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**Abstract:** Medicinal plants are being widely used, either as single drug or in combination in health care delivery system. Indian Sarsaparilla, *Hemidesmus indicus* (Family: Aselepiadaceae) is a commonly known Indian Medicinal Plant, which is widely recognized in traditional systems of Medicine. It contains various phytoconstituents belonging to the category glycosides, flavonoids, tannins, sterols and volatile oils. It has been reported as useful in biliousness, blood diseases, dysentery, diarrhoea, respiratory disorders, skin diseases, syphilis, fever, leprosy, leucoderma, leucorrhoea, itching, bronchitis, asthma, eye diseases, epileptic fits in children, kidney and urinary disorders, loss of appetite, burning sensation, dyspepsia, nutritional disorders, ulcer and rheumatism. Several studies are being carried towards its activities like analgesic, anti-inflammatory, antitumor, hepatoprotective, antioxidant and helicobacteriecidal properties. Further, it also protects radiation-induced DNA damage. With all these potential benefits, this plant is not widely utilized. Hence this review was carried out to explore the hidden potential and its uses, towards the benefit of mankind.

**Key words:** *Hemidesmus indicus*, sariva, Aselepiadaceae, Indian sarsaparilla

**INTRODUCTION**

*Hemidesmus indicus* commonly known as Indian Sarsaparilla, belonging to the family Aselepiadaceae, is a slender latexiferous, twining, sometimes prostrate or semi erect shrub, occurring over the greater part of India (Fig. 1). Roots are woody and aromatic; stems numerous, slender, terete, thickened at the nodes; leaves opposite, short-petioled, very variable, elliptic-oblong to linear-lanceolate often variegated with white above, sometimes silvery white and pubescent beneath; flowers are greenish outside, purplish inside, crowded in subseesile axillary cymes; follicles are slender, four inches long, cylindrical, sometimes curved, divaricate; seeds numerous, black, flattened, with a silvery white coma. This is a common medicinal plant widely used in Indian Systems of Medicine (Anonymous, 1997) and also an official drug in Indian Pharmacopoeia (Anonymous, 1996) and British Pharmacopoeia (Anonymous, 2003).

Various market samples are available in the name, identified as *H. indicus*, *Decalepis hamiltoni* and *Cryptoplepis buchanani* belonging to the family Asclepiadaceae, *Ichnocarpus frutescens* and *Vallaris solanaceae* of the family Apocyanaceae. Apart from this *H. indicus* exists with two variants namely var. *indicus* and var. *pubescens*, which are not given much emphasis. Hence this review was carried out to enumerate the benefits of *H. indicus*.

**Medicinal properties:** Medicinal properties of *H. indicus* were described by Nadkarni (1989), Chopra *et al.* (1956), Anonymous (1986, 1997), Kirthikar and Basu (1980) and Murugesas Mudalayar (1988). The roots are used as antipyretic, anti-diarrhoeal, astringent, blood purifier, diaphoretic, diuretic, refrigerant and tonic (Anonymous, 1986, 1997; Nadkarni, 1989). Roots are useful in biliousness, blood diseases, dysentery, diarrhoea, respiratory disorders, skin diseases, syphilis, fever, leprosy, leucoderma, leucorrhoea, itching, bronchitis, asthma, eye diseases, epileptic fits in children, kidney and urinary disorders, loss of appetite, burning sensation and rheumatism (Mukherjee, 1953; Chopra *et al.*, 1956; Kirthikar and Basu, 1980; Anonymous, 1986; Nadkarni, 1989). Root bark is used to cure dyspepsia, loss of appetite, nutritional disorders, fever, skin diseases, ulcer, syphilis, rheumatism and leucorrhoea.
(Nadkarni, 1989). Stem of *H. indicus* is used as diaphoretic, diuretic, laxative and in treating brain, liver and kidney diseases, syphilis, gleet, urinary discharges, uterine complaints, leucoderma, cough and asthma (Kirthikar and Basu, 1980).

