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A potential review of its traditional uses, Phytochemistry, pharmacology, and toxicity of *Plumbago zeylanica*

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Abstract
The primary source of efficient traditional medications for the treatment of many ailments is medicinal plants. Several pharmacological actions of herbal medicines have led to their usage throughout the past ten years. The useful medical plant *Plumbago zeylanica*, often known as Plumbago, "white leadwort," "Ceylon leadwort," "Doctorbush," "Chitrak" in India, is used extensively in Africa and Asia to cure various maladies. It belongs to the plumbaginaceae family. The family plumbaginaceae are divided into the plumbaginoideae and staticoideae subfamilies, which may be distinguished by morphological, chemical, and molecular traits. It is a significant medicinal plant with a variety of pharmacological activities, including anticancer, antibacterial, antioxidant, etc. Because of the plant's therapeutic value, pharmaceutical companies randomly sample the environment and there is a decline in *Plumbago zeylanica* population, making it an over-exploited plant. Therefore, a different method of mass propagating this plant is required. It is a powerful bioactive substance with a lot of promise for use in traditional medical procedures for the treatment of many different ailments. Although it is a crucial plant in the production of herbal products, finding a different method to allow for the widespread propagation of this plant still requires a great commitment. For the expanding needs of *Plumbago zeylanica*, by in-vitro technologies at a large scale for progress and subsequent crushed plants should be tremendously helpful. The purpose of this review is to focus the value of medicinal applications, Phytochemistry, pharmacology, toxicity, and its prospective pharmaceutical action for the creation of novel herbal preparations. It has given researchers the chance to do further study and development in this area.

Keywords: *Plumbago zeylanica*, traditional uses, pharmacology, toxicology

Introduction
The wonderful symbiosis phenomenon has always been beautifully illustrated by nature. In India, the composition of contemporary medications is around 70% natural. Medicinal plants not only fulfill the requirements of local communities but also act as trade products for distant markets [1]. Additionally, synthetic medications are now extremely costly and frequently contaminated in underdeveloped nations [2]. The earliest source of information on medicinal plants appears to be the Rig Veda, which dates from 3500 to 1800 B.C. Herbs appear to be a crucial part of medicine in other civilizations as well. Chinese, Greek, and African remedies are only a few examples [3]. The German market accounts for almost 50% of the $3.5 billion European market. France, Italy, the United Kingdom, Spain, and the Netherlands are the countries that come in second on this market [4]. Due to their efficiency, lack of negative side effects, and affordability, herbal medications are frequently recommended even when the biologically active ingredients are unknown.

The useful medical plant *Plumbago zeylanica*, often known as Plumbago, "white leadwort," "Ceylon leadwort," "Doctorbush," "Chitrak" in India, is used extensively in Africa and Asia to cure comon illnesses [5]. *Plumbago zeylanica* (Family: Plumbaginaceae) is a therapeutic plant. The 280 species and 10 genera that make up the family plumbaginaceae are divided into the Plumbaginoideae and staticoideae subfamilies, which may be distinguished by morphological, chemical, and molecular traits. Four genera make up the Plumbaginoideae family, with Plumbago having the most species at about 20, distributed all over the world, mostly in arid, salty landscapes like salt flats and seashores, particularly in the Mediterranean and Western Asia [6–8]. The purpose of this evaluation is to highlight the value of medicinal applications, Phytochemistry, pharmacology, toxicity, and its prospective pharmaceutical action for the creation of novel herbal preparations. It has given researchers the chance to do further study and development in this area.

Methodology adopted

Literature search

To summarize the traditional medical applications of *Plumbago zeylanica* and its healing characteristics, a thorough literature study that included data from the last two decades was conducted. Utilizing the terms *Plumbago zeylanica*, its traditional medical applications, Phytochemistry, toxicity, and pharmacological activity, material was retrieved utilizing a variety of internet platforms, including Google Scholar, Pub Med, Springer, and Science Direct. The implementation of the research design and the acceptance criteria for the included studies were based on electronically reporting the retrieved pertinent articles and fully describing the data gathering method.

Synonyms

Arabia: Shitaraj, Ensain, Enkin; Assamese: Agiyachit, Agnachit, Boga agechita; Bengali: Chita, Safaid-chitarak; Burma: Kanchopphiju, Kinkhenphiu; Chinese: Pai Hua T'eng; English: White flowered leadwort, Ceylon leadwort; French: Dentalaire; German: Bleiwurz, Zahnkraut; Gujarati: Chitrakmula; Hindi: Chira, Chitrak; Indonesia: Ceraka, Poksor,Kareka; Kannada: Chitramula, Chitramulika, Vahni, Bilichitramoola; Kashmiri: Chitra, Shatranja; Malayalam: Vellakoduveli, Thumpokkoduveli; Manipuri: Telhidak angouba; Marathi: Chitraka, Chitramula; Nepal: Chitu; Oriya: Chitamula, Chitoparu, Ogni; Punjabi: Chitra; Phillipine: Sagdikit, Talankaw; Sanskrit: Chitraka,Agni, Vahni, Jvalanaakhya, Krishanu, Hutaasa, Dahana, Hutabhuk, Shikhi; Swahili: Sanza; Tamil: Chitramoolam, Kodiveli, Kanilam, Sittragam; Tswana: Mosikomabe; Telugu: Chitramulamu, Agnimata; Urdu: Sheetraj Hindi, Cheetah, Chitalakhri [9-10].

Taxonomic profile

Domain: Eukaryota
Kingdom: Plantae
Phylum: Tracheophyta
Divison: Magnoliophyta
Class: Magnoliopsida
Order: Plumbaginales
Family: Plumbaginaceae
Genus: Plumbago
Species: zeylanica
Botanical name: *Plumbago zeylanica* [11].

Geographical distribution of *Plumbago zeylanica*

Native to Southeast Asia, *Plumbago zeylanica* may be found in tropical and subtropical areas up to a height of 2,000 meters. It grows mostly in the old world tropical regions of Ceylon, the Malay Peninsula, and all of India in its natural condition. It is mostly grown in Andhra Pradesh, Karnataka, and Maharashtra provinces in India [12].

Fig 1: Plumbago zeylanica

Morphology

Habit: A sprawling understory shrub or perennial herb with green branches.

Roots: Straight, unbranched or slightly branched, at least 30 cm extended, 6 mm in width, friable, blackish red in color, bright yellow in freshness, roseate brown in age, with or without subordinate roots, and of a uniform, flat texture. It smells distinctively and tastes caustic and unpleasant.

