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PLUMBAGO INDICA

LAKSHMI ARAMBEWELA & RUVIN A SILVA

INDUSTRIAL TECHNOLOGY INSTITUTE
(CEYLON INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH)
363, BAUDDHALOKA MAWATHA,
COLOMBO 7,
SRI LANKA.

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PREFACE

The medicinal plants of Sri Lanka have been investigated in the Natural Products Development group for many years. This monograph which is the sixth in this series is the result of the literature surveys, researches and experiences of the Natural Products Development group of Industrial Technology Institute (Ceylon Institute of Scientific & Industrial Research). This is intended for varied reading public, the herbal drug manufacturers who need to identify and standardise their herbal raw materials, the Ayurvedic physicians who need some scientific information on medicinal plants, the research workers requiring a quick background on a plant, the industrialist or entrepreneur pondering on commercial ventures and the inquiring lay readers. We hope this monograph fulfils some requirements of each of them.

The authors wish to thank the members of Natural Products Development group for their contribution to this, the Information Service group for providing information, Dept. of Chemistry, University of Sri Jayawardenepura for the TLC scanning facility and Dept. of Botany, University of Colombo for photographs of slides. They also gratefully acknowledge the sponsor National Science Foundation for research grant RG/98/IS/01.

Natural Products Development Group
Industrial Technology Institute
(Ceylon Institute of Scientific & Industrial Research)
P.O.Box 787,
Colombo 7
Sri Lanka
PLUMBAGO INDICA

Synonyms - *Plumbago rosea*
*Plumbago coccinea*
*Thela coccinea*¹

Sinhalese name - Ruthnitul, Ratnetol¹

Other names - english - Rosy-flowered Leadwort
Tamil - Cenkodiveli, Cithiramulam, Akkini, Sengodiveli, sengoduveli, Sengappugodiveli, Sittiramulam,
Hindi - Chitra, Lal-chita, rakta-chitra, Lal-chitarak,
Sanskrit - Agni, Atidipya, Chitraka, Chitranga, Chitravalli, Dahatea, Daruna, Dipika, Dvayagni, Hrasvagni, Kala, Kalamula, Mahanga, Marjana, Pathi, Pavaka, Raktachitra, Raktachitraka, Raktasikha, Sharbudhavhaya, Vahnimula, Vyala,
Bengali - Lalchitra,
Teligu - Errachitramulam,
Marati - Lal,
Kannada - Nelavarike,
Malay - Nilavaka,
Gujarati - Nat-ki-sana¹².

Family - Plumbaginaceae

Parts used - Leaves and roots

Pharmacopoeia - Ayurveda Pharmacopoeia³
Sinhalese Materia Medica⁴
Indian Materia Medica⁵

Official drugs - Concentrated decoctions, medicated wines, tablets³.
The juice of the *Plumbago indica* root blisters the skin. It is used to cause abortion. The juice of the leaves and roots mixed with oil is employed as an application for rheumatism, paralysis and leprosy in Sri Lanka.

In South India, the dried root is valued as a remedy for secondary syphilis and leprosy. The vesicating property of the milky juice is made use of in certain type of leucoderma and scabies. A tincture of the root is used in dyspepsia, piles, flatulence, loss of appetite and other digestive complaints.

The roots are used in dyspepsia, colic, inflammations, cough, bronchitis, helminthiasis, haemorrhoids, elephantiasis, chronic intermittent fever, ring worm, hepatosplenomegaly, amenorrhoea, odontalgia, anaemia, skin diseases, diarrhoea, piles, anasarca and as an abortifacient.

In Malaya the chewing of the root regularly with areca nut is said to cause abortion and is a vesicant and a powerful sialogogue.

In Java, the root is used in veterinary medicine for expelling worms in horses.

Plumbagin may be useful in the treatment of early cases of leucoderma and baldness of head.

Plumbagin has been prescribed for cancer in the Siddha system of medicine.

*Plumbago indica* is an attractive plant, frequently grown in gardens for its showy bright red flowers.

Probably native in South Asia and now cultivated throughout India and Sri Lanka.
Morphology

A perennial glabrous herb, more or less climbing with striated stems and with long succulent roots, leaves simple, alternate, exstipulate, ovate-elliptic, about 10 cm long, tapering into a short somewhat clasping petiole, entire, undulate, glabrous, thin, flowers regular, bisexual, in long purplish-red to scarlet, racemes, bracts shorter than calyx, sepals five, fused into a narrow, tubular, glandular calyx, pubescent with stalked glands, petals five, fused into a tubular salverform corolla, tube about 2.5 cm long, segments obovate, spreading, apiculate, stamens five, distinct, hypogynous, free from the corolla, filaments as long as the corolla tube, anthers exserted just beyond the throat, ovary superior, 5-carpellary, unilocular with basal placenta and one anatropous ovule, style 2.2 cm long, stigmas 5, fruit a membranous circumscissile capsule, enclosed by persistent calyx, the deciduous part often splitting into 5 valves from below.

