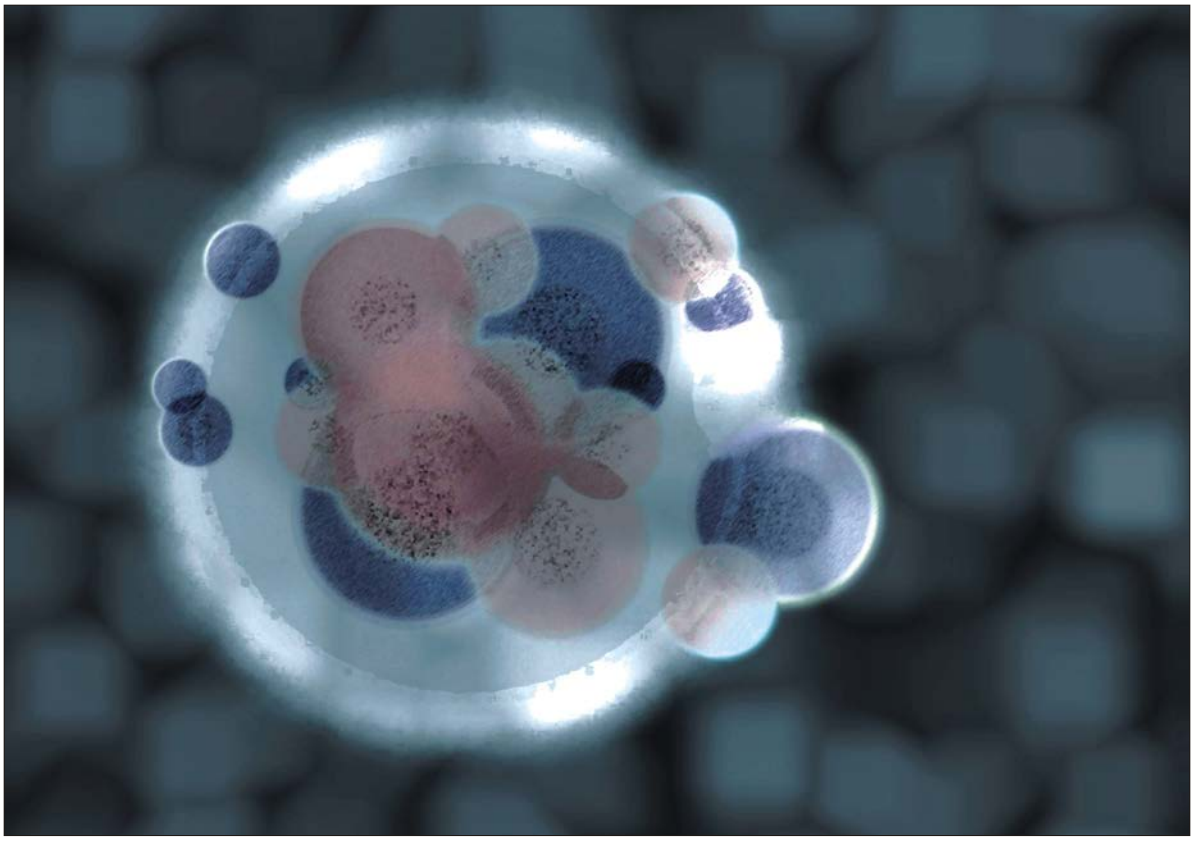

Journal of Biological Sciences

ISSN 1727-3048

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Journal of Biological Sciences 8 (1): 1-12, 2008
ISSN 1727-3048

A Review on Indian Sarsaparilla, *Hemidesmus indicus* (L.) R. Br.

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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: Asclepiadaceae) 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, antiulcer, hepatoprotective, antioxidant and helicobactericidal 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, Asclepiadaceae, Indian sarsaparilla

INTRODUCTION

Hemidesmus indicus commonly known as Indian Sarsaparilla, belonging to the family Asclepiadaceae, is a slender laticiferous, 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 subsessile 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 *Cryptolepis 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 Murugesa Mudhaliar (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

Fig. 1: *Hemidesmus indicus*

(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; Pullaiah 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 (Khanna *et al*., 1996). Root decoction is useful for curing high fever and skin diseases (Sudhakar 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 (Banerjee 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 (Selvanayahgam *et al*., 1994). Decoction taken thrice 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. buchanani* 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. buchanani*, *D. hamiltoni* and *H. indicus* belonging to the family Asclepiadaceae; *I. frutescens* and *V. solanaceae* of the family Apocyanaceae. 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, Aravindakshan 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*, hemidesmol, 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 triconate acid and lupeol octacosonate (Padhy *et al*., 1973), a

coumarino 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, hemidesterol, 2-hydroxy-4-methoxy benzaldehyde, resin acid, glucoside, sterol and tannins (Anonymous, 1997). Mukherjee and Ray (1980) reported that roots of *H. indicus* contain steroid, terpenoid, flavonoid and saponin, but alkaloid is absent. Oberai *et al.* (1985) noted that dried twigs of *H. indicus* yield a pregnane ester diglycoside desinine.