**Ethnobotanical studies:** Ethnobotanical studies on *H. indicus* revealed its benefits towards various ailments, like scorpion sting, snake bite, fever (Sharma et al., 1979) and as a blood purifier (Malhotra and Murthy, 1973; Sharma et al., 1979, Pullaiyah and Kumar, 1996). It has cooling effect and used in venereal diseases including gonorrhoea (Singh and Maheswari, 1983), stomach ulcer (Jain and Singh, 1994; Jain, 1996), diabetes and fever (Khan et al., 1983) increases lactation in mothers (Shukla and Verma, 1996), spermatorrhoea (Singh and Prakash, 1996), biliousness (Balasubramanian and Prasad, 1996) and headache (Khamma et al., 1996). Root decoction is useful for curing high fever and skin diseases (Sudhaker and Rao, 1985; Vyas, 1993). The rind of the root is chewed for sore mouth (Prasad et al., 1964, 1996). Fresh root paste with neem oil applied on scalp of children for development of skull bones to enable carrying head-loads in adult age (Bunerjee and Pal, 1996). The root is used to make sweet smelling drink, which is used in the place of coffee and tea (Prasad et al., 1996). The dried entire plant is used for skin diseases (Shah and Gopal, 1985, Pushpangadan and Atal, 1984). Along with *Piper longum* and *P. nigrum*, it is used for postpartum recovery and also in diarrhoea and to improve appetite (Girach et al., 1994; Reddy et al., 1988). This is also used for impotency (Paul, 1979) and to reduce body heat, as a stimulant and as food (Ramachandran and Nair, 1981). This is said to increase blood circulation and acts as a cure for diarrhoea (Jain and Singh, 1994). The roots are peeled and eaten raw as a blood purifier and as cooling beverage (John, 1984) and for treating skin diseases (Arseculeratne et al., 1985).

Along with *Mimosa pudica*, it is taken orally, during the menstrual period to treat leucorrhoea and also as a body tonic (Bhandary et al., 1995). With black pepper, it is used for fevers of long duration and with milk is taken for anemia (Singh and Prakash, 1996). This is used as an anti-venom (Selvanavayyam et al., 1994). Decoction taken three daily checks menorrhagia (Nagaraju and Rao, 1990). It is also used as anti-rheumatic, diuretic, anti-inflammatory and to treat snake bite (Alam et al., 1994). Externally it is applied to provide relief from scorpion stings (Singh and Ali, 1992). This is also used for venereal diseases (Shah and Gopal, 1985) and as blood purifier (Reddy et al., 1988), to cure stomach pain and diarrhoea (Sabnis and Bedi, 1983). A decoction with *Elephantopus scaber*, *H. indicus* and *P. nigrum* are used for gonorrhoea (Sahu, 1984). This is also used for skin affections, syphilis and as a tonic (Atal et al., 1986). With honey, the fresh roots are used for health and vitality. Along with the woods of *Acacia sundra* and *Cinnamomum zeylanicum*, it is used to make a soft, nourishing beverage to promote youthfulness, health and vitality (Pushpangadan and Atal, 1984; Gupta et al., 1992).

**Pharmacognostical studies:** Microscopic studies on the root and root bark of *H. indicus* were carried out by Prasad and Wahi (1965) and Karnick (1978). The highest concentration of glycosides, flavonoids, tannins and sterols in the entire plant during summer was reported by Karnick (1978). *H. indicus*, *I. frutescens* and *C. bucharani* commonly used as Sariva were differentiated by Wahi et al. (1978).

Along with the above plants *D. hamiltoni* was also differentiated by Togunashi et al. (1978) and Nayar (1979). Prasad et al. (1964) and Roy et al. (1998) reported that market samples of several plants were known by the name sarsaparilla. The market samples were identified as *C. bucharani*, *D. hamiltoni* and *H. indicus* belonging to the family Asclepiadaceae; *I. frutescens* and *V. solanaceae* of the family Apocynaceae. Anoop Austin et al. (2002) carried out pharmacognostical analysis of two varieties of *H. indicus* viz., *var. indicus* and *var. pubescens*. Both varieties have similar habit and more or less, same morphological features. They differ by the nature of the stem and branching pattern and presence and absence of pubescent hairs.

Rafat (1977) reported extractive percentages of *H. indicus* roots in alcohol, water, benzene, chloroform and ether as 12.34, 9.70, 0.39, 0.41 and 0.47%, respectively. Total ash and acid insoluble ash values of the roots of *H. indicus* are 2.60-4.20 and 15.50-18.80%, respectively (Nayar, 1979). However, in another work, Aravindaksham and Ramiah (1982) reported that the total ash value and acid insoluble ash value were 3.20-4.80 and 15.30-17.00%, respectively and Afzal Azam et al. (1996) recorded as 3.56 and 0.60%, respectively. Murthi and Seshadri (1941) reported that *D. hamiltoni* and *H. indicus* have similar chemical compounds. But, the roots of *D. hamiltoni* contain higher percentages of various chemical components.

**Phytochemical studies**

**Roots:** Many phytochemical studies have been carried out on *H. indicus*. From the roots of *H. indicus*, hemidesmosol, resin and glucoside, tannin and resin (Murthi and Seshadri, 1941), lupeol, α and β-amyrins, β-sitosterol (Chatterjee and Bhattacharya, 1955), lupeol, α-amyrin, lupeol acetate, β-amyrin acetate, hexa tricote acid and lupeol octacosonate (Padhy et al., 1973), a
comarino lignoid like hesmidesmine (Mandal et al., 1991), hemidesmin-1 and hemidesmin-2 (Das et al., 1992) were isolated. The constituents of oil obtained from the roots of H. indicus contains 80% crystalline matter, glucose, hemidesmol, hemidesmol, 2-hydroxy-4-methoxy benzaldehyde, resin acid, glucoside, sterol and tannins (Anonymous, 1997). Mukherjee and Ray (1980) reported that roots of H. indicus contain steroidal, terpenoid, flavonoid and saponin, but alkaloid is absent. Oberai et al. (1985) noted that dried twigs of H. indicus yield a pregnancy ester diglycoside desinine.

