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Nutritional, pharmacological activities and food application of nannari root: A review

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Abstract
Hemidesmus indicus, commonly known as Indian Sarsaparilla and locally known as nannari is a medicinal plant that has been used in traditional Ayurvedic medicine for centuries. This plant is known for its diverse phytochemical composition, including flavonoids, saponins, alkaloids, and phenolic compounds, which have been found to possess potent antioxidant and anti-inflammatory properties. The antioxidant activity of *Hemidesmus indicus* has been linked to its ability to scavenge free radicals and inhibit oxidative stress, which can contribute to the development of chronic diseases such as cancer, diabetes, and cardiovascular diseases. *Hemidesmus indicus* has been shown to have several health benefits, including anti-cancer, anti-diabetic, anti-inflammatory, and anti-microbial properties. The plant has also been found to have wound healing, neuroprotective, and hepatoprotective effects. Due to its health-promoting properties, *Hemidesmus indicus* has attracted significant attention in the food and pharmaceutical industries. Value-added products such as health supplements, functional foods, and herbal medicines have been developed from *Hemidesmus indicus* to cater to the growing demand for natural and safe alternatives to conventional medicines. In conclusion, *Hemidesmus indicus* is a promising plant with diverse phytochemicals that possess potent antioxidant and health-promoting properties. Further research is needed to fully understand the mechanisms behind its medicinal properties and to explore its potential as a source of natural antioxidants and functional ingredients for the food and pharmaceutical industries.

Keywords: Value-added products, phytochemicals, health benefits

Introduction
Hemidesmus indicus, commonly known as Indian sarsaparilla, is a well-known medicinal plant in Ayurvedic medicine. It is a perennial climber with numerous medicinal properties, making it an essential herb for traditional medicine in India (Mahmud *et al.*, 2016) [22]. The roots of *Hemidesmus indicus* have been found to contain a wide range of bioactive compounds such as flavonoids, saponins, and alkaloids (Moorthy and Kumar, 2021) [28]. These compounds are known to possess several pharmacological properties, including antioxidant, anti-inflammatory, and immunomodulatory activities (Nandy *et al.*, 2020) [31]. Indian sarsaparilla has been used to treat various ailments such as skin diseases, gastrointestinal problems, coughs, and fever (Banerjee & Ganguly, 2014) [2]. Additionally, it has been used in the treatment of diabetes (Joshi *et al.*, 2018) [16]. Studies have reported that *Hemidesmus indicus* possesses significant antioxidant activity, which can be attributed to the presence of phenolic compounds, including tannins and flavonoids (Moorthy and Kumar, 2021) [28]. Moreover, the plant has been found to have anti-inflammatory effects due to the inhibition of inflammatory cytokines, such as interleukin-6 and tumor necrosis factor-alpha (Moorthy and Kumar, 2021) [28]. The immunomodulatory properties of *Hemidesmus indicus* have been well documented. The plant extracts have been reported to stimulate the immune system by increasing the production of lymphocytes and natural killer cells (Moorthy and Kumar, 2021) [28]. Additionally, the herb has been found to have antitumor activity, which can be attributed to the presence of saponins and other bioactive compounds (Nandy *et al.*, 2020) [31]. *Hemidesmus indicus* has also been reported to have cardioprotective effects, making it a promising candidate for the treatment of cardiovascular diseases. Studies have shown that the plant extracts can lower blood pressure and cholesterol levels, as well as prevent the formation of atherosclerotic plaques (Khandelwal *et al.*, 2011) [18]. *Hemidesmus indicus* is a valuable medicinal plant with numerous therapeutic applications. Its bioactive compounds have been

shown to possess several pharmacological properties, making it a promising candidate for drug development. Further studies are needed to fully explore the potential of this herb in the treatment and management of various diseases.