The presence of α-amyrin triterpene, β-amyrin triterpene and benzaldehyde, 2-hydroxy-4-methoxy benzenoid 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 benzenoid in the roots. Coumarin derivatives namely hemidesmin-1-coumarin and hemidesmin-2-coumarin in the roots were reported by Das *et al.* (1992). Nagarajan 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, lupanone, Δ^{12}-dehydrolupanyl-3-β-acetate, Δ^{12}-dehydro lupeol acetate, 4-hydroxy-3-methoxy benzaldehyde. Chloroform and alcohol extracts of stem yielded two novel pregnane glycosides, hemidescine and emidine (Chandra *et al*., 1994). Oligoglycosides, indicusin and medidesmine, hemisine and desmine were isolated from the plant (Deepak *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 benzenoid 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. indiucs*. 0.0004% of calogenin-3-O-β-D-digitoxopyrano steroid (Prakash *et al*., 1991), side-desinine steroid (Oberai *et al*., 1985), 0.0009% of desminine steroid (Deepak *et al*., 1997), Emidine and hemidescine steroids (Chandra *et al*., 1994), 0.0004% of hemidine steroid (Prakash *et al*., 1991) and hemisine 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 lupanone 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 Arseculeratne *et al.* (1985). He also reported the absence of pyrrolizidine 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, denicumine (calogenin 3-O-3-O-methyl-β-D-fucopyranosyl-(1->4)-O-β-D-oleandropyranosi de) and heminine (calogenin 3-O-β-D-cymaropyranosyl-(1->4)-O-β-D-digitoxopyranoside+ ++).

Leaves: 2.50% of tannins were present in the leaves (Daniel *et al*., 1978). Coumarinolignoids like hemidesminine (Mandal *et al*., 1991), hemidesmin, 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 flavanoid glycosides identified in the flowers of *H. indicus* were hyperoside, isoquercitin and rutin (Subramanian and Nair, 1968). He also reported the presence of iso-quercitrin 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 oleanenes, which were identified as olean-12-en-21 β-yl acetate and olean-12-en-3 α-yl acetate, three ursenes were characterized as 16 (17)-seco-urs-12, 20 (30)-dien-18-α H-3β-yl actetate, 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 us 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. hamiltoni: Harish *et al.* (2005) identified 2-hydroxy-4-methoxybenzaldehyde, p-anisaldehyde, vanillin, borneol, salicylaldehyde and bis-2,3,4,6-galloyl-α/β-D-glucopyranoside 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-methylresorcylaldehyde (9.12%), benzyl alcohol (3.16%) and α-atlantone (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) evolved qualitative variations among seasonal samples and varieties. Physiochemical 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 Sarasan *et al.* (1994), Malathy and Pai (1995), Sharma and Yelne (1995), Jayanthi 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-benzyl aminopurine 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-butyric 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} (IC_{50}), methanolic extract at 200 μg mL^{-1} (IC_{50}) and 50% methanolic extract at 320 μg mL^{-1} (IC_{50}) 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 jeanselmei*, *Piedraia hortae* and *Trichophyton mentagrophytes*. Aqueous extract was studied against *M. canis*, *M. gypseum*, *Phialophora jeanselmei*, *Piedraia hortae* and *T. mentagrophytes*. Antiyeast 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 Kiuchi *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 disc diffusion 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 helicobactericidal 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 tritepenoid 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 inhibits *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 ESβL-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 carageenin, 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. $PGF_{2\alpha}$. var. *indicus* exerts mucoprotective effect comparable with standard drugs Ranitidine and Omeprazole. var. *indicus* was more potent mucoprotective properties compared to var. *pubescens*.

Hepatotonic 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 CCl_4 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 jejunam, 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 by 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, cardiotoxicity, 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 TBAPS and superoxide dismutase activities, which helps in neutralizing the venom. The study was further continued in Rabbits (Alam and Gomes, 1998b). The venom neutralizing capacity of this antiserum in rabbits immunized with *Vipera russellii* 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.

Antileprotic: Ethanolic (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-dimethyl-benz[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 tumourogenesis. 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 cumene 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 *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 *in vitro* and *ex vivo* models (Ravishankara *et al.*, 2002). It scavenges DPPH and superoxide radicals, its activity was intense (EC_{50} = 18.87 and 19.9 μg mL^{-1}, respectively) while in scavenging NO radical, it was moderate. It also inhibited lipid peroxidation of liver homogenate (EC_{50} = 43.8 μg mL^{-1}) and the haemolysis induced by phenylhydrazine (EC_{50} = 9.74 μg mL^{-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 *in vitro* and inhibited low-density lipoprotein oxidation, which helps in preventing oxidative damage. Mary *et al.* (2003a) found out that methanolic extract of *H. indicus* roots inhibited lipid peroxidation and scavenges hydroxyl and superoxide radicals *in vitro*. 50% inhibition of lipid peroxide formation was achieved at 217.5 μg mL^{-1}, scavenges hydroxyl radicals at 73.5 μg mL^{-1} and superoxide radicals at 287.5 μg mL^{-1}, respectively. Intravenous administration at a dose of 5 mg kg^{-1} b.wt. for rabbits delayed plasma recalcification time and enhanced the release of lipoprotein lipase enzyme significantly. The extract also inhibited ADP-induced platelet aggregation *in vitro* (50-250 μg), which was comparable with commercial heparin.