Stems: Terate, striate, spreading, somewhat woody, and glabous. It may grow up to a height of 1.6-6.6 ft. The bark has a tinny, chocolate color.

Leaf: Modest, alternating, oval or rectangle leaves about 8 cm extended by 3 cm wide, with a slender petiole that is amplexicaul at the base and frequently opened into stipule-like auricles.

Inflorescence: A terminal raceme-type inflorescence with numerous flowers that is between 6 and 30 cm long.

Flower: Flowers are bisexual, snowy in color, 10-25 cm extended, inodorous, inbracteate, and have lengthened spikes at the axillary and terminal ends, thickly populated with sticky, stalked glands on the calyx. Corolla has five free stamens and is white, extremely thin, and tubular.

Fruit: A solitary seed-containing, oblong, capsule with five ridges. Each seed has a rectangle shape, is 5-6 mm long, and ranges in color from reddish-brown to dim brown.

Miniature description

The root's transverse slice reveals the following structure:

Cork: The cork's outermost layer is made up of five to seven rows of dark brown, cubical to four-sided cells.

Secondary cortex: The subordinate cortex is made up of two to three rows of rectangular, light brown cells with thin walls, the majority of which are filled with starch grains.

Cortex: Consists of big, irregularly shaped parenchymatous cells that range in size and form from polygonal to tangentially elongate. Some of the fibers are dispersed individually or in groups of two to six.

Phloem: A tinny zone of many-sided, thin-walled cells with regular components and phloem fibers, similar to the cortical zone. They resemble secondary cortex in size and shape. They typically occur in groups of two to five but can occasionally occur alone.

Cambium: Not specific.

Xylem: Pale yellow to white; radial or single rows of xylem channels; tracheids also contain starch granules.

Medullary ray: Radially elongated, single to multifaceted and filled with modest to complex starch particles.

Leaves: Dicotyledonous in structure and amorphous in form, the leaves. The leaf's T.S. reveals the following structure: Two to three spongy layers are sandwiched between a palisade layer.

Mesophyll: Less tannin-rich intercellular gaps than those of *P. indica* rarely included idioblast cells.

Trichomes: Not found [13].

Propagation

Plumbago zeylanica is mostly propagated by the use of seeds, rooted shoots from the plant's base, or semi-ripe cuttings that have been maintained with development regulators. Seeds germinate in 21–30 days and prolonged storage (more than 3 months) causes a significant decline in germination rate. A preferred way of growing *Plumbago zeylanica* plants is from seed, which is then transplanted to the crushed at a thickness of 58 x 58 cm. Despite the fact that the plant may grow in a variety of soils, it prefers well penetrating sandy to clayey loam soil with high carbon-based content. In their native environments, plants thrive in moist soil rich in carbon-based matter, fairly shady locations, and somewhat warm temperatures. Most conventional methods of proliferating have proven to be troublesome and insufficient to satisfy the growing commercial demand for herbal plants. The primary causes are widely acknowledged to be inadequate seed propagation and premature seedling deaths on plantations under unfavorable conditions. On the other hand, *Plumbago zeylanica* is successfully mass-multiplied via the method of *In vitro* proliferation through the use of nodal explants, axillary buds, leaf, root explants, and callus cultures [14].

Traditional and contemporary view of *Plumbago zeylanica*

Plumbago zeylanica has been used medicinally for a number of years. The roots are used as pastes, decoctions, or powders to cure non-bleeding piles, depigment the skin, treat filariasis, relieve constipation, and cleanse the uterus (abortifacient).

A) *Plumbago zeylanica* in Ayurveda

A big portion of our population receives medications from ayurveda, which is known as the science of life. Ayurvedic medical system, chitraka plant is regarded as an efficient herbal medication. All of the plant's components are utilized to cure a variety of illnesses, but the roots of the Chitraka plant exhibit the most therapeutic potential [15]. While reducing Kapha and Vata, it strengthens Pitta dosha. The traditional medical system Ayurveda describes chitraka as anti-dyspepsia and tumor-negating. This is classified as an appetizer, anti-saturative, anti-anorexic, painkiller, and anti-hemorrhoid in the Charaka Samhita [16].

Dysentery, digestive issues, leukoderma, inflammation, piles, bronchitis, itchiness, liver illness, and tridosha are just a few of the conditions that root and root barks have been used to treat in Ayurveda. Ulcers and scabies are treated with root bark milk juice [17]. Roots act as an abortifacient, vesicant, antidiarrheal, appetising, sudorific, laxative, expectorant, alexipharmic, thermogenic, antiatherogenic, cardiotonic, neuroprotective, nervous stimulant, diuretic, caustic, antiseptic, antiperiodic, narcotic, rubefacient, aphrodisiac, alternative or restorative [18-19]. Anasarca, piles, leprosy, anaemia, ringworm, scabies, jaundice, urinary calculi, migraine, internal abscesses, seminal weakness, hysteria, obesity, nervous and rheumatic infections, indolent ulcer, asthma, cough, colic, and helminthiasis are other conditions that can benefit from its use [20]. Leaves are used to treat digestive issues including dysentery and diarrhea as well as infections. To treat chronic or itchy skin conditions as well as painful rheumatic conditions, chitraka leaf paste is administered. The plant's fruit and blossom both have digestive properties. Muscle soreness can be reduced by using the seed's decoction [20].

B) Traditional uses

Plumbago zeylanica is regarded as a valuable therapeutic herb in the traditional medical system. It works well for treating rheumatic pain, dysmenorrhea, leprosy, ulcers, inflammation, contusion of the extremities, and the removal of duodenal parasites. It also works well for treating skin conditions including acne, rashes, dermatitis, and hookworm anemia. This is suggested for the cure of dyspepsia, piles, diarrhea, and skin conditions in the Indian medical system, and it is also used to boost digestion and promote appetite [21–22]. Additionally, root paste is said to work well against the filarial leg. When combined with lemon juice, leaves and roots of this plant are used in West Africa to treat gonorrhea, syphilis, TB, rheumatic pain, wounds, and swelling.

In certain African countries, mixing root paste with milk, vinegar, or root produced beneficial results for treating flu and black water fever. Root extracts are used to treat asthma. Root decoction made with boiling milk is used to treat tongue, throat, and chest discomfort. Root extract is also used to treat diarrhea and dyspepsia in Mauritius and Rodrigues. This is mostly used to treat fever and malaria in India [23]. According to reported research, dry root powder is used to treat anemia brought on by "stagnant blood", rheumatism, internal and external damage, and toxic edema [24–25].

