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Silvics, phytochemistry and ethno pharmacy of *Strychnos potatorum* Linn: A review

Madhab Chandra Behera, Uma Sankar Nayak and Tanmay Lalitendu Mohanty

Abstract

Strychnos potatorum L. (Loganiaceae) commonly known as Nirmali is a well-known plant in rural India. Seed powder often used for treating drinking water. Seed, bark, leaves and root are used by resource poor people for treatment of chronic diarrhoea, gastrological disorders, gonorrhoea, leucorrhoea, bronchitis, dysentery, renal and vesicle calculi, diabetes, scleritis, ulcers, conjunctivitis and other eye disease. Seed is rich in alkaloid diaboline and official in many traditional systems of medicines viz Ayurveda, Unani and Homeopathy. Pharmacologically nirmali seed is tasted for anti-microbial, antiarthritic, nephroprotective, antidiabetic, anti-inflammatory, antidiarrhoeal, antinociceptive, antipyretic and contraceptive activity. Potential of seeds in coagulation, defluoridization and biosorption of toxic heavy metals like chromium (VI), lead etc. from waste water is experimentally authenticated. Unscientific overexploitation, poor regeneration along with loss of habitat put this magical plant under vulnerable list. In this review an effort has been made to elucidate the morphophenology, nursery techniques, silvicultural management, pharmacognostic authenticity of crude drug, scientifically validated therapeutic uses in a lieu to assist further research in chemical screening of elite genotypes, developing agrotechniques of cultivation, varietal development, by-products extraction thereby protecting it from extinction.

Keywords: *Strychnos potatorum*, morphophenology, nursery techniques, silvicultural management, ethnopharmacy, pharmacognosy, diaboline

Introduction

Genus *strychnos* is much valued in folklore and traditional systems of medicines for alkaloids strychnine, brucine, diaboline etc. It comprises 200 species of which about 75 species are found in Africa, 73 species in America and 44 species in Asia. Five species of genus *Strychnos* are endemic to South India and Andaman Islands [1]. *Strychnos potatorum* commonly known as clearing nut tree or nirmali is the only species found both in Asia and Africa. It is distributed in Myanmar, India and China. In India nirmali distributed in tropical and subtropical forests of southern states including Odisha, West Bengal and Chhattisgarh [2].

Nirmali is an important medicinal plant in Ayurveda, Unani, Siddha and in folk medicine recommended for treating several ailments including microbial infections, diarrhoea and diabetes. Seed is official in the Ayurvedic Pharmacopoeia of India. Phytochemical studies revealed presence of alkaloids diaboline, brucine, mannose, sucrose, arachidonic, lignoceric, linoleic, oleic, palmitic and stearic acids [3, 4]. Seed tastes bitter and used as astringent, aphrodisiac, tonic, diuretic and liver tonic. In traditional system of medicine, seeds including other plant parts are advocated for treatment of chronic diarrhoea, gastrological disorders, gonorrhoea, leucorrhoea, bronchitis, dysentery, renal and vesicle calculi, diabetes, conjunctivitis, scleritis, ulcers and other eye disease [5, 6]. Pharmacologically seed evaluated for anti-microbial, antiarthritic, nephroprotective, antidiabetic, anti-inflammatory, antidiarrhoeal, antinociceptive, antipyretic and contraceptive activity [7, 8]. Apart from medicinal uses fruit pulp and seed powder is used for treating potable water [9]. Seed powder can effectively remove turbidity of muddy water in a dose dependent manner [10], remediate fluoride [11], chromium (VI) [12], lead [13], cadmium [14] contaminated water. The present review provides elucidative information on morph phenology, ethno pharmacy, silvics, post-harvest management, phytochemistry and pharmacology in a lieu to assist further research identifying elite genotypes, developing agro-techniques of cultivation, varietal development, by product extraction, and thereby protecting this prized drug plant from extinction.