Toxicity studies: Toxicity studies of *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_{50}. It was found to be 2500 mg kg^{-1}. Anoop Austin and Jegadeesan (2002, 2003a) carried out toxicity studies on *H. indicus* var. *indicus* and var. *pubescens*. They also established the influence of seasonal variation and maturity of the parts. LD_{50} was found to be 915.21 and 853.7 mg kg^{-1} during vegetative and flowering seasons of 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. pubesecns possessed only nonspecific hepatomegaly which might be reversible, but care should be taken in liver diseases. LD_{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 *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 ghirta and Mahatiktaka ghrita for peptic ulcer, where *H. indicus* is a major ingredient in Mahatiktaka ghrita. Sharma *et al.* (1994) carried out studies on Sariva ghanasatva, which contains *H. indicus* as a major ingredient was found to be effective against allergic conjunctivitis. It was also found that *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-inflammatory and hypolipidaemic activities in rats. It was found to scavenge superoxide and hydroxyl radicals; the IC_{50} required being 55.0 and 610.0 μg mL^{-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 antifertility 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 atmost 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.

REFERENCES

Afzal Azam, M.D., A. Rahamathullah, S. Raveendran and Rajeev Dube, 1996. Formulation and evaluation of polyherbal haircare powders. Anc. Sci. Life, 16: 15-20.

Ahmad, I. and F. Aqil, 2006. *In vitro* efficacy of bioactive extracts of 15 medicinal plants against ESβL-producing multidrug-resistant enteric bacteria. Microbiol. Res., (In Press).

Alam, M.I., B. Auddy and A. Gomes, 1994. Isolation, purification and partial characterization of viper venom inhibiting factor from the root extract of the Indian medicinal plant sarsaparilla (*Hemidesmus indicus* R. Br.). Toxicon, 32: 1551-1557.

Alam, M.I., B. Auddy and A. Gomes, 1996. Viper venom neutralization by Indian medicinal plant (*Hemidesmus indicus*, *Pluchea indica*). Phytother. Res., 10: 58-61.

Alam, M.I. and A. Gomes, 1998a. Viper venom-induced inflammation and inhibition of free radical formation by pure compound (2-hydroxy-4-methoxy benzoic acid) isolated and purified from Anantamul (*Hemidesmus indicus* R. Br. root extract. Toxicon, 36: 207-215.

Alam, M.I. and A. Gomes, 1998b. Adjuvant effects and antiserum action potentiation by a (herbal) compound 2-hydroxy-4-methoxy benzoic acid isolated from the root extract of the Indian medicinal plant sarsaparilla *Hemidesmus indicus* R. Br. Toxicon, 36: 1423-1431.

Ali, M.A., M. Mikage, F. Kiuchi, Y. Tsuda and L. Kondo, 1991. Screening of crude drugs used in Bangladesh for nematodical activity on the larva of *Toxocara canis*. Shoyakugaku Zasshi, 45: 206-214.

Anonymous, 1986. The useful plants of India. CSIR, New Delhi, India.

Anonymous, 1996. Indian Pharmacopoeia. Indian Pharmacopoeia Committee, Ministry of Health and Family Welfare, Government of India, New Delhi.

Anonymous, 1997. The Wealth of India. Raw materials, Vol. III, V and X, CSIR, New Delhi, India.

Anonymous, 2003. British Pharmacopoeia. British Pharmacopoeia Commission, Market Towers, 1 Nine Elms Lane, London.

Anoop Austin and M. Jegadeesan, 2002. Acute and sub-acute toxicity studies of *Hemidesmus indicus* var. *pubescens* R. Br. Anc. Sci. Life, 12: 34-41.

Anoop Austin, M. Jegadeesan and G. Shanthi, 2002. Pharmacognostical studies on roots of varieties of *Hemidesmus indicus* R. Br. J. Swamy Bot. Club., 19: 37-43.

Anoop Austin and M. Jegadeesan, 2003a. Toxicological studies on *Hemidesmus indicus* var. *indicus* R. Br. Hamdard Medicus, 46: 91-96.

Anoop Austin and M. Jegadeesan, 2003b. Influence of seasonal changes in the toxicity of *Hemidesmus indicus* var. *pubescens* R. Br. Convergence, 5: 56-63.