The presence of α-amyrin triterpene, β-amyrin triterpene and benzaldehyde, 2-hydroxy-4-methoxy benzoin found in the root of Indian H. indicus were reported by Gupta (1981). Alam et al. (1994) reported the presence of benzoic acid, 2-hydroxy-4-methoxy benzoin in the roots. Coumarin derivatives namely hemidesmin-1-coumarin and hemidesmin-2-coumarin in the roots were reported by Das et al. (1992). Nargaran and Rao (2003) isolated 2-hydroxy-4-methoxybenzaldehyde from the roots of D. hamiltonii and H. indicus which is responsible for its aromatic nature, was found to be >90% in their volatile oil, which was isolated from both, fresh and dried roots of different origin. Among the methods adopted, steam hydrodistillation was suitable for extraction of the volatile oils and the quantity varied from 0.03 to 0.54%.

**Stem:** Glycosides like indicine and hemidine were isolated from stem (Prakash et al., 1991). Gupta et al. (1992) found that hexane soluble portion of ethanol extract of stem yielded lactone, lupanine, Δ12-dehydro-lupanyl-3-β-acetate, Δ12-dehydro lupacol acetate, 4-hydroxy-3-methoxy benzaldehyde. Chloroform and alcohol extracts of stem yielded two novel pregnane glycosides, hemidesmine and emidine (Chandra et al., 1994). Oligoglycosides, indicusin and medesmine, hemidine and desmine were isolated from the plant (Deeapak et al., 1995, 1997). Deepak et al. (1997) reported that the plants belonging to the family Asclepiadaceae are rich in pregnane and cardiac glycosides. The benzoin derivatives in the stem were reported by Gupta et al. (1992). It contains benzaldehyde, 2-hydroxy-4-methoxy benzenoid, benzaldehyde, 3-hydroxy-4-methoxy benzenoid and benzaldehyde, 4-hydroxy-3-methoxy benzenoid.

Various steroidal compounds are also found in H. indicus, 0.0004% of calagenin-3-O-β-D-digitoxopyrano steroid (Prakash et al., 1991), side-desamine steroid (Oberai et al., 1985), 0.0009% of desminrane steroid (Deepak et al., 1997), Emidine and hemidesmine steroids (Chandra et al., 1994), 0.0004% of hemidine steroid (Prakash et al., 1991) and hemidine steroid (Deepak et al., 1997) are reported from the stem.

The percentage of triterpene in the stem from India was reported by Gupta et al. (1992). It also contains 0.0007% of lup-12-en-21-28-olide, 3-keto-triterpene, 0.01% of lup-12-en-3-β-ol acetate triterpene, 0.00666% of lupanine triterpene, 0.03333% of lupeol acetate triterpene and 0.03333% of β-sitosterol. Deepak et al. (1997) reported the presence of 0.0008% of medidesmine steroid in the stem from India. The presence of 0.2666% of palmitic acid, a lipid in the stem from India was reported by Gupta et al. (1992). The presence of alkaloids in the stem and root were reported by Arsecularatte et al. (1985). He also reported the absence of pyrroliidine alkaloids in the stem and roots. Das et al. (2003) revealed the presence of tannins, steroids, triterpenoids and carbohydrates. Sigler et al. (2000) isolated two novel pregnane glycosides, demecine (calagenin 3-O-3-O-methyl-β-D-fucopyranosyl-(1→4)-O-D-oleandropyranosi de) and hemine (calagenin 3-O-β-D-cumaropyranosyl-(1→4)-O-β-D-digitoxopyranoside++).

**Leaves:** 2.5% of tannins were present in the leaves (Damel et al., 1978). Coumarinolignoids like hemidesmine (Mandal et al., 1991), hemidesmin 1 and hemidesmin 2 were isolated by Mandal et al. (1995) and they reported that coumarinolignoids are new and rare group of naturally occurring compound with cytotoxic and antihepatotoxic properties. Subramanian and Nair (1968) further, reported the presence of flavonoids viz., hyperoside and rutin.

**Flowers:** The flavonoid glycosides identified in the flowers of H. indicus were hyperoside, isoorquercit in and rutin (Subramanian and Nair, 1968). He also reported the presence of isoorquercitin flavonoid and rutin flavonoid in the flowers from India.