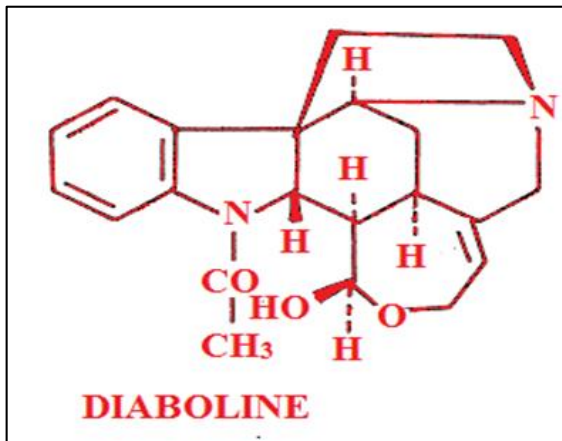


Fig 1: Major alkaloid from *S. potatorum* seed

Botanical Classification

Kingdom	: Plantae
Division	: Magnoliophyta
Class	: Magnoliopsida
Order	: Gentianales
Family	: Loganiaceae
Genus	: <i>Strychnos</i>
Species	: <i>S. potatorum</i>
Botanical name	: <i>Strychnos potatorum</i> Linn

Morphology

S. potatorum is a medium sized deciduous tree having height upto 12 m. Trunk densely branched, irregularly fluted, covered with pale gray to brown or blackish cracked and scaly bark. Wood hard & close grained. Branches pale to dark brown, dichotomous, terete, apex modified into spine like tip. Leaves are simple, opposite, variable in shape & size (elliptic or ovate), acute, glabrous, shining on both sides, pointed at tip and more or less rounded at base. Two pairs of distinct secondary veins curved along margin from the base. Inflorescence is terminal cyme, appears just before or with green flush after winter senescence. Flowers are small (large for the genus), hermaphrodite, tubular, fragrant, nectariferous, 4-5 merous, peduncle small seems to be sessile, often clustered, variable in shape and size. Calyx dark green, connate at base, ovate to oblong; corolla campanulate, white-creamy, outside glabrous, inside pilose with white hairs on the base of the lobes. Stamens are short filamentous inserted at the mouth of the corolla tube, exerted; anthers oblong & glabrous. Stigma is capitate (occasionally obscurely bilobed) with long thick style; ovary ovoid or conical in shape. Fruit is a globose berry; black when ripe, 1-2 seeded [5, 15, 16].

Phenology

The tree is deciduous in nature but occasionally observed evergreen. Leaf fall starts during the advent of summer season. New coriaceous shining leaves unfold during second half of April followed by floral bud burst. Blooming progress through April and terminates at the end of May with peak of three weeks between April-May. Fruits take about 7-8 months for maturing and 1-2 seed per fruit is common. Fruits attain black colour in maturity and falls during January [17].

Ecology

Nirmali commonly found in tropical moist deciduous forests & scrub lands of Andhra Pradesh, Karnataka, Kerala,

Tamilnadu, Odisha, Madhya Pradesh, Chhatisgarh and West Bengal up to an altitude of 1200m amsl. Also, observed in open landscapes in Deccan Plateau, Eastern Ghats, Northern plains, Eastern plateau, Northern eastern hills and Eastern coastal plains agro-ecological regions of India. The mean annual temperature and rain fall of its natural ecosystem ranges between 25-35 °C and 1100-2500 mm/annum respectively. It is a shade tolerant plant and grows well under the canopy of dominants. Saplings and poles are draught resistant and can withstand seasonal draught [17].

Status of the plant

Commercial cultivation of nirmali is absent or scanty and almost all domestic and industrial demand of seed is collected from natural population in the wild. Unscientific heavy exploitation, destructive encroachment of habitat, climate change and poor natural regeneration restricts this native species in specific pockets of tropical and subtropical forests. Self non generative mechanism of seeds in fruits (fungal decay of seeds as soon as they fall) is also another major cause of poor density of recruits. Presently this species is included in the vulnerable plant lists of some states like Odisha [18].

Propagation

Nirmali can be propagated through seeds, stem cuttings, root suckers and micro-propagation of leaf explants but by seed is much assertive.