C) Current view

In the current environment, adulteration is the main problem that the global herbal industry is dealing with. People no longer have confidence in these remedies because of this major drawback in the advertising of herbal pharmaceuticals [26–29]. The practice of species adulteration is one of the most common. Adulteration has been suspected in the natural medication industry for a time. Consumer health is negatively impacted [30]. This is well-known cases of species adulteration

from China, while more than 100 women developed kidney failure as a result of the adulteration of a species, namely the roots of the anti-inflammatory plant *Stephania tetrandra* by the roots of the poisonous plant [31]. The quality of herbal medicines is being diminished in one way or another by a number of additional procedures that are now part of the commercial market for herbal remedies. One of them is the usage of synthetically produced substance that imitates the original medicine. When it comes to pricey herbal treatments, this is the adulteration method that occurs the most frequently [32–33]. The rate of toxicity has grown as a result of the presence of many adulterants, and the high cost is an additional contributing factor [34].

Phytochemistry

A phytochemical is a naturally occurring bioactive substance created by a plant's regular metabolic process. The term "Secondary metabolities" is frequently used to describe these substances. This includes phenols, gums, tannis, coumarins, terpenes, flavonoids, and alkanoid among others. These phytochemicals come from plant-based foods and combine with the body's nutrients and dietary fiber to defend it against illness.

Flavonoids, alkaloids, saponins, glycosides, tannins, steroids, triterpenoids, carbohydrates, coumarins, fixed oil, phenolic compounds, lipids, naphthoquinones, and proteins are among the secondary metabolites found in *Plumbago zeylanica* [35]. According to the screening of various plant components, linoleic acid, nonylnonanoate, palmitic acid, stigmasterol acetate, lupeol acetate, lupeol, friedelinol, lupanone, stigmasterol, and sitosterone were also found [36–38]. More microelements, macroelements, and eight more elements, and Arsenic are found in higher concentrations in the plant's leaves, stem, and roots [39]. Plumbagin, isohinanolone, plumbagic acid, beta-sitosterol, 4-hydroxybenzaldehyde, trans-cinnamic acid, vanillic acid, 2, 5-dimethyl-7-hydroxychromon, and indole-3-carboxaldehyde are the chemical components found in the aerial section of the plant [40]. Betasitosterol, beta-sitosteryl-3-beta-glucopyranoside, betasitosteryl-3-beta-glucopyranoside-6'-O-palmitate,
lupenone, plumbagin, lupeol acetate, and trilinolein are all found in the dichloromethane extract recovered from aerial sections of the plant [41]. The root of the plant contains different bioactive products which include plumbagic acid glucosides [42] along with five naphthoquinones as plumbagin [43], chitranone, [44] maritime, [45] elliptinone and isoshinanolone [46] and five coumarins such as seselin, [47] 5-methoxyseselin, [48] suberosin [49], xanthyletin [50] and xanthoxyletin [51]. Plumbagin, chitranone, 3- biplummbvagin, chloroplumbagin, and elliptone are examples of naphthoquinones found in the plant. Saponaretin, isoaffinetin, beta-sitosterol, 2-dimethyl-5-hydroxy-6-acetylchromene, zeylanone, campesterol, isozeylanone, plumbaginol, and chitanone are also detected [52].

Pharmacology

Plumbago zeylanica has been shown to have anti-inflammatory, anti-diabetic, memory promoting, lipid metabolism, anti-malarial, allergic and modulatory, anti-fertility, anti-bacterial, anti-viral, anti-cancer, antioxidant, and larvicidial properties. The following are the documented pharmacological actions of different components of *Plumbago zeylanica*.

Antimicrobial activity

Shweta and Dubey looked at the antibacterial effects of the plant's leaf extracts in comparison to certain well-known medications. *In vitro* research was done on the crude extract's antibacterial activity and lowest inhibitory concentration in comparison to common antibiotics. Leaf extracts had the strongest inhibition when compared to conventional antibiotics [53]. In a separate investigation, Singh and colleagues investigated the antibacterial properties of methanolic extracts of the stem and leaves against nine fungal species and six bacterial species. Both extracts are shown dose-dependent bactericidal activity. The *Plumbago zeylanica* stem's methanolic extract has a strong antibacterial effect, according to one research [54]. *Plumbago zeylanica* root bark ethanolic extract was evaluated for its antibacterial properties against seven bacteria in a different investigation by Ogunleye and colleagues. The bacteria were taken from two Akure dumpsites. The antibacterial activity of the extract, according to the research, rises with concentration [55]. Recently, *Plumbago zeylanica*'s antifungal properties were examined by Jain *et al.* Investigations were made into the antifungal abilities of *Fusarium oxysporum*, *Rhizoctonia solanii*, *Alternaria sp*., and *Sclerotium rolfsii*. It exhibits significant inhibitory efficacy at 62.5 g/ml against *Alternaria spp*. but not against *S. rolfsii*, according to the research [56].

Anti-inflammatory activity

Sheeja *et al.* used in vivo experimental mice to examine the anti-inflammatory effects of acetone and petroleum ether extracts of *Plumbago zeylanica* leaves at two dose levels. When compared to the control group, the acetone extracts considerably reduced the inflammation caused by carrageenan in the rats. A study found that the extract's anti-inflammatory effects were not caused by the presence of preexisting inflammatory chemicals but rather by a decrease in prostaglandin generation and release. Thanigavelan *et al.* investigated the anti-inflammatory activity of *Plumbago zeylanica* root bark hydroalcoholic extract *In vitro* using human red blood cell membrane protective activity and *in vivo* using carrageenan-induced rat paw oedema and complete Freund's adjuvant-induced chronic inflammatory model in rats. One research suggests that prostaglandin inhibition may be responsible for the anti-inflammatory benefit [60]. Furthermore, using diene-conjugate and -glucuronidase tests, Nile *et al.* examined the anti-inflammatory effectiveness of *Plumbago zeylanica* root and shoot extracts at doses of 25, 50, 75, and 100 mg/mL [61]. Subramaniyan *et al.* later evaluated *Plumbago zeylanica* dichloromethane extract against carrageenan-induced paw oedema at doses of 250 mg/kg and 500 mg/kg. One research suggests that the inhibitory action may be related to its scavenging of free radicals and prevention of apoptosis [62]. In a different study [63], Poosarla *et al.* investigated a freeze-dried ethyl acetate fraction (PZE-6) of *Plumbago zeylanica* roots for the management of joint inflammation. Zaki *et al.* claim that plumbagin decreased the expression of highmobility group box 1, which in turn lowered the activities of inflammatory cascades including nuclear factor B (NF-B), tumour necrosis factor-alpha (TNF), and myeloperoxidase (MPO) [64].