Anoop Austin and M. Jegadeesan, 2003c. Biochemical studies on the anti-ulcerogenic potential of *Hemidesmus indicus* var. *indicus* R. Br. J. Ethnopharmacol., 84: 149-156.

Anoop Austin and M. Jegadeesan, 2003d. Anti-ulcer potential of *Hemidesmus indicus* var. *pubescens* R. Br. Hamdard Medicus, 46: 62-69.

Anoop Austin, M. Jegadeesan and R. Gowrishankar, 2003a. A study on *Hemidesmus indicus* var. *pubescens* R. Br. against *Helicobacter pylori*. Indian J. Applied Pure Biol., 18: 107-110.

Anoop Austin, M. Jegadeesan and R. Gowrishankar, 2003b. Antimicrobial activity of *Hemidesmus indicus* var. *indicus* R. Br. against human isolates of *Helicobacter pylori*. Nat. Prod. Sci., 9: 1-3.

Aravindakshan, N.G. and N. Ramiah, 1982. Physiochemical methods of identification and estimation of substitutes/adulterants in the single drug mixture and finished product. J. Sci. Res. Plant Med., 3: 57-60.

Arseculeratne, S.N., A.A.L. Gunatilaka and R.G. Panabokke, 1985. Studies on medicinal plant of Srilanka. Part 14: Toxicity of some traditional medicinal herbs. J. Ethnopharmacol., 13: 323-335.

Atal, C.K., M.L. Sharma, A. Kaul and A. Khajuria, 1986. Immunomodulating agents of plant origin. I: Preliminary screening. J. Ethnopharmacol., 18: 133-141.

Baheti, J.R., R.K. Goyal and G.B. Shah, 2006. Hepatoprotective activity of *Hemidesmus indicus* R. Br. in rats. Indian J. Exp. Biol., 44: 399-402.

Balasubramanian, P. and N.S. Prasad, 1996. Medicinal Plants among the Irulars of Attappady and Boluvampatti Forests in the Nilgiri Biosphere Reserve. In: Ethnobotany in South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Banerjee, D.K. and D.C. Pal, 1996. Plant Used by the Tribals of North India Plains for Hair and Scalp Preparation. In: Ethnobiology in Human Welfare, Jain, S.K. (Ed.). Deep Publications, New Delhi, India.

Bhandary, M.J.M., K.R. Chandrashekar and K.M. Kaveriappa, 1995. Medical ethnobotany of the siddis of Uttara Kannada district, Karnataka. India J. Ethnopharmacol., 47: 149-158.

Bopanna, K.N., N. Bhagyalakshmi, S.P. Rathod, R. Balaraman and J. Kannan, 1997. Cell culture derived *Hemidesmus indicus* in the prevention of hypercholesterolemia in normal and hyperlipidaemic rats. Indian J. Pharmacol., 29: 105-109.

Chandra, R., D. Deepak and A. Khare, 1994. Pregnane glycosides from *Hemidesmus indicus*. Phytochemistry, 35: 1545-1548.

Chatterjee, R.C. and B.K. Bhattacharya, 1955. A note on the isolation of β-sitosterol from *Hemidesmus indicus*. J. Ind. Chem. Soc., 32: 485-486.

Chatterjee, I., A.K. Chakravarty and A. Gomes, 2006. *Daboia russellii* and *Naja kaouthia* venom neutralization by lupeol acetate isolated from the root extract of Indian sarsaparilla *Hemidesmus indicus* R.Br. J. Ethnopharmacol., 106: 38-43.

Chopra, R.N., S.L. Nayar and I.C. Chopra, 1956. Glossary of Indian Medicinal Plants. CSIR, New Delhi, India.

Daniel, M., S.D. Sabins and N.V. Mani, 1978. Estimation of tannins in some of the forest resources of Gujarat. Indian J. For., 1: 223.

Das, P.C., P.C. Joshi, S. Mandal, A. Das and A. Chatterjee, 1992. New Coumarinolignoids from *Hemidesmus indicus* R. Br. Indian J. Chem., 31B: 342-345.

Das, S., R. Prakash and S.N. Devaraj, 2003. Antidiarrhoeal effects of methanolic root extract of *Hemidesmus indicus* (Indian sarsaparilla)-an *in vitro* and *in vivo* study. Indian J. Exp. Biol., 41: 363-366.

Das, S. and S.N. Devaraj, 2006a. Antienterobacterial activity of *Hemidesmus indicus* R. Br. root extract. Phytother Res., 20: 416-421.

Das, S. and S.N. Devaraj, 2006b. Glycosides derived from *Hemidesmus indicus* R. Br. root inhibit adherence of *Salmonella typhimurium* to host cells: Receptor mimicry. Phytother Res., (In Press).

Deepak, S., S. Srivastava and A. Khare, 1995. Indicusin A pregnane diester triglycoside from *Hemidesmus indicus* R. Br. Nat. Prod. Lett., 6: 81-86.