I). Propagation through seed

Ripe fruits are collected during January-February, macerated (de-pulped), thoroughly washed and shade dried. Seeds possess morphological dormancy which could be overcome by treating with GA₃ and warm water [19]. Pre-treated seeds are sown in sand beds for proper germination which starts 40-45 days after sowing. 18-24 months old seedlings are ready for eventual planting out [20]. Being a slow growing species does not require heavy pruning.

II) Propagation through vegetative methods

Asexually *S. potatorum* can be propagated through stem cuttings and root suckers. Hard wood cuttings of 15-20 cm long possessing 2-3 internodes are suitable. In-vitro it can be successfully propagated through root and leaf explants using different growth Media [21, 22].

Silviculture management

S. potatorum prefers well drained red alluvial soils having good depth. Presence of hard pan or kankar limits plant growth. Container raised propagules are planted during onset of monsoon. Approximately 400 trees per hectare are recommended. Fruiting starts 15-18 years after planting. It does not require any pruning for canopy management. Coppicing or pollarding of trees reduces the size of the tree and causes a loss in seed production which is never likely to be made up. Though it is a draught hardy species, seed production reduced under prolonged water stress condition. Plant is normally free of pest and diseases.

Gray or black colour of fruit indicates maturity. Matured fruits are manually collected, fleshy pericarp was removed, macerated properly and shade dried up to 10% moisture content. Seeds prone to fungal attack very quickly after maturity and hence prompt action for cleaning and drying are needed. Seeds are then graded according to size and stored in gunny bags at ambient temperature [23, 24].

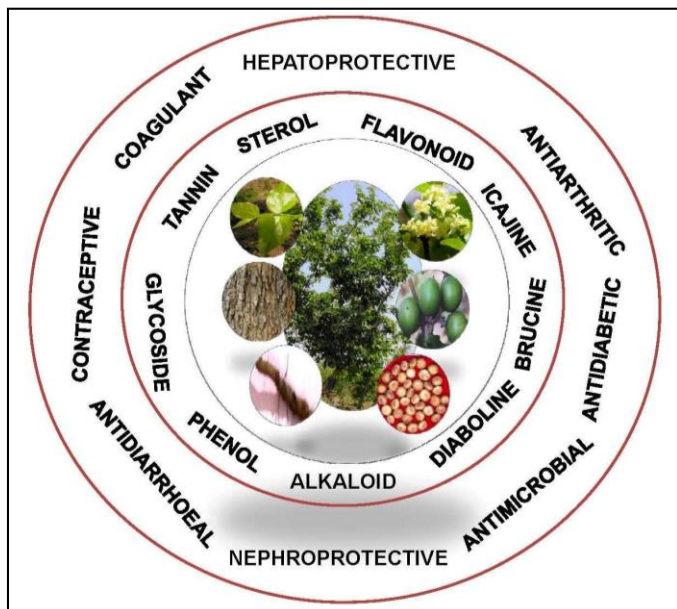


Fig 2: Phytochemicals and therapeutic uses of *Strychnos potatorum*

Pharmacognostic character of crude drug

Though seed is official in the Ayurvedic pharmacopoeia of

India, bark, leaves, flower, and fruit pulp are often recommended for ailment of different health disorders. Proper identification of crude drug is essential for its authenticity.

Macroscopic character of seed

Dry seeds of *S. potatorum* are hard, yellowish white in colour, 7.0-8.0 mm in diameter, circular to elliptical in shape, surface even, smooth to fine reticulate marks; edge thin, smooth or sometimes with circular ridge, odour less and bitter less. Presence of small trichomes gives shiny appearance [25].

Microscopic Character of seed

Study of TS of seed shows two distinct layers of seed coat (testa) viz the uneven outer zone consisting of tangentially elongated, thin walled parenchyma and dense trichome layer. Trichomes are thick walled, basal portion lignified & ramified, upper portion have narrow longitudinal lumens (Table-1). Calcium oxalate crystals are common in seed surface as well as on the surface of the endosperm tissue [26].

Characteristics of powdered raw drug

Powdered drug coloured creamish-yellow, oily, shows fragments of seed coat, trichomes, endosperm cells and oil globules [26].