Antioxidant activity

The anti-oxidant properties of *Plumbago zeylanica* have drawn a lot of interest. Aqueous extracts were shown to be more effective in the ABTS assay, whereas ethanolic extracts were more successful in the FRAP/DPPH studies. These extracts contained a greater level of polyphenols and

flavonoids, and they also prevented lipid peroxidation. Investigations into antioxidants and pulse radiolysis were done to determine the exact mechanisms of action [65]. In order to test the free radical scavenging abilities of methanolic root extract (ME) and ethylacetate extract (EA), Gabriel and colleagues utilised 1, 1-diphenyl2-picrylhydrazyl (DPPH). When compared to EA extract, ME extract was shown to have the highest antioxidant activity [66].

Hair growth promoter and regulation

A kind of baldness known as androgenetic alopecia results in progressive hair loss. The anti-AGA effectiveness of *Plumbago zeylanica* roots extract was assessed by Yamada *et al.* SRD5A2 expression was shown to be up-regulated in DP cells that were senescent, however *Plumbago zeylanica* root herbal extract boosted DP cell proliferation while lowering SRD5A2 expression in DP cells. Observations showed that senescent DP cells play a role in the formation of AGA by upregulating SRD5A2 expression, and they also suggested that *Plumbago zeylanica* extract and plumbagin may be able to prevent the growth of AGA by promoting DP cell growth and decreasing SRD5A2 expression in DP cells [67].

Antidiabetic activity

The presence of plumbagin, the major active ingredient of *Plumbago zeylanica*, is responsible for its tasty inactivation property. *Plumbago zeylanica's* effectiveness in treating diabetes has been supported by several studies. An ethanolic extract of the roots of *Plumbago zeylanica* was shown to have anti-diabetic properties by Zarmouh *et al.* Although blood levels of acid phosphatase, alkaline phosphatase, and lactate dehydrogenase dropped, hepatic hexokinase activity dramatically increased [68]. A research was also done to determine whether plumbagin, which is derived from the root of the *Plumbago zeylanica* plant, has any anti-diabetic properties. According to the research, plumbagin significantly reduces the risk of diabetes [69]. Khatwani *et al.* examined the possible synergistic effects of aqueous extracts of the roots of *Plumbago zeylanica*, *Annona squamosa*, and *Murraya koenigii* in a diabetic rat model induced by STZ. The study findings with the polyherbal formulation were shown to be more significant than Glibenclamide [70].

Antiulcer activity

Aqueous *Plumbago zeylanica* root extract was evaluated by Falang and associates against acute stomach ulcers brought on by aspirin and indomethacin in albino mice. The ulcer score, ulcer index, and percentage of protection of the extract were computed and compared with negative and positive control groups. At doses of 25, 50, and 100 ml/kg, the extract prevented damage to the stomach mucosa caused by aspirin, whereas at 50 and 100 mg/kg, it prevented ulcers brought on by indomethacin [71].

Antiobesity

Kotecha and Rao looked at Plumbago zeylanica's ability to combat obesity. Obese individuals from Jamnagar, Gujarat's IPGT and R Hospital had a clinical evaluation. The patients underwent a 45-day experiment during which they received Plumbago zeylanica and haridra powder in capsule form at doses of 500 mg and 1 g (4 times per day), respectively, in addition to a restricted meal schedule and low-calorie diet. The proposed intervention of Plumbago zeylanica and haridra powder revealed a potential weight decrease in the patient when compared to haridra alone [72].

Antihyperlipidemic activity

In rats with diet-induced hyperlipidemia, Pendurkar and Mengi looked into the antihyperlipidemic effects of *Plumbago zeylanica* root aqueous extract. Following oral administration of the extract at doses of 20, 40, and 80 mg kg 1, the effect on individuals with hyperlipidemia was lessened by lowering cholesterol and triglyceride levels. Fenofibrate and atorvastatin, the reference medicines, produced similar outcomes. Furthermore, it was discovered that the extract significantly reduced the amount of total lipids in the liver. The outcomes demonstrated that *Plumbago zeylanica* root aqueous extract was efficient in hyperlipidemic circumstances [73].

Hepatoprotective activity

A petroleum ether extract of *Plumbago zeylanica* roots was shown to have hepatoprotective activity against paracetamol-induced liver damage by Kanchana *et al.* Numerous biochemical markers were looked into in order to judge the hepatoprotective effectiveness. The significant liver damage that paracetamol induced in animals showed up as elevated levels of markers in those animals. A significant decrease in serum markers was seen after the extract injection, indicating that the extract was successful in restoring the hepatocytes' ability to operate normally. The results suggest that *Plumbago zeylanica* root petroleum ether extract may provide significant protection against paracetamol-induced hepatocellular damage [74].

Wound healing activity

Traditional medicine has long praised *Plumbago zeylanica* for its capacity to heal wounds. A methanolic extract of *Plumbago zeylanica* roots was found to have significant wound healing activity in wistar rats by Kodati *et al.* The extract raised the percentage of wound contraction while decreasing the time it took for a wound to close. Additionally, the groups treated with the extract showed complete wound healing after 16 days, but the control group showed epithelization after more than 20 days [75]. In a different investigation, Jyothi and colleagues investigated the ability of *Plumbago zeylanica* ethanolic root extract to cure wounds. The presence of phytoconstituents in the ethanolic root extract may be the cause of the enhanced wound healing capacity, which may work singly or in combination [76].

Nephroprotective activity

In Swiss albino mice with cisplatin-induced nephrotoxicity, Rajakrishnan and colleagues looked into the nephroprotective effectiveness of a hydroalcoholic extract of *Plumbago zeylanica* roots. HAPZ's renoprotective function was demonstrated by the fact that a high dose (400 mg/kg) injection significantly reversed the negative effects of cisplatin on kidney weight, serum urea, and creatinine. The results of the study support *Plumbago zeylanica* hydroalcoholic extract's nephroprotective properties [77].