** Entire plant:** Deepak et al. (1995) reported that the entire plant from India contain indicusin steroid. Roy et al. (2001) isolated six new pentacyclic triterpenes including two alkanes, which were identified as olean-12-en-21-β-yl acetate and olean-12-en-3-α-yl acetate, three urenses were characterized as 16-(17)-seco-urs-12, 20(30)-dien-18-α-H-3-[β]-yl acetate, urs-20(30)-en-18-β-H-3-[β]-yl acetate and 16-(17)-seco-urs-12, 20(30) dien-18-α-H-3-[β]-ol and a lupene formulated as lup-1,12-dien-3-on-21-ol including a known compound, β-amyrin acetate, on the basis of spectroscopic techniques and chemical means.

**D. hamiltonii:** Harish et al. (2005) identified 2-hydroxy-4-methoxybenzaldehyde, p-ansaldehyde, vanillin, borneol, salicylaldehyde and bis-2,3,4,6-galloyl-α/β-D-gluco pyranoside from D. hamiltonii which possess
antioxidant properties in *in vitro*. Thangadurai *et al.* (2002) found out that hydrodistillation of *D. hamiltonii* roots yielded an essential oil (0.33% v/w) which contain 2-hydroxy-4-methoxybenzaldehyde (37.45%), 2-hydroxybenzaldehyde (31.01%), 4-O-methylresorcyloxyaldehyde (9.12%), benzyl alcohol (3.16%) and 2-ethyl-9,10-dimethyl anthracene (2.06%) as major constituents, with aromatic aldehydes constituting the main fraction of this root's essential oil. They exhibited strong antimicrobial activity against *Bacillus cereus*, *B. megaterium*, *Candida albicans*, *Escherichia coli*, *Micrococcus luteus*, *M. roseus* and *Staphylococcus aureus*. Results suggested that it can be considered as an inexpensive source of an essential oil rich in antimicrobial compounds against food borne pathogens; *Candida albicans* is not a food borne pathogens.

**Phytochemical variation among seasonal samples:** Anoop Austin *et al.* (2002) evaluated qualitative variations among seasonal samples and varieties. Physicochemical properties, microscopic characteristics and finger printings were evolved in identifying the drug in preparations and standardization. Var. *pubescens* had high content of β-sitosterol (13.95%) and tannins (4.01%) whereas var. *indicus* had high content of phenol (1.05%) and 7.34% of free amino acids. Significant variations were observed among the seasonal samples which are major contributing factors in ascertaining the maturity of the plants. Amino acids, proline, cysteine, ornithine and lysine were present in var. *indicus* and proline, valine, cysteine, ornithine, lysine and histidine in var. *pubescens*. Terpenoids, saponins and alkaloids were identified and TLC patterns were evolved for differentiation. Extractive values were high in variety pubescent compared to var. indicus.

**Plant tissue culture studies:** Plant tissue culture studies on *H. indicus* were reported by Sarasas *et al.* (1994), Malathy and Pai (1995), Sharma and Yelne (1995), Jayanth and Patil (1995) and Patnaik and Debata (1997). Organogenesis and somatic embryogenesis were induced from callus. Callus was initiated from leaf and stem explants of *H. indicus*. Patnaik and Debata (1997) reported micropropagation of *H. indicus* through axillary bud culture. Malathy and Pai (1995) found that callus contains para methoxy salicylaldehyde, β-sitosterol and tannins. Cell culture extracts of *H. indicus* prevents hypercholesterolemia in normal and hyperlipidemic rats (Bopanna *et al.*, 1997). Giridhar *et al.* (2004) developed tissue culture techniques for *D. hamiltonii*. He initiated multiple shoots on MS media supplemented with 2 mg L⁻¹ 6-benzylaminopurine and 0.5 mg L⁻¹ indole-3-acetic acid from axillary buds. Profuse rooting were achieved by supplementing 1.0 mg L⁻¹ indole-3-carboxylic acid. He also established that 0.14 and 0.12% of 2-hydroxy-4-methoxybenzaldehyde was present in one-year-old tissue culture raised field grown plants and greenhouse grown plants, respectively. Gururaj *et al.* (2004) found that phloroglucinol had synergistic effect on shoot multiplication when added with N6-benzyladenine and gibberellic acid.