Deepak, S., S. Srivastava and A. Khare, 1997. Pregnane glycosides from *Hemidesmus indicus*. Phytochemistry, 44: 145-151.

Dhar, M.L., M.M. Dhar, B.N. Dhawan, B.N. Mehrotra and C. Ray, 1968. Screening of Indian plants for biological activity: Part I. Indian J. Exp. Biol., 6: 232-247.

Dutta, M.K., T.K. Sen and S. Sikdar, 1982. Some preliminary observations on the anti-inflammatory properties *Hemidesmus indicus* in rat. Indian J. Pharmacol., 14: 78.

Evans, D.A., S. Rajasekharan and A. Subramoniam, 2004. Enhancement in the absorption of water and electrolytes from rat intestine by *Hemidesmus indicus* R. Br. root (water extract). Phytother. Res., 18: 511-515.

Girach, R.D., Aminuddi, P.A. Siddiqui and S.A. Khan, 1994. Traditional plant remedies among the Kondh of district Dhenkanal (Orissa). Int. J. Pharmacog., 32: 274-283.

Giridhar, P., T. Rajasekaran, S. Nagarajan and G.A. Ravishankar, 2004. Production of 2-hydroxy-4-methoxybenzaldehyde in roots of tissue culture raised and acclimatized plants of *Decalepis hamiltonii* Wight and Arn. an endangered shrub endemic to Southern India and evaluation of its performance vis-a-vis plants from natural habitat. Indian J. Exp. Biol., 42: 106-110.

Gupta, P.N., 1981. Antileprotic action of an extract from Anantamul. (*Hemidesmus indicus* R. Br.), Lepr. India, 53: 354-359.

Gupta, M.M., R.K. Verma and L.N. Misra, 1992. Terpenoids from *Hemidesmus indicus*. Phytochemistry, 31: 4036-4037.

Gururaj, H.B., P. Giridhar and G.A. Ravishankar, 2004. Efficient clonal propagation method for *Decalepis hamiltonii*, an endangered shrub, under the influence of phloroglucinol. Indian J. Exp. Biol., 42: 424-428.

Harish, R., S. Divakar, A. Srivastava and T. Shivanandappa, 2005. Isolation of antioxidant compounds from the methanolic extract of the roots of *Decalepis hamiltonii* (Wight and Arn.). J. Agric. Food Chem., 53: 7709-7714.

Iddamaldeniya, S.S., N. Wickramasinghe, I. Thabrew, N. Ratnatunge and M.G. Thammitiyagodage, 2003. Protection against diethylnitrosoamine-induced hepatocarcinogenesis by an indigenous medicine comprised of *Nigella sativa*, *Hemidesmus indicus* and *Smilax glabra*: A preliminary study. J. Carcino., 2: 6.

Iddamaldeniya, S.S., M.I. Thabrew, S.M. Wickramasinghe, N. Ratnatunge and M.G. Thammitiyagodage, 2006. A long-term investigation of the anti-hepatocarcinogenic potential of an indigenous medicine comprised of *Nigella sativa*, *Hemidesmus indicus* and *Smilax glabra*. J. Carcino., 9: 11.

Jain, S.P. and S.C. Singh, 1994. Ethno-medico-botanical survey of Ambikapur Dist., M.P. 4th International Congress of Ethnobiology. NBRI, Lucknow, U.P., India.

Jain, S.P., 1996. Ethno-Medico-Botanical Survey of Chaibasa, Singhbhum District, Bihar. In: Ethnobotany in South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Jain, A. and E. Basal, 2003. Inhibition of Propionibacterium acnes-induced mediators of inflammation by Indian herbs. Phytomedicine, 10: 34-38.

Jayanthi, M. and V. Patil, 1995. Micropropagation studies of some medicinal plants of Western Ghats. Proceeding International Conference on Current Progress on Medicinal and Aromatic Plant Research, Calcutta, India.

John, D., 1984. One hundred useful raw drugs of the kani tribes of Trivandrum forest division, Kerala, India. Int. J. Crude Drug Res., 22: 17-39.

Karnick, C.R., 1978. Ethnobotanical, pharmacognostical and cultivation studies of *Hemidesmus indicus* R. Br. (India Sarasaparilla). Chem. Abst., 88: 130.

Khan, L.A., A.Q. Khan and S.H. Afaq, 1983. A medicinal study of Ushba, (Sarasaparilla, Asclepiadaceae). Nagarjun, pp: 149-151.

Khanna, K.K., V. Mudgi, G. Shukla and P.K. Srivastava, 1996. Unreported Ethnomedicinal Uses of Plants from Mirzapur Dist. U.P. In: Ethnobotany in South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Kirthikar, K.R. and B.D. Basu, 1980. Indian medicinal plants. Vol. 1-4. Bishen Singh Mahendra Pal Singh, Dehradun, India.