Antifertility activity

The ability of *Plumbago zeylanica* leaf extracts to prevent infertility was investigated by Edwin and colleagues. It was discovered that the ethanol and acetone extracts more effectively disrupted the rat's estrous cycle [78]. In a separate investigation, Vishnukanta and Rana assessed the antiimplantation effectiveness of the hydroalcoholic extract of *Plumbago zeylanica* leaves. On female Wistar rats with

immature ovariectomies, the extract's estrogenic and antiestrogenic activity was examined for 1 to 7 days postcoitum. At a dosage of 200 mg/kg, significant antiimplantation action was discovered. The uterus had significant structural and functional alterations as a result of the extract's antiestrogenic action [79].

Anticancer and cytotoxic activity

Plumbago zeylanica reportedly contains a number of phytoconstituents having cytotoxic effects. Plumbagin is one of the primary bioactives that has been thoroughly investigated for its potential to be cytotoxic and anticancer. Eldhose *et al.* looked into the efficiency of plumbagin against colon cancer cells. The results of the study show that plumbagin has no negative effects on colon cells that are healthy while having a strong anti-survival effect on colon cancer cells [80]. Numerous researches have demonstrated the extracts' *In vitro* anticancer effects.

Mani and Jayachitra carried out an experimental study to contrast the anticancer properties of an ethanolic extract of *Plumbago zeylanica* leaves with the conventional 5-Fluorouracil. With a decline in blood flows, serum enzyme levels, and lipid profiles that were relatively within normal ranges, it was discovered that both doses of EEPZ significantly decreased average body weight, decreased the number of tumour cells that were viable for packed cell volume, and prolonged the lifespan of mice for DAL therapy [81]. The cytotoxicity activity and potential toxicity of the Plumbago zeylanica root petroleum ether, acetone, and hydroalcoholic extracts were also examined by Kumar *et al.* in rats. Based on LD50 values, a study found that PZPE was riskier than PZAC and PZHA. *Plumbago zeylanica* root extract appears to have a deleterious effect on the liver and kidney in addition to other organs, according to a research [82].

Tokarz *et al.* examined *Plumbago zeylanica*'s adaptation of its photosynthetic system to lead poisoning as a survival tactic in a recent study. A research found that plants become used to lead poisoning by storing lead in their roots [83].

Anthelmintic activity

Desai and colleagues assessed the anthelminitic effects of the root extracts in terms of worm paralysis and death time in both aqueous and methanolic extracts. When compared to aqueous extract, methanolic extract exhibited a noticeable effect [84]. In a separate investigation, Weldemariam *et al.* assessed the anthelmintic efficacy of the roots' chloroform and ethanolic extracts in both crude and fractions. The worms are quicker paralysed and killed by crude and fractions than by the positive control. The results from chloroform extracts were significantly better than those from ethanolic extract. These major findings point to the plant's long-term usage for helminthes [85].

Toxicology

Plumbagin, a highly caustic crystalline glycoside that resembles fine, glittering needles of a golden yellow colour, is found in the roots of several plants. It dissolves in hot water but not cold, and it dissolves in ether, chloroform, alcohol, and benzene as well. Plumbagin is a potent irritant with potent bacterial and single-celled organism-killing properties. A damaged root or twing placed on the skin causes it to swell up and turn red. When occupied internally in tiny dosages, the plant functions as a sudorific and promotes the contraction of the heart, colon, and uterine muscle tissue. When taken in excessive dosages, the herb functions as an irritating toxin, causing gastrointestinal colicky agony. Other signs include dilated pupils, flushed skin, and itching that is covered in perspiration. The signs of hypotonia include gasping breaths, a slow or irregular pulse, and hypotonia itself. Possible results include myotonia, coma, and respiratory failure-related death. 178 g of powdered was used in the lethal dose. The deadly phase may not always occur. Aspects of law and medicine: The root is applied to the cervix directly or through an abortion stick as a paste as an abortifacient. It is utilised by malingerers to fabricate bruising. It is extremely infrequently used as a murderous poison [86].

Antidote

Pittashamaka, Snighda, and Sheeta preparations are recommended. Kshira and Chandana are two examples. Purification (Rakta Chitraka Sodhana). Citraka mula is cut into little pieces and immersed in lime water and then rinsed and sun dried [87].

Aspects of safety

The medicine taken in standard prescribed dosages may be deemed harmless. Powder: 1-2 g.

Formulations of Chitraka

As well as promoting agni (the power of digestion), pippalyadya churna produced from chitraka also removes vayu (flatus) from the koshta (gastrointestinal tract). Treatments for Kapha, gulma (phantom tumor), sprue syndrome, anemia, splenic problems, and fever include Chitrakadya gutika (stimulates the power of digestion and metabolism), and Kshirasatpalaka grita, which mostly contains chitrak [88].

Future Prospectus

Even though *Plumbago zeylanica* is a crucial plant in the production of herbal medicines, a significant commitment is still required to create a different method for the plant's widespread propagation. *Plumbago zeylanica* random sampling is now being conducted in forested regions. This puts the natural occurrence of *Plumbago zeylanica* at danger. The breeding process is restricted by using marker-aided assortment and the rapid genotype development of *Plumbago zeylanica* underpins the growth of the crop. Huge-scale *In vitro* procedures for growth and subsequent ground plantings could be tremendously beneficial for the expanding demand for *Plumbago zeylanica.*

Conclusion

The current review examined *Plumbago zeylanica* pharmacological characteristics, phytochemical profile, and traditional therapeutic applications. The information found showed that *Plumbago zeylanica* has excellent therapeutic capabilities and is a rich source of a variety of phytoconstituents. The plant's principal known constituents were flavonoids, alkaloids, glycosides, saponins, steroids, tannins, triterpenoids, coumarins, and phenolic compounds. Literature demonstrates its enormous effectiveness in considering a wide range of illnesses, for example cancer, diabetes, ulcers, liver issues, wound healing, and cardiovascular abnormalities. The majority of the conventional claims about its health advantages were supported by the study under consideration. However, it was discovered during the literature search that the majority of the work has been done on extracts; as a result, further research is required to identify, characterize, and isolate the

pharmacologically active agents that give *Plumbago zeylanica*. its medicinal properties. This research is also necessary to understand the configurations of these agents and the mechanisms by which they apply their curative effects. Additionally, the separation studies can aid in maximizing the pharmacological qualities whereas minimizing the negative consequences.