**Microbiological studies:** Antibacterial activity was carried out by Naovi *et al.* (1991) and Rajendra Prasad *et al.* (1983). Aqueous extract at 410 µg mL⁻¹ (IC₅₀), methanolic extract at 200 µg mL⁻¹ (IC₅₀) and 50% methanolic extract at 320 µg mL⁻¹ (IC₅₀) was active against *Streptococcus mutans*. Ethanolic extract (95%) was effective against *Corynebacterium diphtheriae*, *Diplococcus pneumoniae*, *Staphylococcus aureus*, *Streptococcus pyogenes* and *Streptococcus viridans*. Aqueous extract was effective against *C. diphtheriae*, *D. pneumoniae*, *Staph. aureus*, *S. pyogenes* and *S. viridans*. Antifungal activity was studied against *Microsporum canis*, *M. gypseum*, *Phialophora jeanesiemi*, *Piedraia hortae* and *Trichophyton mentagrophytes*. Aqueous extract was studied against *M. canis*, *M. gypseum*, *Phialophora jeanesiemi*, *Piedraia hortae* and *T. mentagrophytes*. Antilyse activity for 95% ethanolic and aqueous extracts was studied against *Candida albicans* and *C. tropicalis*, but the antifungal activities were not effective.

Antiviral activity was carried out by Dhar *et al.* (1968) against Ranikhet. Plaque formation suppressant study was carried out by Namba *et al.* (1985). Antifilarial activity was studied by Suresh and Rai (1990). It had weak activity against *Setaria digitata* at a dose of 15000 ppm (IC₁₀₀).

The nematocidal activity was analysed by Ali *et al.* (1991) with aqueous and methanolic extracts against *Toxocara canis*. The nematocidal activity was studied by Knueh *et al.* (1989). The decoction had weak activity against *T. canis* at a concentration of 10 mg mL⁻¹. Qureshi *et al.* (1997) found out that the extract does not produce inhibitory activity against keratinophilic fungi. Methanolic extract possessed inhibitory activity against *S. typhimurium*, *E. coli* and *S. flexneri*, in *in vitro* cultures by agar well die diffus and broth culture (Das *et al.*, 2003). Jain and Basal (2003) proved that *H. indicus* does not inhibit the activity of the anaerobic pathogen *Propionibacterium acne*, though it has anti-inflammatory properties.

Anoop Austin *et al.* (2003a, b) established the helicobacterioidal activity of various extracts against *Helicobacter pylori*, which were comparable with standard antibacterials. Chloroform extract of var. *indicus* possessed bioactive principles and MIC was found to be...
75 µg among vegetative and flowering seasons whereas MLC was found to be 75 µg for flowering season sample and 100 µg for vegetative seasons. The activity is due to the triterpenoid or saponins fractions present in it. Flowering season samples of var. pubescens had effective bioactive principles against H. pylori. The results were comparable with standard antibacterials like Amikacin, Tobramycin, Gentamycin, Norfoxacin, Ciprofloxacin and Co-trimoxazole.

Das and Devaraj (2006a) found that the methanolic and chloroform extracts of H. indicus were effective against S. flexneri, least effective against S. dysenteriae and moderately effective against the other enterobacterial strains. They found that the presence of antimicrobial trace elements such as copper and zinc, along with other active constituents may contribute to its antienterobacterial activity. Das and Devaraj (2006b) found out that glycosides present in H. indicus root inhibit S. typhimurium induced pathogenesis, by reducing bacterial surface hydrophobicity and the presence of hexose, hexosamine, fucose and sialic acid etc. might mimic, host cell receptor saccharides and thereby blocking the bacterial ligands from binding to the host cells.

Ahmad and Aqil (2006) found that H. indicus demonstrated relatively high activity against ESBL-producing multidrug-resistant enteric bacteria, when fractionated into acetone, ethyl acetate and methanol. Further, in vitro haemolytic activity on sheep erythrocytes demonstrated no haemolysis.

Pharmacological studies: Satoskar et al. (1962) was the first to carry out pharmacological studies. After which so many workers have worked on this plant on varied aspects.

Antinociception: Verma et al. (2005) revealed that alcoholic extract of H. indicus possesses a dose-dependent antinociceptive effect from 25-100 mg kg⁻¹ orally, in all the models viz., acetic acid induced writhing, hot plate and tail flick method of antinociception and it blocked both the neurogenic and inflammatory pain and its activity is due to the presence of triterpenes, flavonoids and sterols.

Anti-inflammatory: Dutta et al. (1982) found that the ethyl acetate extract of roots of H. indicus exhibited significant anti-inflammatory activity in both acute and subacute inflammation as revealed by significant inhibition of inflammation induced by carrageenin, bradykinin, S-hydroxy tryptamine, employing granuloma pouch and cotton pellet implantation methods in rats. However, it was found less active than phenyl butazone or β-methasone, against granuloma pouch and cotton pellet implantation. It is ineffective in dextran induced inflammation.

Antiulcer: Anoop Austin and Jegadeesan (2003c, d) established the antiulcer activity of H. indicus var. indicus and var. pubescens. Flowering season samples of var. pubescens possessed better antiulcer properties. It acts through mucoprotective action selectively inhibiting prostaglandin. PGE₂ var. indicus exerts mucoprotective effect comparable with standard drugs Ranitidine and Omeprazole. var. indicus was more potent mucoprotective properties compared to var. pubescens.