Table 1: Macroscopic and microscopic characteristics of crude drug of *S. potatorum*

Plant part	Macroscopic	Microscopic	Reference
Seed	Circular to elliptical shape, tough and sturdy in dry, yellowish white colour, odour & tasteless, fine reticulate markings	Two distinct layers of testa, outer uneven layer consisting tangentially elongated, shrunken parenchyma; inner lignified dense trichome layer and presence of oil globules	[2, 25, 26]
Leaves	Simple, ovate or elliptic, glabrous, shining on both sides, two pairs of prominent secondary veins	Polygonal paranchymatous cells in upper epidermis, amphibrachyparacytic stomata only on abaxial surface, stomatal index-20.1, vein islets-12 and vein termination-16	[4]
Stem bark	Pale gray to brown or blackish, cracked and scaly	Presence of suberin and tannins	[27]

Physicochemical constants of powdered drug

Apart from macro and microscopic parameters other physical parameters like total ash, acid soluble ash, water soluble ash,

extractive values etc. helps in judging the authenticity of powdered drugs [1]. Physicochemical constants and fluorescence analysis of crude drug are given in Table-2.

Table 2: Physical constants of powdered drug of *S. potatorum*

Parameters	Value % (w/w)				Reference
	Leaf	Stem Bark	Root	Seed	
Moisture content	3.4	*	*	7.65%	[25, 26]
Total ash	3.5	20.45	14.5	1.43%	
Acid insoluble ash	0.5	16.52	8.35	0.09%	
Water soluble ash	2.8	*	*	-	
Water soluble extractive	3.0	6.97	5.9	10.23	
Fluorescence analysis of powdered drug (UV light)	Dark Green	Black	Ivory	Seafoam-Ivory	

*Not available

Ethno pharmacy

Nirmali used in folk medicines for alleviating many health disorders. Perusal of classic and modern literatures reveals a wide range of therapeutic utility of almost every plant part which are summarised below [5, 6, 28].

Leaf: Pounded leaves are used to treat watering and aching eyes, leaf decoction is taken to treat epilepsy and cough, as poultice over maggot infected ulcers

Fruit: Useful as emetic, diaphoretic, curing eye diseases and hallucinations. Pounded fruits are used as fish poison.

Seeds: Seeds are used for the treatment of complaints of the liver, kidneys, stomach and gonorrhoea, venereal diseases

including leucorrhoea, strangury and piles, bronchitis, chronic diarrhoea, kidney and bladder stones, diabetes, eye diseases and good remedy for snake bite. Rubbed seeds are also used to clear muddy water.

Bark: Crushed bark powder mixed with lime effective against cholera.

Roots: Aphrodisiac, used in curing venereal diseases, leucoderma.

Phytochemicals

Root, stem bark, leaves and seeds contain alkaloids, flavonoids, glycosides, lignins, phenols, saponins, sterols and tannins [3, 4, 25]. Seed is official in traditional pharmacopoeias

as well as in modern treatise. The major alkaloid present in seed is diaboline and its acetates. Other plant parts also

contain alkaloids of medicinal importance and summarised in Table-3.

Table 3: Phytochemicals of plant parts of *S. potatorum*

Plant part	Phytochemicals	References
Leaves	Alkaloids, glycosides, tannins, flavonoids, sterols, fats, oils, phenols and saponins	[4]
Stem bark	Alkaloids, flavonoids, sterols, glycosides, protein, aminoacids, gums and mucilage	[29]
Flower	α -Pinene, Methyl chavicol, Mycrene, Bornyl acetate, Terpinyl acetate, 1,8 Cineol, α -Borneol Nerol, β -Caryophyllene, Linalyl acetate, d-Cadinene and d-Limonene	[30]
Fruit	Glycosides, carbohydrates, flavonoids, phenolic compounds and diterpenes	[31]
Seeds	Alkaloids: diaboline, brucine, brucine Noxide, strychnine, strychnine N-oxide and pseudostrychnine, Vomisine, Icajine and novacine β -sitosterol, oleanolic acid, 3 β -acetoxy oleanolic acid; flavonoids, sterols etc.	[32, 33]
Root bark	Harmene carboxamide, Cantleyine, 18,19-Dihydrousambarensine, Polyneuridine, Norharmene, Akuammidine, Nor-C-Fluorocurarine, Ochrolifuanine-A, Bisnordihydrotoxiferine, Ochrolifuanine-E, Normacusine-B, Normavacurine, Henningsamine, 11-Methoxyhenningsamine, Dihydrologicaudatine, Dihydrologicaudatine Y, Antirrhine, 20-Dihydroantirrhine, 11-methoxy-12-hydroxydiaboline, Diaboline, 11-methoxydiaboline, Desacetylretuline and Diaboline N-oxide	[34]