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Conflict of Interest
There is no conflict of interest, according to the authors.

References
1. Verma Sheetal, Singh SP. Current and future Status of Herbal Medicines. Veterinary World. 2012;1(11):347-350.
2. Jeyachandran R, Mahesh A, Cindrella L. Antibacterial Activity of Plumbagin and Root Extracts of *Plumbago zeylanica* L. Acta Biologica Cracoviensia Series Botanica. 2009;51(1):17-22.
3. Sandhya B, Thomas S, Isabel W, Shenbagarathai R. Ethnomedicinal Plants Used By the Valaiyan Community of Piranmalai Hills (Reserved Forest), Tamilnadu, India. - A Pilot Study. Afr. J. Trad. CAM. 2006;3(1):101-114.
4. Alok Sharma, Shanker C, Lalit Kumar Tyagi, Mahendra Singh. Herbal Medicine for Market Potential in India: An Overview. Academic Journal of Plant Sciences. 2008;1(2):26-36.
5. Nguyen AT, Malonne H, Duez P, Vahaelen-Fastre R, Vanhaelen M, Fontaine J. Cytotoxic constituents from Plumbago zeylanica. Fitoterapia. 2004;75(5):500-504.
6. Perveen Anjum Qaiser. Pollen Flora of Pakistan – xxxix. Plumbaginaceae. Pak. J. Bot. 2004;36(2):221-227.
7. Kantha Deivi Arunachalam, Velmurugan P, Balaji Raja R. Anti-inflammatory and Cytotoxic Effects of Extract from *Plumbago zeylanica*. African Journal of Microbiology Research. 2010;4(12):1239-1245.
8. Dolores Lledo M, Manuel B Crespo, Michael F Fay, Mark W Chase. Molecular Phylogenetics of Limonium and Related Genera (Plumbaginaceae): Biogeographical and Systematic Implications. American Journal of Botany. 2005;92(7):1189-1198.
9. Synonyms, *Plumbago zeylanica* (Root). Available from http://logayurveda.com/plantprofiles/143-plumbago-zeylanica.html.
10. Kirtikar KR, Basu BD.Indian Medicinal Plants, Vol. 2. Dehradun: International Book Distributors. 2006; 1468.
11. Taxonomy, Plumbago. Available from http://zipcodezoo.com/Plants/P/Plumbago_zeylanica/.
12. Van der Vijver LM. Lötter AP. The constituents in the roots of *Plumbago auriculata* Lam. and *Plumbago zeylanica* L. responsible for antibacterial activity. Planta medica. 1971;20(03):8-13.
13. Paras Jain, HP Sharma, Fauziya Basri, Binit Baraik, Soni Kumari, Chanchala Pathak. Pharmacological Profiles of Ethno-Medicinal Plant: *Plumbago zeylanica* l. A Review. Int. J. Pharm. Sci. Rev. Res. 2014;24(1):157-163.
14. Richa Tyagi 1, Ekta Menghani. A Review on *Plumabgo zeylanica*: A Compelling Herb, Richa Tyagi *et al.* / International Journal of Pharma Sciences and Research (IJPSR). 2014;5:04.
15. Chatterjee A, Pakrashi SC. Treaties on Indian medicinal plants: national institute of science communication and information resources. New Delhi, India. 2003;3:146-147.
16. Dev, S. Selection of prime ayurvedic plant drugs. Anamaya Publishers; c2006.
17. Bhutya RK. Ayurvedic Medicinal Plants of India. Scientific Publishers 2011;1:1.
18. Gogte VM. Prajapati ND, Purohit SS, Sharma AK, Kumar T. Ayurvedic Pharmacology and therapeutic uses of Medicinal plants (Dravyagunavignyan), translation by the academic team of Bharatiya Vidya Bhavan's SPARC. Chaukhambha Publication, New Delhi. A Handbook of Medicinal Plants (Agrobios, Jodhpur); c2009. p. 370-2.
19. Olagunju JA, Fagbohunka BS, Oyedapo OO, Abdul AIA. Effects of an ethanolic root extract of *Plumbago zeylanica* Linn on some serum parameters of the rats. RPMP-Drug Dev. Mol. 2006;11:268- 276.
20. Chiu NY, Chang KH. The Illustrated Medicinal Plants of Taiwan, Vol. 2. SMC Publishing Inc., Taipei, Taiwan. 1995;2:285.
21. Sharma N, Kaushik, P. Medicinal, biological and pharmacological aspects of *Plumbago zeylanica* (Linn.). Journal of Pharmacognosy and Phytochemistry. 2014;3(4):117-120.
22. Jiangsu S. New Medical College, Zhonyao Dictionary (Encyclopedia of Chinese Materia). Scientific and Technological Press, Shanghai; c1979. p. 711-712.
23. Simonsen HT, Nordskjold JB, Smitt UW, Nyman U, Palpu P, Joshi P, Varughese G. *In vitro* screening of Indian medicinal plants for antiplasmodial activity. Journal of Ethnopharmacology. 2001;74(2):195-204.
24. Uniyal MR, Joshi GC. Historical view of the basic principles of the identification of controversial drugs, problems and suggestions. Sachitra Ayurved. 1993;45(7):531-536.
25. Saraswathy A. Adulterants and substitutes in Ayurveda. Sachitra Ayurved. 2001;54(1):63-66.
26. Song J, Yao H, Li Y, Li X, Lin Y, Liu C, Chen S. Authentication of the family Polygonaceae in Chinese pharmacopoeia by DNA barcoding technique. Journal of Ethnopharmacology. 2009;124(3):434-439.
27. Newmaster SG, Grguric M, Shanmughanandhan D, Ramalingam S, Ragupathy S. DNA barcoding detects contamination and substitution in North American herbal products. BMC Medicine. 2013;11(1):1-13.
28. Gilbert N. Regulations: Herbal medicine rule book. Nature. 2011;480(7378):98-99.
29. Mitra SK, Kannan R. A note on unintentional adulterations in Ayurvedic herbs. Ethnobotanical Leaflets. 2007;(1):3.
30. Poornima B. Adulteration and substitution in herbal drugs a critical analysis. IJRAP. 2010;1(1):8-12.
31. Roy A, Mallick A, Kaur A. Adulteration and substitution in Indian medicinal plants. IJPRBS. 2013;2:208-18.
32. Goswami A, Barooah PK, Sandhu JS. Prospect of herbal drugs in the age of globalization-Indian scenario. J Scientific Industrial Research. 2002;61(6):423-431.
33. Ahmad I, Aqil F. *In vitro* efficacy of bioactive extracts of 15 medicinal plants against ESβL producing multidrug-resistant enteric bacteria. Microbiological Research. 2007;162(3):264-275.
34. Devi CK, Krishna DG. Pharmacognostic, phytochemical and biological study of Plumbago zeylanica. International Journal of Natural Products Research. 2012;1(2):21-23.