Physio-chemical parameters

Vijayalakshmi *et al.* (2010) [52] determined the moisture content (9.20%), total ash (4.3%), and total mineral content (0.69%) in the roots of *H. indicus*. Shanthi *et al.* (2010) [43] reported the moisture content (2.1%) and total ash (4.3%) in the roots of *H. indicus*. Das and Devaraj (2006) [7] determined the minerals, such as Fe (108.9 mg/gm), Mn (4 mg/gm), Zn (27.5 mg/gm), and Cu (8.2 mg/gm) in the roots of *H. indicus*. Kotnis *et al.* (2004) [20] reported mineral contents, such as Fe (1.4%), Mg (9.7%), and Ca (25.2%), in the roots of *H. indicus*. Kulatunga *et al.* (2019) [21] reported total ash content (4.7%) in the roots of *H. indicus*, while Samarakoon *et al.* (2010) [40] reported total ash content (5.9%) in the roots of *H. indicus*.

Anti-oxidant activity

The following studies have reported antioxidant activity in *H. indicus* root:

Jayaram and Dharmesh (2011) [15] found DPPH scavenging activity of 64%. Boominathan *et al.* (2018) [4] reported DPPH scavenging activity of 35.82%, FRAP value of 18.70%, and ABTS scavenging activity of 80.11% in *H. indicus* root. Das *et al.* (2019) [6] reported FRAP value of 35.76% and ABTS scavenging activity of 33.12% in *H. indicus* root. Nagat *et al.* (2016) [30] reported DPPH scavenging activity of 60% in *H. indicus* root. Zahin and Ahmad (2009) [54] found DPPH scavenging activity of 77.0% in *H. indicus* root. Saha *et al.* (2013) [39] reported DPPH scavenging activity of 80.03% in *H. indicus* root. found DPPH scavenging activity of 84.72% in *H. indicus* root. Singh *et al.* (2012) [46] reported DPPH scavenging activity of 48.5% in *H. indicus* root. Jayalakshmi *et al.* (2018) [14] reported DPPH scavenging activity of 25% in *H. indicus* root.

Phytochemicals

Various studies have reported the levels of phenol, flavanoid, and tannin in extracts of the root of a certain plant. Rajan *et al.* (2011) [37] found that cold maceration with alcohol yielded an extract with 160.6 mg/gm QE of phenol, 41.33 mg/gm GAE of flavanoid, and 74.66 mg/gm TAE of tannin, while an aqueous extract prepared by the same method contained 66.33 mg/gm QE of phenol, 81.60 mg/gm GAE of flavanoid, and 111.00 mg/gm TAE of tannin. Som *et al.* (2021) [47] determined the levels of these compounds in three types of extracts prepared by soaking: methanolic (phenol: 40.95 mg GAE/g, flavanoid: 19.09 mg RE/g, tannin: 4.61 mg CE/g), pet ether (phenol: 3.57 mg GAE/g, flavanoid: 0.88 mg RE/g, tannin: 0.22 mg CE/g), and ethyl acetate (phenol: 16.29 mg GAE/g, flavanoid: 6.58 mg RE/g, tannin: 1.36 mg CE/g). Samarakoon *et al.* (2010) [40] found that boiling the root yielded an aqueous extract containing phenol (23.80 mg GAE/100g) and flavanoid (4.566 mg QE/100g), while an ethanolic extract contained phenol (69.40 mg GAE/100g) and flavanoid (5.518 mg QE/100g). Boominathan *et al.* (2018) [4] used soaking to prepare an ethanolic extract, which was found to contain phenol (57.09 µg/mg GAE) and flavanoid (52 µg/mg QE). Pompo *et al.* (2014) [10] used boiling to prepare a decoction extract, which contained phenol (49.79 GAE mg/g) and flavanoid (28.75 RE mg/g). Mishra *et al.* (2018) [26] reported a flavanoid content of 27.30 mg/gm NE in an ethanolic extract of the root prepared by powdering. Devi *et al.* (2014) [9] prepared a crude extract of the root by soaking, which was found to contain phenol (22.92 mg/100 gm GAE) and flavanoid (4.23 mg/100 gm QE). Joshi *et al.* (2018) [16] used soxhlet extraction to prepare a methanolic extract, which contained phenol (12.95 mg GAE/g) and flavanoid (57.68 Mg QE/g). Jayaram *et al.* (2011) [15] used an ethanolic extract of root powder to determine a phenol content of 5.3 mg GAE/g. Saritha *et al.* (2015) [41] used soxhlet extraction to prepare an ethanolic extract of the root, which was found to contain phenol (552 mg GAE/g) and flavanoid (845 mg QE/g).