Pharmacological activities

Strychnos potatorum is a valuable drug plant in traditional systems of medicine as well as in modern treatise. Therapeutic potentials claimed by the ethnic people like nephroprotective, Hepatoprotective, contraceptive,

antidiabetic, antidiarrhoeal action etc. is scientifically validated. Still some medicinal actions against gonorrhoea, leucorrhoea, bronchitis, eye problems etc. needs examination. Mode of action of plant extractives is summarized in Table-4.

Table 4: Scientifically validated therapeutic uses of *S. Potatorum*

Pharmacological Property/Action	Plant part/ extract	Action/ Effect	Reference
Antimicrobial	Seed extract	Anti bacterial (gram positive, gram negative and acid-fast bacteria) and anti-fungal action	[35, 36]
Nephroprotective	Ethanollic seed extract	Protective against renal injury induced by nephrotoxins especially gentamicin.	[37]
Antidiabetic	Ethanollic seed extract	Reduces blood glucose level in experimental animals	[38, 39]
Antiarthritic	Aqueous seed extract as well as whole seed powder	At the specified dose level of 200 mg/kg, reduced developing and developed phases of Freund's adjuvantinduced arthritis in rats	[40]
Anti-inflammatory	Aqueous seed extract as well as whole seed powder	Inhibition of induced paw edema in rats in a dose dependent manner	[41]
Antidiarrhoeal	Methanollic seed extract	Reduced significantly frequency of defecation and wetness of faecal droppings	[42]
Hepatoprotective	Aqueous seed extract and seed powder	Reduces serum marker enzymes like serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT)	[43]
Antiulcerogenic	Aqueous seed extract and seed powder	Antisecretory and mucoprotective actions	[44]
Antinociceptive and antipyretic	Aqueous seed extract and seed powder	Reduces pyrexia in a dose dependant manner	[45]
Contraceptive	Aqueous solution of Methanollic extract of seed	Decreasing number of spermatogonia and sertoli cells	[8]
Antioxidant & free radical scavenging potential	Ethanollic & aqueous epicarp extract	<i>In vitro</i> evaluation through DPPH, hydrogen peroxide, nitric oxide and ABTS radical scavenging assay method	[46, 47]
Antiuroliithatic	Methanollic extract of seed	Dissolution of calcium oxalate stones	[48]
Diuretic	Methanollic extract of seed	Increase total urine volume and the concentration of sodium, potassium & chloride ions in urine	[49]
Anthelmintic	Ethanollic root, stem bark, seed extract	Paralysis and/or mortality of the parasitic nematode pathogen, <i>Heterorhabditis indicus</i>	[50]
Antianaphylactic	Petroleum ether, chloroform and methanollic seed extract	Inhibitory effect on anaphylactic reaction of foreign material	[51]

Conclusion

S. potatorum is a promising drug plant in many classical as well as modern systems of medicine. Few medicinal actions viz hepatoprotective, nephroprotective, antiuroliithatic, antidiabetic, antimicrobial, contraceptive etc. are evaluated against animals but still many ethno medicinal uses needs validation. The mechanism of coagulation and flocculation in clearing muddy and potable water is tested experimentally. There is vast scope for use in the phytoremediation of toxic heavy metals from polluted water. Most of the seeds are collected from forests unscientifically. Poor natural

regeneration, scarcity of seeds in soil seed bank, illicit felling and habitat loss are responsible for its vulnerability. Genotypic evaluation for elite population having high alkaloid content, breeding for early fruiting varieties and development of agro techniques of cultivation are few areas needs attentions which will be helpful for commercial cultivation and there by conservation of this drug plant.

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