35. Sankaram AV, Srinivasarao A, Sidhu GS. Chitranone: A new binaphthaquinone from Plumbago zeylanica. Phytochemistry; c1976.
36. Kodithala K, Hopfinger AJ, Thompson ED, Robinson MK. Prediction of skin irritation from organic chemicals using membrane-interaction QSAR analysis. Toxicological Sciences. 2002;66(2):336-346.
37. Kulkarni A, Hopfinger AJ, Osborne R, Bruner LH, Thompson ED. Prediction of eye irritation from organic chemicals using membrane interaction QSAR analysis. Toxicological Sciences. 2001;59(2):335-345.
38. Zhang QR, Mei ZN, Yang GZ, Xiao YX.. Chemical constituents from aerial parts of *Plumbago zeylanica* Linn. Zhong yao cai= Zhongyaocai. Journal of Chinese Medicinal Materials. 2007;30(5):558-560.
39. Nguyen AT, Malonne H, Duez P, VanhaelenFastre R, Vanhaelen M, Fontaine, J. Cytotoxic constituents from *Plumbago zeylanica*. Fitoterapia. 2004;75(5):500-504.
40. Dinda B, Hajra AK, Das SK. Chemical Constituents of *Plumbago indica* Roots. ChemInform. 1998;29:48.
41. Gunaherath GKB, Gunatilaka AL, Sultanbawa MUS, Balasubramaniam S1, 2 (3)-Tetrahydro-3, 3′ - biplumbagin: A naphthalenone and other constituents from *Plumbago zeylanica*. Phytochemistry. 1983;22(5):1245-1247.
42. Sankaram AV, Srinivasarao A, Sidhu GS. Chitranone: A new binaphthaquinone from *Plumbago zeylanica*. Phytochemistry; c1976.
43. Tezuka M, Takahashi C, Kuroyanagi M, Satake M, Yoshihira K, Natori S. New naphthoquinones from Diospyros. Phytochemistry. 1973;12(1):175-183.
44. Murray RD, Zeghdi S. Synthesis of the natural coumarins, murraol (CM-c2), transdehydroosthol and swietenocoumarin G. Phytochemistry. 1989;28(1):227-230.
45. Ganesan K. Gani S. Ethno medical and Pharmacological Potentials of *Plumbago zeylanica* LA. American Journal of Phytomedicine and Clinical Therapeutics. 2013;(3):313-337.
46. Nayar MNS, Bhan MK. Coumarins and other constituents of Hesperethusa crenulata. Phytochemistry. 1972;11(11):3331-3333.
47. WU T, Kuoh C, Furukawa H. Acridone Alkaloids. VI. The Constituents of Citrus depressa. Isolation and Structure Elucidation of New Acridone Alkaloids from Citrus genus. Chemical and Pharmaceutical Bulletin. 1983;31(3):895-900.
48. Ito C, Matsuoka M, Oka T, Juichi M, Niwa M, Omura M, *et al.* New Binary Coumarins from Citues Plants. Chemical and Pharmaceutical Bulletin. 1990;38(5):1230-1232.
49. Lin LC, Chou CJ, Meroterpenes and C-glucosylflavonoids from the aerial parts of *Plumbago zeylanica*. The Chinese Pharmaceutical Journal. 2003;55(1):77-81.
50. Pant M, Lal A, Rana S, Rani A. *Plumbago zeylanica* L.: A mini review. International Journal of Pharmaceutical Applications. 2012;3(3):399-405.
51. Chaudhari SS, Chaudhari GS. A review on *Plumbago zeylanica* linn. - A divine medicinal plant. International Journal of Pharmaceutical Sciences Review and Research. 2015;30(2):119-127.
52. Vishnukanta RA, Rana, AC. Evaluation of anticonvulsant activity of *Plumbago zeylanica* Linn leaf extract. Asian Journal of Pharmaceutical and Clinical Research. 2010;3(1):76-78.
53. Shweta S, Dubey S. Antimicrobial activity of leaves extract of *Plumbago zeylanica* plant against known drugs. Int J Res Stud Biosci. 2015;3(6):1-6.
54. Singh M, Pandey A, Sawarkar H, Gupta A, Gidwani B, Dhongade H, *et al.* Methanolic extract of *Plumbago zeylanica*: a remarkable antibacterial agent against many human and agricultural pathogens. Aust J Pharm. 2017;1:18-22.
55. Ogunleye AB, Akinneye JO. Antibacterial activity of the ethanolic root bark extract of *Plumbago zeylanica* (Linn.). Int. J Res Sci Innov. 2019;6(10):149-54.
56. Jain P, Sharma HP, Singh P. Antifungal, antioxidant and phytochemical analysis of *Plumbago zeylanica* Linn. Vegetos. 2020;33(2):247-57.
57. Sheeja E, Joshi SB, Jain DC. Bioassay-guided isolation of anti-inflammatory and antinociceptive compound from *Plumbago zeylanica* leaf. Pharm Biol. 2010;48(4):381-7.
58. Aleem M. Anti-inflammatory and antimicrobial potential of *Plumbago zeylanica* L: A review. J Drug Deliv Ther. 2020;10(5):229-35.
59. Arunachalam KD, Velmurugan P, Raja RB. Anti-inflammatory and cytotoxic effects of extract from *Plumbago zeylanica*. African J Microbiol Res. 2010;4(12):1239-45.
60. Thanigavelan V, Venkatachalam K, Venkatachalam L, Natarajan S, Murugan PK, Savarimuthu JA. Hydroalcoholic extract of *Plumbago zeylanica* Linn root bark exhibit analgesic and anti-inflammatory activities in experimental rat models. Am J Pharm Health Res. 2014;2(4):209-21.
61. Nile SH, Patil UB, Park SW. HPTLC analysis, antioxidant, anti-inflammatory and xanthine oxidase inhibitory activity of *Plumbago zeylanica* L. Chiang Mai J Sci. 2015;42(4):886-95.
62. Subramaniyan V, Paramasivam V. Potential anti-inflammatory activity of *Plumbago zeylanica.* Asian J Pharm Clin Res. 2017;10(10):372-5.
63. Poosarla A. Effect of *Plumbago zeylanica* ethyl acetate extract in prevention or treatment of arthritis using adjuvant induced arthritic rat model. Indian J Appl Res. 2017;7(11):44-6.
64. Zaki AM, El-Tanbouly DM, Abdelsalam RM, Zaki HF. Plumbagin ameliorates hepatic ischemia-reperfusion injury in rats: role of high mobility group box 1 in inflammation, oxidative stress and apoptosis. Biomed Pharmacother. 2018;106:785-93.
65. Tilak JC, Soumyakanti A, Thomas PA. Devasagayam. Antioxidant properties of *Plumbago zeylanica*, an Indian medicinal plant and its active ingredient, plumbagin. Redox Rep. 2004;9(4):219-27.
66. Gabriel O, Ademuyiwa O, Lasisi AA, Olagunju JA. Free radical scavenging activities of extracts and bioactive constituents from the roots of *Plumbago zeylanica* (Linn.). Eur J Biol Med Sci Res. 2019;7(2):21-33.
67. Yamada N, Miki K, Yamaguchi Y, Takauji Y, Yamakami Y, Hossain MN, *et al.* Extract of *Plumbago zeylanica* enhances the growth of hair follicle dermal papilla cells with down regulation of 5α reductase type II. J Cosmet Dermatol. 2020;19(11):3083-90.
68. Zarmouh MM, Subramaniyam K, Viswanathan S, Kumar PG. Cause and effect of *Plumbago zeylanica* root extract on blood glucose and hepatic enzymes in experimental diabetic rats. Afr J Microbio Res. 2010;4(24): 2674-7.