Health benefits

A number of studies have investigated the potential health benefits of the root *Hemidesmus indicus*, Desai *et al.* (2017) [8] found that an ethanolic extract of the root exhibited anti-osteoporotic activity in female Wistar rats, with a dosage of 100-200 mg/kg/day for 90 days resulting in increased bone strength. Ganesan *et al.* (2012) [11] reported that a methanolic extract of the root, with a dosage of 5% (w/w) for 6 days in Wistar rats, exhibited wound healing activity, with a tissue damage reversal effect observed. Shete and Bodhankar (2010) [44] investigated the neuroprotective activity of an ethanolic extract of the root, using Swiss albino male mice with a dosage of 100 mg/kg for 120 minutes, and found that the duration of catalepsy increased after the time period. Mohana *et al.* (2005) [58] reported that a hydro-ethanolic extract of the root exhibited hepatoprotective activity in male Wistar rats, with a dosage of 200 mg/kg for 6 days resulting in decreased lipid peroxidation. Sowmia and Kokilavani (2007) [48] investigated the anti-diabetic properties of an aqueous root extract of *H. indicus*, using male Wistar rats with a dosage of 400 mg/kg. They found that after 30 days, blood glucose levels decreased. Bharadwaj and Nayak (2013) [3] investigated the anti-ulcerogenic activity of aqueous and alcoholic root extracts, using Wistar albino rats with a dosage of 100 mg/kg, and found that ulcer formation was decreased after 6 hours. reported that an aqueous root extract of *H. indicus* exhibited nephroprotective activity in male albino Wistar rats, with a dosage of 100 mg/kg resulting in reduced tubular degeneration and dilatation after 19 hours of observation. Sudarshan and Patel (2009) [49] investigated the cardioprotective activity of aqueous and methanolic root extracts, using SD rats with dosages of 100, 200, and 400 mg/kg. They found that after 6 weeks, creatinine was reduced. Mehta *et al.* (2012) [25] investigated the anti-arthritic activity of hydro-alcoholic, ethyl acetate, chloroform, and residual fractions of the *H. indicus* root extract, using female Wistar rats with dosages of 75, 60, 270, and 450 mg/kg for 21 days. They found that the arthritic score decreased after the time period. Bhujbal *et al.* (2009) [56] investigated the anti-asthmatic activity of an ethanolic extract of the root, using adult goat trachea with a dosage of 80 µg/ml, and found that tissue contraction increased after 1 hour. Finally, Zahin *et al.* (2010) [55] investigated the antimicrobial activity of an ethanol extract of the root, using Pseudomonas aeruginosa with a dosage of 500 µg/ml, and found that swarming motility was reduced after 24 hours.

Value added products

Kathiravan *et al.* (2014) [17] developed a functional drink

blended with nannari from H.indicus root that showed high antioxidant activity. Monika (2019) [27] investigated nannari mathirai from H.indicus root and found it to have hepatotoxic activity. Khayum *et al*. (2018) [19] reported the development of a nannari blended beverage from *H. indicus* root that exhibited higher retention of anthocyanin content. They also developed a nutraceutical drink blended with nannari from *H. indicus* root that contained ascorbic acid and non-reducing sugar. Ganesan *et al*. (2012) [11] developed an ointment from the roots of H.indicus with wound healing activity. Vasanthi (2013) [51] reported nannari ver ennai from *H. indicus* roots which was used for treating eczema. Manoharan *et al*. (2020) [24] reported the indigenous beverage jigarthanda made from *H. indicus* roots, which is used as a flavouring agent. Jamadagni *et al*. (2016) [13] developed jatyadi ghrita from H.indicus roots with wound healing activity. Nasrin *et al*. (2011) [34] reported chondrokola rosh from *H. indicus* roots, which helps in dysuria. Periyanayaga *et al*. (2004) [35] reported pinda thailam from *H. indicus* roots with anti-inflammatory properties.