Hepatotoxic and hepatotoxic: Prabakan et al. (2000) found out that oral administration of ethanolic (70%) extract of H. indicus at a dose of 100 mg kg⁻¹, for 15 days, significantly prevented Rifampicin and Isoniazid-induced hepatotoxicity in rats. Srivastava and Shivanandappa (2006) demonstrated the hepatoprotective activity, both in single (50, 100 and 200 mg kg⁻¹ b.wt.) and multiple doses (50 and 100 mg kg⁻¹ b.wt. for 7 days) of aqueous extract D. hamiltonii against ethanol-induced oxidative stress and liver damage suggesting enhanced antioxidant defense mechanism. Baheti et al. (2006) established the hepatoprotective effect of H. indicus by oral route. Methanolic extract of H. indicus at a dose of 250 mg kg⁻¹ b.wt. was effective in CCl₄ induced hepatic damage whereas 500 mg kg⁻¹ b.wt. was effective in paracetamol induced hepatic damage. Biochemical parameters like Serum Glutamate Pyruvate Transaminase (SGPT), Serum Glutamate Oxaloacetate Transaminase (SGOT), Alkaline Phosphatase (ALP), total and direct bilirubin were within normal range and the results were comparable with standard hepatoprotective agent silymarin at a dose of 100 mg kg⁻¹ b.wt.

On the contrary, Anoop Austin and Jegadeesan (2002a) found that ethanolic (50%) extract of H. indicus var. indicus and var. pubescens produced hepatomegaly, which was confirmed by biochemical and histopathological studies. The reason may due to the extraction methodology, which might be due to a principle present in this type of extraction. Secondly the degree of hepatotoxicity was comparatively low in var. pubescens which needs further detailed studies. But this controversial result suggests further detailed studies in this aspect.

Diuretic: Satoskar et al. (1962) found out that alcoholic and steam distilled extracts of roots of H. indicus had no significant diuretic activity, whereas aqueous extract
caused a slight increase in urinary flow in rats, but not in dogs. Kotnis et al. (2004) found out that H. indicus as an adjunct therapy along with aminoglycosides, such as Gentamicin was able to reduce nephrotoxicity, caused by them.

Antidiarrhoeal: Das et al. (2003) proved that methanolic extract at a dose of 500-1500 mg kg\(^{-1}\) b.wt. elicited antidiarrhoeal activity which was effective than the standard antidiarrhoeal drug, Lomotil and the activity was due to inhibition of intestinal motility and its bactericidal activity. Evans et al. (2004) found out the aqueous extract at a dose of 50-200 mg kg\(^{-1}\) increases absorption of water, Na\(^+\) and K\(^+\) from the jejunum, on the contrary ethanolic extract decreased. Intestinal motility was not influenced. He suggested that this can be incorporated in Oral Dehydrating Salt solution (ORS) for increasing its anti-diarrhoeal efficacy.

Antivenom: The methanolic extract of H. indicus significantly neutralized viper-venom induced lethality and haemorrhagic activity in albino rat and mouse. Maximum neutralization was achieved (Alam et al., 1996). Chatterjee et al. (2006) isolated and purified Lupeol acetate from the methanolic extract of H. indicus which was found to neutralize venom induced action of Daboia russellii and Naja kaouthia on experimental animals. It could significantly neutralize lethality, haemorrhage, defibrinogenation, edema, PLA(2) activity induced by D. russellii venom. It also neutralized N. kaouthia venom induced lethality, cardotoxicity, neurotoxicity and respiratory changes in experimental animals.

Alam and Gomes (1998a) found out that 2-hydroxy-4-methoxy benzoic acid, isolated and purified from the methanolic extract possessed potent anti-inflammatory, antipyretic and antioxidant properties. It neutralized inflammation induced by Vipera russelli venom in male albino mice and reduced cotton pellet-induced granuloma. In addition, it also produced a significant fall in body temperature in yeast-induced pyrexia and did not change normothermic body temperature. The compound effectively neutralized viper-venom-induced changes in serum phosphatase and transaminase activities and neutralized free radical formation as estimated by TBAP and superoxide dismutase activities, which helps in neutralizing the venom. The study was further continued in Rabbis (Alam and Gomes, 1998b). The venom neutralizing capacity of this antiserum in rabbits immunized with Vipera russelli venom showed positive adjuvant effects as evident by the higher neutralization capacity (lethal and hemorrhage) when compared with the antiserum raised with venom alone. It potentiated the lethal action neutralization of venom by commercial equine polyvalent snake venom antiserum in experimental models. These observations raised the possibility of the use of chemical antagonists (from herbs) against snake bite, which may provide a better protection in presence of antiserum, especially in rural parts of India.