69. Christudas S, Veeramuthu D, Paul A, Savarimuthu I. Antidiabetic effect of plumbagin isolated from *Plumbago zeylanica* L. root and its effect on GLUT4 translocation in streptozotocin-induced diabetic rats. Food Chem Toxicol. 2012;50(12):4356-63.
70. Khatwani PK, Gurale VV, Kulkarni SR. Evaluation of polyherbal oral formulation for antidiabetic activity. Int J Phytopharm. 2015;6(4):184–90.
71. Falang KD, Uguru MO, Wannang NN, Azi IH, Chiamaka N. Antiulcer activity of *Plumbago zeylanica* Linn root extract. J Nut Prod Plant Resour. 2012;2(5):563-567.
72. Kotecha M, Rao KS. Clinical evaluation of. Haridra & chitrak in the management of medoroga (obesity). J Ayurveda. 2007;1:226-8.
73. Pendurkar RS, Mengi SA. Antihyperlipidemic effect of aqueous extract of *Plumbago zeylanica* roots in diet-induced hyperlipidemic rat. Pharm Biol. 2009;47(10):1004-10.
74. 74. Kanchana N, Sadiq AM. Hepatoprotective effect of *Plumbago zeylanica* on paracetamol induced liver toxicity in rats. Int. J Pharm Pharmaceut Sci. 2011;3:151-4.
75. Kodati D, Shashidher B, Galipelly SK, Kumar GP. Evaluation of wound healing activity of methanolic root extract of *Plumbago zeylanica* L. in wistar albino rats. Asian J Plant Sci Res. 2011;1:26-34.
76. Jyothi VA, Fathima B. Phytochemical evaluation & pharmacological screening of wound healing & antioxidant activity of *Plumbago zeylanica*. Int. J Pharm Technol. 2013;5:5879-91.
77. Rajakrishnan R, Lekshmi R, Benil PB, Thomas J, Farhan AH, Rakesh V, *et al.* Phytochemical evaluation of roots of *Plumbago zeylanica* L. and assessment of its potential as a nephroprotective agent. Saudi J Biol Sci. 2017;24(4):760-766.
78. Edwin S, Siddheswar JB, Dharam CJ. Antifertility activity of leaves of *Plumbago zylanica* Linn. In female albino rats. Eur J Contracept Reprod Health Care. 2009;14:273-7.
79. Vishnukanta S, Rana AC. Evaluation of the antifertility activity of the hydroalcoholic extract of the leaves of *Plumbago zeylanica* L. (Plumbaginaceae) in female wistar rats. Indian J Pharm Educ Res. 2010;44(1):49-55.
80. Eldhose B, Gunawan M, Rahman M, Latha MS, Notario V. Plumbagin reduces human colon cancer cell survival by inducing cell cycle arrest and mitochondria-mediated apoptosis. Int J Oncol. 2014;45(5):1913-1920.
81. Mani H, Jayachitra A. Anti-cancer activity of ethanolic extract of *Plumbago zeylanica* against dalton's ascitic lymphoma in mice. Int. J Appl Eng Res. 2019;14(7):1715-21.
82. Kumar D, Patil PA, Roy S, Kholkute SD, Hegde HV, Nair V. Comparative toxicity profiles of *Plumbago zeylanica* L. root petroleum ether, acetone and hydro alcoholic extracts in wistar rats. Ayu. 2015;36(3):329-34.
83. Tokarz KM, Makowski W, Tokarz B, Hanula M, Sitek E, Muszynska E. Can Ceylon leadwort (*Plumbago zeylanica* L.) acclimate to lead toxicity?-studies of photosynthetic apparatus efficiency. Int. J Mol Sci; c2020.
84. Desai HP, Kapadia MD, Kharat AR. Evaluation of anthelmintic activity of *Plumbago zeylanica* Linn. Int. J Pharm Sci Res. 2012;3(11):1000-1004.
85. Weldemariam Y, Afework G, Bezabh M. In-vitro anthelmintic efficacy of fractions from *Plumbago zeylanica* L (Family - Plumbaginaceae) root extract. Am J Life Sci. 2015;3(3):134-142.
86. Parikh's, text book of Medical jurisprudence, Forensic Medicine and Toxicology, 6th Edition, 9.37.
87. Rasatarangini, Shree Sadanan Sharma, Editing by Pandit Kashinath Shastri, 11 Edition, Taranga 24; 575.
88. The Ayurvedic Pharmacopoeia of India. 1st Edition. New Delhi; Government of India, Ministry of Health and family welfare, Department of Health. 1989;1(1):29.