Fig: 1  1. Leaf  2. Flower  3. Root
Fig 2: Cross section of *Plumbago indica* leaf
A. Cuticle  B. Upper epidermis  C. Palisade parenchyma cells
D. Chloroplast  E. Spongy parenchyma cells  F. Lower epidermis

Fig 3: Cross section of *Plumbago indica* stem
A. Epidermis  B. Cortex  C. Cholenchyma  D. Phloem  E. Xylem
Fig 4: Cross section of *Plumbago indica* root
A. Cork  B. Cortex  C. Phloem  D. Xylem

Fig 5: Cross section of *Plumbago indica* root
A. Cork  B. Cortex  C. Vascular bundle
Powder Analysis: Leaves

Macroscopic characters
- Colour: Brownish black
- Odour: Slightly pungent
- Taste: Very slightly bitter

Microscopic character
The powder of *Plumbago indica* leaves shows:
Wilt irregular shape parenchyma cells and their parts.
Large numbers of droplet like granules that have come out from the cells.

![Image of powder of *Plumbago indica* leaves under the microscope]

**Fig 6**: Powder of *Plumbago indica* leaves under the microscope
A. Part of parenchyma cells  
B. Cell content
Powder Analysis: Roots

Macroscopic characters

<table>
<thead>
<tr>
<th>Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Brownish black</td>
</tr>
<tr>
<td>Odour</td>
<td>Slightly pungent</td>
</tr>
<tr>
<td>Taste</td>
<td>Very slightly bitter</td>
</tr>
</tbody>
</table>

Microscopic character

The powder of *Plumbago indica* roots shows-

- Thin walled parenchyma cells.
- Fragments of thick walls of tracheids / vessels and parts of tracheids / vessel, wilt irregular shape parenchyma cells and their parts.
- Large numbers of droplet like granules that have come out from the cells.

**Fig 7**: Powder of *Plumbago indica* leaves under the microscope

- A. Part of parenchyma cells
- B. Cell content
- C. Fragment of thick cell wall
**Table 1 : Physico – Chemical Analysis**

<table>
<thead>
<tr>
<th>Test</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol extract of leaves</td>
<td>1.5-3.5%</td>
</tr>
<tr>
<td>Ash content of aerial part</td>
<td>&lt;19.5%</td>
</tr>
<tr>
<td>Acid insoluble ash content of leaves</td>
<td>&lt;1.44%</td>
</tr>
<tr>
<td>Ethanol extract of pods</td>
<td>1.13-3.3%</td>
</tr>
<tr>
<td>Ash content of pods</td>
<td>&lt;16.87%</td>
</tr>
<tr>
<td>Acid insoluble ash content of pods</td>
<td>&lt;9.4%</td>
</tr>
</tbody>
</table>
AGRONOMY

Some studies on agronomy of *Plumbago indica* are reported. Incropping of agricultural crops in the mature strands of *Hevea brasiliensis* is difficult. However many medicinal species are adapted to grow under very low light intensities. They are *Plumbago rosea*, *Strobilanthes heyneanus*, *Adhatoda vasica*. There are possibilities of using these species for inter cropping in mature strands of *Hevea* profitably without affecting the latex yield of rubber trees. Higher yields have resulted in plants grown under coconut compared to those in open area7,8.

PHYTOCHEMISTRY

*Plumbago indica* aerial parts contain sitosterol, stigmasterol, campesterol, plumbagin (2-methyl-5-hydroxy-1-4-naphthoquinone), 6-hydroxyplumbagin, plumbaginol, fatty alcohol, tannin, flavonol, azalein, anthocyanin, capensin9,10,11

*Plumbago indica* roots contain naphthoquinone, droserone, elliptinone and zeylanone, plumbagin (2-methyl-5-hydroxy-1-4-naphthoquinone), 6-hydroxyplumbagin, binaphthoquinone roseanone, droserone, elliptinone, zeylanone12,13.

PHARMACOLOGY

Tumor growth inhibitory and radiosensitizing effects of the alcoholic root extract of *Plumbago rosea* was studied in experimental mouse tumors, S-180 solid tumor and Ehrlich ascites carcinoma *in vivo*. The results demonstrate that though *Plumbago rosea* extract may have only a weak antitumor effect, it may be a good candidate for use with radiation to enhance the tumor killing effect. The purified plumbagin more toxic than the extract14,15.