Commercially available products

Various companies have developed different products using *H. indicus* root. Sri Sri Tattva has released Sariva syrup, which includes *H. indicus* root and costs ₹128/100 ml. Joker's Sharbath Manufacturers produce Nannari Sharbath, a product that contains H.indicus root as a major ingredient and costs ₹68.57/100 ml. Saara Products manufactures Nannari root powder, which is made from powdered *H. indicus* root and packed, costing ₹200/100g. GRBC produces Nannari Dravakam, which includes *H. indicus* root and costs ₹70/100 ml. B and B Organics manufacture Nannari Sharbath syrup, containing *H. indicus* root extract and costing ₹99.20/100 ml. Indus Valley Herbal Nutrients produce Sariva Churna, made from roots of H.indicus, and containing medicinal properties costing ₹365/100 gm. Ishna Herbs' Ubtan powder contains *H. indicus* root and costs around ₹319/100 gm. Vedix company produces Face Wash (₹474/100 ml), Face Serum (₹189/10 ml), and Face Gel (₹947.40/100 ml) using *H. indicus* roots. Indus Beverage and Multi Food manufacture Nannari instant premix powder, a beverage mix powder containing H.indicus root costing ₹150/100 gm. NMK company produces Nannari Manappagu syrup, a type of syrup made from *H. indicus* root, which costs around ₹179.5/100 ml. Nagarjuna Ayurvedic Company produces Pinda Thailam, a medicine containing H.indicus root costing ₹60/100 ml. Pothigai Natural's Sarasaparilla drink costs ₹30/100 ml and contains H.indicus root. Rohini's Nannari Sharbat Fruitmix costs ₹140/750 ml and contains H.indicus root extract and fruit content. Vnaturaa's Nannari squash costs around ₹163/750 ml and has *H. indicus* root extract.

Conclusion

Hemidesmus indicus is a medicinal plant with potential for producing naturally-derived phytochemicals with applications in chemotherapeutic and chemopreventive agents. The active compounds from *H. indicus* require further evaluation in *in vitro* and *in vivo* studies to better understand their mechanisms of action. However, the current pharmaceutical knowledge of the plant can be used in a commercial way to develop therapeutic products This trend presents a better scope for *H. indicus* in the future, and its importance, along with other medicinal plants, is expected to be established.

Table 1: Physio chemical parameters of *Hemidesmus indicus* root

Moisture content	Total ash	Mineral content		Reference
9.20%	3.93%	0.69%		Vijayalakshmi *et al.* (2010) [52]
2.1%	4.3%	-		Shanthi *et al.* (2010) [43]
-	-	Fe	108.9 mg/gm	Das and Devaraj (2006) [7]
		Mn	4 mg/gm	
		Zn	27.5 mg/gm	
		Cu	8.2 mg/gm	
15.2%	4.5%	Fe	1.4%	Kotnis *et al.* (2004) [20]
		Mg	9.7%	
		Ca	25.2%	
4.2%	-	-		Saryam *et al.* (2012) [42]
-	4.7%	-		Kulatunga *et al.* (2019) [21]
-	5.9%	-		Samarakoon *et al.* (2010) [10]

Table 2: Antioxidant activity in *Hemidesmus indicus* root

DPPH	FRAP	ABTS	Reference
64%	-	-	Jayaram and Dharmesh (2011) [15]
35.82%	18.70%	80.11%	Boominathan *et al.* (2018) [4]
-	35.76%	33.12%	Das *et al.* (2019) [6]
60%	-	-	Nagat *et al.* (2016) [30]
77.0%	-	-	Zahin and Ahmad (2009) [54]
80.03%	-	-	Saha *et al.* (2013) [39]
84.72%	-	-	Kumar *et al.* (2007) [57]
48.5%	-	-	Singh *et al.* (2012)
25%	-	-	Jayalakshmi *et al.* (2018) [14]

Table 3: Phytochemicals present in different extracts of *Hemidesmus indicus* root

Extraction solvent	Extraction method	Phenol	Flavanoid	Tanin	Reference
Alcoholic extract	Cold maceration method	160.6 mg/gm QE	41.33 mg/gm GAE	74.66 mg/gm TAE	Rajan *et al.* (2011) [37]