Kiuchi, F., M. Hioki, N. Nakamura, N. Miyashita, Y. Tsuda and K. Kondo, 1989. Screening of crude drugs used in Srilanka for nematocidal activity on the larva of Toxocaria canis. Shoyakugaku Zasshi, 43: 288-293.

Kotnis, M.S., P. Patel, S.N. Menon and R.T. Sane, 2004. Renoprotective effect of *Hemidesmus indicus*, a herbal drug used in gentamicin-induced renal toxicity. Nephrology (Carlton), 9: 142-152.

Kulkarni, A.S., 1998. A ray of hope for cancer patients. Proceeding International Seminar on Holistic Management of Cancer, Chennai, India.

Lampronti, I., M.T. Khan, N. Bianchi, A. Ather, M. Borgatti, L. Vizziello, E. Fabbri and R. Gambari, 2005. Bangladeshi medicinal plant extracts inhibiting molecular interactions between nuclear factors and target DNA sequences mimicking NF-kappaB binding sites. Med. Chem., 1: 327-333.

Malathy, S. and J.S. Pai, 1995. Studies on tissue culture of *Hemidesmus indicus*, Abst. International Seminar on Recent Trends in Pharmaceutical Sciences, Ootacamund, South India.

Malhotra, S.K. and S. Murthy, 1973. Some useful and medicinal plants of Chandrapur district (Maharastra state). Bull. Bot. Surv. India, 15: 13-21.

Mandal, S., P.C. Das, P.C. Joshi, A. Das and A. Chatterjee, 1991. Hemidesmine, a new coumarino lignoid from *Hemidesmus indicus* R. Br. Indian J. Chem., 30: 712-713.

Mandal, S., P.C. Das, P.C. Joshi and A. Chatterjee, 1995. Chemistry of coumarinolignoids, a rare class of plant products having anti-cancer and anti hepatotoxic activities. Proceeding Seminar on Research in Ayurveda and Siddha. CCRAS, New Delhi.

Mary, N.K., C.R. Achuthan, B.H. Babu and J. Padikkala, 2003a. *In vitro* antioxidant and antithrombotic activity of *Hemidesmus indicus* (L.) R. Br. J. Ethnopharmacol., 87: 187-191.

Mary, N.K., B.H. Babu and J. Padikkala, 2003b. Antiatherogenic effect of Caps HT2, a herbal Ayurvedic medicine formulation. Phytomedicine, 10: 474-482.

Mukherjee, B., 1953. The Indian pharmaceutical codex, Vol. II, Indigenous drugs. CSIR, New Delhi, India.

Mukherjee, K. and L.N. Ray, 1980. Screening of some Indian plant species. Q. J. Crude Drug Res., 18: 77-82.

Murthi, B.R. and T.R. Seshadri, 1941. A study of the chemical components of the roots of *Decalepis hamiltoni*, Part III. Comparison with *Hemidesmus indicus* (Indian Sarasaparilla). Proceeding Indian. Acad. Sci., 13: 399-403.

Murugesa Mudhaliar, K.S., 1988. Gunapadam. Vol. I (In Tamil), Tamil Nadu Siddha Medical Board, Chennai, India.

Nadkarni, A.N., 1989. Indian Material Medica, Vol. I, Popular Book Depot, Bombay, India.

Nagarajan, S. and L.J. Rao, 2003. Determination of 2-hydroxy-4-methoxybenzaldehyde in roots of *Decalepis hamiltonii* (Wight and Arn.) and *Hemidesmus indicus* R.Br. J. AOAC Int., 86: 564-567.

Nagaraju, N. and K.N. Rao, 1990. A survey of plant crude drugs of Rayalaseema, Andhra Pradesh, India. J. Ethnopharmacol., 29: 137-158.

Namba, T., M. Tsunezuka, D.M.R.R.B. Dissanayake, U. Pilaptiya, K. Saito, N. Kakiuci and M. Hattori, 1985. Studies on dental caries prevention by traditional medicines (Part VII). Screening of Ayurvedic medicines for antiplaque action. Shoyakugaku Zasshi, 39: 146-153.

Naovi, S.A.H., M.S.Y. Khan and S.B. Vohora, 1991. Antibacterial, antifungal and anthelmintic investigations on Indian medicinal plants. Fitoterapia, 62: 221-228.

Nayar, R.C., 1979. A review on the Ayurvedic drug Sariva. J. Res. Ind. Med. Yoga Homoeo., 14: 69-79.

Oberai, K., M.P. Khare and N.L. Dutta, 1985. A pregnane ester diglycoside from *Hemidesmus indicus*, Phytochemistry, 24: 2395-2397.

Padhy, S.N., S.B. Mahato and N.L. Dutta, 1973. Asclepiadaceae Terpenoides from the roots of *Hemidesmus indicus*. Phytochemistry, 12: 217-218.

Patnaik, J. and B.K. Debata, 1997. Micropropogation of *Hemidesmus indicus* (L.). R. Br. through axillary bud culture. Plant Cell Rep., 15: 427-430.