Antileptico: Ethanol (95%) extract was carried out for its delayed type cutaneous hypersensitivity stimulation effects by Atal et al. (1986). The aqueous extract of H. indicus was given orally at a concentration of 2% of diet in mice was active against Mycobacterium leprae (Gupta, 1981). The mice were infected with the test organism taken from leprosy patients. It delayed the cutaneous hypersensitivity stimulation at a dose of 100 mg kg\(^{-1}\). It also possessed immuno-modulator as well as immuno-suppressant activities at 100 mg kg\(^{-1}\). Phagocytosis was also decreased at 100 mg kg\(^{-1}\).

Anticancer: Sultana et al. (2003b) established the chemopreventive potential on 7,12-dimethylbenz[a]anthracene (DMBA)-initiated and 12-O-tetradecanoyl 13-phorbol acetate (TPA) promoted murine skin carcinogenesis. Topical application of H. indicus resulted in significant protection against cutaneous tumourgenesis. Topical application of plant extract at a dose level of 1.5 and 3.0 mg kg\(^{-1}\) b. wt. in acetone prior to that of TPA treatment resulted in significant inhibition of oxidative stress. The level of lipid peroxidation was significantly reduced. In addition, depleted levels of glutathione and reduced activities of antioxidant enzymes were restored, respectively which indicates its potent chemopreventive nature in skin carcinogenesis.

Decoction comprised of Nigella sativa seeds, H. indicus root bark and Smilax glabra rhizome treated for 10 week significantly inhibited diethylnitrosamine mediated expression of Glutathione S-transferase P form in rat liver (Iddamaldeniya et al., 2003). Thabrew et al. (2005) proved that it has a strong dose-dependent cytotoxic activity, which was further continued by Iddamaldeniya et al. (2006) revealed, anti-hepatocarcinogenic potential by inhibiting rat liver not only inhibiting diethylnitrosamine mediated expression of Glutathione S-transferase P form, but also the carcinogen mediated development of overt tumours and histopathological changes leading to tumour development.

Chemopreventive: Sultana et al. (2003a) found that H. indicus is an effective chemopreventive agent in skin and capable of ameliorating euene hydroperoxide-induced cutaneous oxidative stress and tumor promotion,
in a dose dependent manner from 1.5-3.0 mg kg\(^{-1}\) b.wt. Atal et al. (1986) studied the effect of ethanolic extract on delayed type hypersensitivity, humoral responses to sheep red blood cells, skin allograft rejection and phagocytic activity of the reticuloendothelial system in mice. He found that \textit{H. indicus} suppressed both the cell-mediated and humoral components of the immune system. Shetty et al. (2005) found that the radioprotective effect on lipid peroxidation in rat liver microsomes and plasmid DNA protected microsomal membranes by minimizing lipid peroxidation, which could protect DNA from radiation.

**Antioxidant and free radical scavenger:** Methanolic (50\%) extract demonstrated antioxidant properties by several \textit{in vitro} and \textit{ex vivo} models (Ravishankara et al., 2002). It scavenges DPPH and superoxide radicals, its activity was intense (EC\textsubscript{50} = 18.87 and 19.9 \mu M L\(^{-1}\), respectively) while in scavenging NO radical, it was moderate. It also inhibited lipid peroxidation of liver homogenate (EC\textsubscript{50} = 43.8 \mu M L\(^{-1}\)) and the haemolysis induced by phenylhydrazine (EC\textsubscript{50} = 9.74 \mu M L\(^{-1}\)) confirming membrane stabilization activity. He suggested that the free radical scavenging property might be one of the mechanisms, by which this drug is effective in several free radical mediated disease conditions. Srivastava et al. (2006) isolated the compounds, which exhibits free radical scavenging activity \textit{in vitro} and inhibited low-density lipoprotein oxidation, which helps in preventing oxidative damage. Mary et al. (2003a) found out that methanolic extract of \textit{H. indicus} roots inhibited lipid peroxidation and scavenges hydroxyl and superoxide radicals \textit{in vitro}. 50\% inhibition of lipid peroxide formation was achieved at 217.5 \mu M L\(^{-1}\), scavenges hydroxyl radicals at 73.5 \mu M L\(^{-1}\) and superoxide radicals at 287.5 \mu M L\(^{-1}\), respectively. Intravenous administration at a dose of 5 mg kg\(^{-1}\) b.wt. for rabbits delayed plasma recalification time and enhanced the release of lipoprotein lipase enzyme significantly. The extract also inhibited ADP-induced platelet aggregation \textit{in vitro} (50-250 \mu g), which was comparable with commercial heparin.