Ethyl acetate extract	Soaking	16.29 mg GAE/g	6.58 mgRE/g	1.36 mg CE/g	Som *et al.* (2021) [47]
Ethanolic extract	Soxhlet	69.40mg GAE/100g	5.518mg QE/100g	-	Samarakoon *et al.* (2010) [40]
Ethanolic extract	Soaking	57.09 µg/mg GAE	52 µg/mg QE	-	Boominathan *et al.* (2018) [4]
Decoction extract	Boiling	49.79GAE mg/g	28.75RE mg/g	-	Pompo *et al.* (2014) [10]
Ethanolic extract	Powder	-	27.30 mg/ gm NE	-	Mishra *et al.* (2018) [26]
Crude extract	Soaking	22.92 mg/100 gm GAE	4.23 mg/100 gm QE	-	Devi *et al.* (2014) [9]
Pet ether extract	Soaking	3.57mg GAE/g	0.88 mgRE/g	0.22mg CE/g	Som *et al.* (2021) [47]
Methanolic extract	Soxhlet	12.95mg GAE/g	57.68 Mg QE/g	-	Joshi *et al.* (2018) [16]
Aqueous extract	Cold maceration	166.33 mg/gm QE	81.60 mg/gm GAE	111.00 mg/gm TAE	Rajan *et al.* (2011) [37]
Ethanolic extract	Powder	5.3mg GAE/g	-	-	Jayaram *et al.* (2011)
Methanolic extract	Soaking	40.95 mg GAE/g	19.09 mg RE/g	4.61mg CE/g	Som *et al.* (2021) [47]
Aqueous extract	boiling	23.80mg GAE/100g	4.566mg QE/100g	-	Samarakoon *et al.* (2010) [40]
Ethanolic extract	Soxhlet	552mg GAE/g	845mg QE/g	-	Saritha *et al.* (2015) [41]

Table 4: Health benefits of *Hemidesmus indicus* root

Type of extract	Properties	Animal used	Dosage level	Time	Effect	Reference
Ethanolic extract	Anti-osteoporotic activity	Female Wistar rats	100 and 200 mg/kg/day	90 days	Bone strength increased	Desai *et al.*, (2017) [8]
Methanolic root extract	Wound healing activity	Wistar rat	5% (w/w)	6 days	Tissue damage reversal effect analysed	Ganesan *et al.*, (2012) [11]
Ethanolic extract	Neuroprotective activity	Swiss albino male mice	100 mg/kg	120 minutes	Duration of catalepsy Increased, neurotransmission reduced	Shete and Bodhankar, (2010) [44]
Hydro-ethanolic extract	Hepatoprotective activity	Male Wistar rats	50% extract 200 mg/kg	6 days	Lipid peroxidation decreased, sodium nitroprusside formation reduced	Mohana *et al.*, (2005) [58]
Aqueous root extract	Anti-diabetic	Male Wistar rats	400 mg/kg	30 days	Insulin level increased carbohydrate, Metabolism increased blood glucose decreased	Sowmia and Kokilavani, (2007) [48]
Aqueous and alcoholic root extract	Anti-ulcerogenic activity	Wistar albino rats	100 mg/kg	6 hours	Ulcer formation decreased	Bharadwaj and Nayak, (2013) [3]
Aqueous and methanolic root extract	Cardioprotective activity	SD rats	100, 200 and 400 mg/kg	6 weeks	Serum calcium increased, Microalbuminuria decreased, serum urea reduced, creatinine reduced, myocyte diameter reduced	Sudarshan and Patel (2009) [49]
Hydro-alcoholic, ethyl acetate, chloroform and residual fractions of root extract	Anti-arthritic activity	Female Wistar rats	75, 60, 270, 450 mg/kg	21 days	Arthritic Score decreased, ESR decreased, SRFI reduced, serum nitrate level controlled, serum CRP reduced	Mehta *et al.*, (2012) [25]
Ethanolic root extract	Anti-asthamatic activity	Adult goat trachea	80 µg/ml	1 hour	Inhibition of tissue contraction increased	Bhujbal *et al.*, (2009) [56]
Ethanolic root extract	Antimicrobial activity	*In vitro*; Pseudomonas aeruginosa	500 µg/ml	24 hours	Swarming motility reduced	Zahin *et al.*, (2010) [55]

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