Paul, S.R., 1979. Medicinal plants of Netarhat, Bihar (India). Q. J. Crude Drug Res., 15: 79-97.

Prabakan, M., R. Anandan and T. Devaki, 2000. Protective effect of *Hemidesmus indicus* against Rifampicin and Isoniazid-induced hepatotoxicity in rats. Fitoterapia, 71: 55-59.

Prakash, K., A. Sethi, D. Deepak, A. Khare and M.P. Khare, 1991. Two pregnane glycosides from *Hemidesmus indicus*. Phytochemistry, 30: 297-299.

Prasad, S., S.P. Wahi and L.C. Mishra, 1964. Pharmacognostical investigation on Indian Sarasaparilla, its substitutes and adulterants, Part I *Hemidesmus indicus* R. Br. Indian J. Pharmacy, 36: 81.

Prasad, S. and S.P. Wahi, 1965. Pharmacognostical investigation on Indian Sarasaparilla Part I. Root and root-stock of *Hemidesmus indicus* R. Br. Indian J. Pharmacy, 37: 35-39.

Prasad, N.P., A.J.A. Ranjit Singh, L.M. Narayanan and C.R. Natarajan, 1996. Ethnobiology of the Kamkkars of South Tamil Nadu. In: Ethnobotany in South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Pullaiah, T. and D.C.T. Kumar, 1996. Herbal Plants in Mannanur Forest Mahaboob Nagar Dist., AP. In: Ethnobotany in South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Pushpangadan, P. and C.K. Atal, 1984. Ethno-medico-botanical investigations in Kerala I. Some primitive tribals of Western ghats and their herbal medicine. J. Ethnopharmacol., 11: 59-77.

Qureshi, S., M.K. Rai and S.C. Agrawal, 1997. *In vitro* evaluation of inhibitory nature of extracts of 18-plant species of Chhindwara against 3-keratinophilic fungi. Hindustan Antibiot. Bull., 39: 56-60.

Rafat, U.S., 1977. A study of pharmacognosy of Ushba (Sarasaparilla). Thesis (Submitted) Muslim University, Aligarh.

Rajendra Prasad, Y., G.S.J.G. Alankararao and P. Baby, 1983. Antimicrobial studies on essential oil of *Hemidesmus indicus* R. Br. Indian Perfumer, 27: 197-199.

Ramachandran, V.S.S. and N.C. Nair, 1981. Ethnobotanical observations on Irulars of Tamil Nadu (India). J. Econ. Tax. Bot., 2: 183-190.

Ravishankara, M.N., N. Shrivastava, H. Padh and M. Rajani, 2002. Evaluation of antioxidant properties of root bark of *Hemidesmus indicus* R. Br. (Anantmul). Phytomedicine, 9: 153-160.

Reddy, M.B., K.R. Reddy and M.N. Reddy, 1988. A survey of medicinal plants of Chenchu tribes of Andhra Pradesh. India Int. J. Crude Drug Res., 26: 189-196.

Roy, S.K., M. Ali and M.P. Sharma, 1998. Phytochemical standardization of an Ayurvedic controversial drug Sariva. Proceeding IPCA, Mumbai, India.

Roy, S.K., M. Ali, M.P. Sharma and R. Ramachandram, 2001. New pentacyclic triterpenes from the roots of *Hemidesmus indicus*. Pharmazie, 56: 244-246.

Sabnis, S.D. and S.J. Bedi, 1983. Ethnobotanical studies in Dadra-Nagar Haveli and Daman. Indian J. For., 6: 65-69.

Sahu, T.R., 1984. Less known uses of weeds as medicinal plants. Anc. Sci. Life, 3: 245-249.

Sarasan, V., E.V. Soniya and G.M. Nair, 1994. Regeneration of Indian sarasaparilla, *Hemidesmus indicus* R. Br. through organogenesis and somatic embryogenesis. Indian J. Expt. Biol., 32: 284-287.

Satoskar, R.S., L.G. Shah, K. Bhatt and U.K. Sheth, 1962. Preliminary study of pharmacologic properties of Anantmul (*Hemidesmus indicus*). Indian J. Physiol. Pharmacol., 6: 68-76.

Selvanayahgam, Z.E., S.G. Gnanevendhan, K. Balakrishna and R.B. Rao, 1994. Antisnake venom botanicals from ethnomedicine. J. Herbs Spices Med. Plants, 2: 45-100.

Shah, G.L. and G.V. Gopal, 1985. Ethnomedical notes from the tribal inhabitants of the North Gujarat. J. Econ. Taxon. Bot. (India), 6: 193-201.

Sharma, P.K., S.K. Dhyani and V. Shankar, 1979. Some useful and medicinal plants of the district Dehradun and Siwalik. J. Sci. Res. Plant Med., 1: 17-43.

Sharma, K.R., R.P. Bhatia and B.P. Reddy, 1994. The role of the indigenous drug Sarivaghanasatva in allergic conjunctivitis. Ann. Ophthalmal-Glaucoma, 26: 141-144.

