropagation of *Hemidesmus indicus* for cultivation and production of 2-hydroxy 4-methoxy benzaldehyde. Plant Cell Tissue and Organ Culture, 2000; 62: 211-218.
20. Nadkarni AN. Indian Material Medica, Popular Book Depot, Bombay, India, 1989, I.
21. Murti PBR, Sheshadri TR. A study of the chemicalcomponents of the roots of Decalepis hamiltonii Part III: Comparison with *Hemidesmus indicus* (Indian Sarsaparilla); Proc. Indian Acad. Sci., 1941; 13: 399-403.
22. Chatterjee RC, Bhattacharya BK. A note on the isolation of (β-sitoserol from *Hemidesmus indicus*. Journal of Indian Chemical Society, 1995; 32: 485-486.
23. Padhy SN, Mahato SB, Dutta NL. Triterpenoids from the roots of *Hemidesmus indicus*. Phytochemistry, 1973; 12(1): 217-218.
24. Anonymous. The Wealth of India. Raw materials, CSIR, New Delhi, India, 1997, III, V, X.
25. Prakash K, Sethi A, Deepak D, Khare A, Khare MP. Two pregnane glycosides from *Hemidesmus indicus*. Phytochemistry, 1991; 30(1): 297-299.