**Toxicity studies:** Toxicity studies of \textit{H. indicus} was carried out by Arseculeratne et al. (1985). The dried stem were fed to albino rats at a dose of 25\% in their diet for ten days. Histopathological studies showed hepatotoxic activity. There were diffuse hydropic degeneration and focal hepatocellular necrosis. Toxicity was seen in the liver, but not in the lungs or kidney. Atal et al. (1986) carried out quantitative toxicity assessment by oral route for LD\textsubscript{50}. It was found to be 2500 mg kg\(^{-1}\). Anoop Austin and Jegadeesan (2002, 2003a) carried out toxicity studies on \textit{H. indicus} var. \textit{indicus} and var. \textit{pubescens}. They also established the influence of seasonal variation and maturity of the parts. LD\textsubscript{50} was found to be 915.21 and 853.7 mg kg\(^{-1}\) during vegetative and flowering seasons of \textit{var. indicus}. Hepatomegaly and sclerosed glomeruli were observed, which were confirmed by biochemical parameters. This contradictory observation among the other studies as a hepatoprotective drug might be due to the fact of the aqueous alcoholic extract used for this study. Vegetative samples were safe compared to flowering seasonal samples. The reason for the changes in the difference in the qualitative and quantitative change in the biological active compound is due to genetic, climatic and development phase of the medicinal plants. var. pubescens possessed only nonspecific hepatomegaly which might be reversible, but care should be taken in liver diseases. LD\textsubscript{50} was found to be 848.3 and 813.7 mg kg\(^{-1}\) among seasonal variations.

**Cell culture studies:** Lampronti et al. (2005) analysed antiproliferative activity of extracts of \textit{H. indicus} on different human cell lines, including erythroleukemia K562, B-lymphoid Raji, T-lymphoid Jurkat and erythroleukemia HEL cell lines by electrophoretic mobility shift assay (EMSA). He found that low concentrations inhibit the interactions between nuclear factors and target DNA elements mimicking sequences recognized by the nuclear factor kappaB (NF-kappaB). This activity along with its tumor cell growth might be a source for anti-tumor compounds, while extracts inhibiting NF-kappa B/DNA interactions with lower effects on cell growth, could be of interest in the search of compounds active in inflammatory diseases, for which inhibition of NF-kappaB binding activity without toxic effects.

**Clinical studies:** Warrier et al. (1988) carried out a comparative clinical study with Indukanta ghrita and Mahatiktaka ghrita for peptic ulcer, where \textit{H. indicus} is a major ingredient in Mahatiktaka ghrita. Sharma et al. (1994) carried out studies on Sariva ghanasatva, which contains \textit{H. indicus} as a major ingredient was found to be effective against allergic conjunctivitis. It was also found that \textit{H. indicus} was effective in advanced cases of malignancies like multiple myeloma, adenocarcinoma, squamous cell carcinoma, Hodgkin’s lymphoma etc. though not a cure (Kulkarni, 1998).

**Miscellaneous:** Mary et al. (2003b) evaluated the antiatherogenic effect of a herbal formulation Caps HT2, by evolving its antioxidant, anticoagulant, platelet antiaggregatory, lipoprotein lipase releasing, anti-inflamatory and hypolipidemic activities in rats. It was found to scavenge superoxide and hydroxyl radicals; the IC\textsubscript{50} required being 55.0 and 610.0 \mu M L\(^{-1}\), respectively.
Lipid peroxidation was inhibited by 48.5 μg mL⁻¹. Intravenous administration at a dose of 5 mg kg⁻¹ delayed plasma recalcification time in rabbits and enhanced the release of lipoprotein lipase enzyme. It also inhibited ADP induced platelet aggregation in vitro, which was comparable to commercial heparin. It also possessed significant anti-inflammatory actions in acute and chronic inflammations induced by carrageenan and formalin, respectively in rats. Its hypolipidaemic effect in diet-induced hyperlipidaemia in rats was elucidated at a dose level of 100, 200, 300 and 400 mg kg⁻¹ and raised HDL cholesterol levels. The atherogenic index and reduction in body weight indicated its effectiveness against hyperlipidaemia and obesity. Study suggested that it can be suggested for vascular intimal damage and atherogenesis leading to various types of cardiovascular problems.

CONCLUSION

From the time immemorial, plants have been widely used as curative agent for variety of ailments. Roots are found in various herbal preparations that are in market today. Indian Sarsaparilla preparations are widely available and employed by practitioners of natural health for treatment of Peptic Ulcer Diseases (PUD), antioxidant, anti-inflammatory and antifeetility agent. The plant serves various purposes in improving mucin content, inhibiting H. pylori, improving gastric defensive factors and decreasing offensive factors, nephro-protective, antitumor, anticarcinogenic and in the management of many diseases, wherein a detailed research work on characterization and standardization is utmost required for this potential plant. However various studies are carried out, an authenticated comparative study will explore much debth about the plants used in the name Indian Sarsaparilla.

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