Sharma and Yelne, 1995. Observations on *in vitro* propagation of Sariva (*Hemidesmus indicus* R. Br)., Proceeding Seminar on research in Ayurveda and Siddha, New Delhi.

Shetty, T.K., J.G. Satav and C.K. Nair, 2005. Radiation protection of DNA and membrane *in vitro* by extract of *Hemidesmus indicus*. Phytother Res., 19: 387-390.

Shukla, G. and B.K. Verma, 1996. Roots a Vital Plant Part of Cure Body Ailments Among Tribals/Rural Folk-Lore of Western Bihar. In: Ethnobotany of South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Sigler, P., R. Saksena, D. Deepak and A. Khare, 2000. C21 steroidal glycosides from *Hemidesmus indicus*. Phytochemistry, 54: 983-987.

Singh, K.K. and J.K. Maheswari, 1983. Traditional phytotherapy among the tribals of Varanasi dist., U.P. J. Econ. Tax. Bot., 4: 803-829.

Singh, V.K. and Z.A. Ali, 1992. A contribution to the ethno-pharmacological study of the Udaipur forests of Rajasthan, India. Fitoterapia, 63: 136-144.

Singh, K.K. and A. Prakash, 1996. Observations on Ethnobotany of the Koltribe of Varanasi District, U.P., India. In: Ethnobotany of South Asia, Maheswari, J.K. (Ed.). Scientific Publishers, Jodhpur, India.

Srivastava, A. and T. Shivanandappa, 2006. Hepatoprotective effect of the aqueous extract of the roots of *Decalepis hamiltonii* against ethanol-induced oxidative stress in rats. Hepatol. Res., 35: 267-275.

Srivastava, A., R. Harish and T. Shivanandappa, 2006. Novel antioxidant compounds from the aqueous extract of the roots of *Decalepis hamiltonii* (Wight and Arn.) and their inhibitory effect on low-density lipoprotein oxidation. J. Agric. Food Chem., 54: 790-795.

Subramanian, S.S. and A.G.R. Nair, 1968. Flavonoids of some Asclepiadaceous plants. Phytochemistry, 7: 1703-1704.

Sudhakar, S. and R.S. Rao, 1985. Medicinal plants of upper East Godavari district (Andhra Pradesh) and need for establishment of medicinal farm. J. Econ. Tax. Bot., 7: 399-405.

Sultana, S., N. Khan, S. Sharma and A. Alam, 2003a. Modulation of biochemical parameters by *Hemidesmus indicus* in cumene hydroperoxide-induced murine skin: Possible role in protection against free radicals-induced cutaneous oxidative stress and tumor promotion. J. Ethnopharmacol., 85: 33-41.

Sultana, S., A. Alam, N. Khan and S. Sharma, 2003b. Inhibition of cutaneous oxidative stress and two-stage skin carcinogenesis by *Hemidesmus indicus* (L.) in Swiss albino mice. Indian J. Exp. Biol., 41: 1416-1423,

Suresh, M. and R.K. Rai, 1990. Cardol the antifilarial principle from *Anacardium occidentale*. Curr. Sci., 59: 477-479.

Thabrew, M.I., R.R. Mitry, M.A. Morsy and R.D. Hughes, 2005. Cytotoxic effects of a decoction of *Nigella sativa*, *Hemidesmus indicus* and *Smilax glabra* on human hepatoma HepG2 cells. Life Sci., 77: 1319-1330.

Thangadurai, D., S. Anitha, T. Pullaiah, P.N. Reddy and O.S. Ramachandraiah, 2002. Essential oil constituents and *in vitro* antimicrobial activity of *Decalepis hamiltonii* roots against foodborne pathogens. J. Agric. Food Chem., 50: 3147-3149.

Togunashi, V.S., S.N. Yoganarasimhan and B.S. Venkataram, 1978. A new source of sariva and identification of shweta sariva. J. Res. Ind. Med. Yoga Homoeo., 13: 75-80.

Verma, P.R., A.A. Joharapurkar, V.A. Chatpalliwar and A.J. Asnani, 2005. Antinociceptive activity of alcoholic extract of *Hemidesmus indicus* R. Br. in mice. J. Ethnopharmacol., 102: 298-301.

Vyas, Y., 1993. Utility of Juvardhan dashomani in the treatment of fever. Sachitra Ayurved, 45: 748-755.

Wahi, A.K., R.L. Khosa and A.K. Mukherjee, 1978. Diagnostic characters of Sariva. J. Res. Ind. Med. Yoga Homoeo., 14: 166-169.

Warrier, P.K., P.P.N. Bhattathriti, P. Radhakrishnan and P. Balachandran, 1988. Comparative clinical study of Indukanta Ghirta and Mahatiktaka Ghrita in Parinamasula (Peptic ulcer). J. R.A.S., 10: 15-29.