Mouse melanoma cells treated with plumbagin, either alone or followed by 2Gy gamma radiation (RT), had following results: *Plumbago* alone produced a significant decrease in the cell count on days 3 and 4, whereas radiation treatment significantly enhanced the growth inhibitory effect when compared to radiation or *Plumbago* alone. These findings suggest the radiosensitizing effect of *Plumbago rosea* on mouse melanoma cells *in vitro*16.
The roots are acrid, astringent, thermogenic, anthelmintic, constipating, expectorant, anti-inflammatory, abortifacient, alterant, antiperiodic, carminative, digestive, sudorific, narcotic, gastric, nervous stimulant and rejuvenating\textsuperscript{17}.

The ethanolic root extract of \textit{Plumbago rosea} was studied for acute toxicity in mice and subacute toxicity in rats. The 24 h LD\textsubscript{50} values of the extract in mice were 239.88 mg and 1148.15 mg/kg body weight for intraperitoneal and oral routes, respectively. Oral administration of doses above 1250 mg/kg produced severe diarrhoea\textsuperscript{22}.

\textbf{Plumbagin -}

Small doses of plumbagin, has a stimulant action on central nervous system, muscles, secretion of sweat, urine and bile\textsuperscript{2},

Blood pressure shows a slight fall\textsuperscript{2},

The peripheral vessels are found to dilate\textsuperscript{2},

Acts as a powerful irritant and has well marked antiseptic properties\textsuperscript{2},

Inhibits pathogenic fungi such as \textit{Coccidioides immitis}, \textit{Histoplasma capsulatum}, \textit{Ctesnomyces radians} and \textit{Trichophyton ferrugineum}\textsuperscript{2},

Acts as an antimetabolite towards \textit{Mycobacterium tuberculosis}\textsuperscript{2},

Induces antiimplantation\textsuperscript{18},

Abortifacient\textsuperscript{18},

Antiovulatory\textsuperscript{18},

Causes selective testicular lesions in dogs\textsuperscript{18},

Causes mitotic inhibition\textsuperscript{18},

Exhibits anticoagulant effect\textsuperscript{18},

Showed antigonadotrophic activity\textsuperscript{18},

In lower concentrations it behaves like a spindle poison but in higher concentrations. It exhibits radiomimetic nucleotoxic and cytotoxic effects\textsuperscript{18},

Showed anticancer effect on experimental tumors\textsuperscript{19}.

The antioxidant nature of plumbagin against lipid peroxidation induced by oxidants was investigated. It indicated that 1mM concentration of plumbagin prevented the oxidative tresses, induced lipid peroxidation in liver and heart homogenates of rats\textsuperscript{20,21}.

The synergistic effect of plumbagin and alkaloid isolated from \textit{Plumbago indica} along with insecticides such as endosulphan, methyl parathion etc. Showed that plumbagin has higher synergistic effect with methyl parathion than in the presence of other insectisides\textsuperscript{19}.

Plumbagin isolated from \textit{P. indica} root bark was highly effective on third and fourth instar larvae of \textit{Culex quinquefasciatus}\textsuperscript{23}.
Plumbagin and naphthoquinone derivative, obtained from P. rosea, P. zeylanica, P. europea have been reported to possess potent antifertility activity. Plumbagin has been reported to possess strong ant-progestational activity and devoid of any oestrogenic, anti-oestrogenic, progestational, androgenic and anti-androgenic activities.

Crude extracts and partially purified as well as purified fractions were prepared from three Thai medicinal plants, namely, Plumbago indica Linn, Acanthus ebracteatus Vahl and Rhinacanthus nasuthus Kurz, and then tested for their mutagenic and antimutagenic potentials using the Salmonella / microsome mutagenicity test. All fractions tested were not mutagenic toward either strain TA98 or TA100. Furthermore, these fractions could markedly inhibit the activity of rat liver aniline hydroxylase, which is one of the cytochrome-P450-mediated reactions. These results therefore suggest that these Thai medicinal plants contain an antimutagen(s), which inhibits chemical mutagenesis by inhibiting the enzyme activities necessary for activation of indirect mutagens/carcinogens.
Fig 8 Compounds present in *Plumbago indica*
Fig 9  Compounds present in *Plumbago indica*
Sample preparation

Sample detail
- *P. indica* leaves

Sample preparation
- *P. indica* leaves (5.0g) were extracted with ethanol and concentrated (28.5mg/10ml) 15 μl of extract was applied to TLC plate.

Adsorbent
- Silica gel GF<sub>254</sub>

Solvent system
- Benzene : ethyl acetate (3 : 7)

Detection

Direct evaluation
- UV<sub>254</sub>nm, UV<sub>366</sub>nm
  Rf values (UV<sub>254</sub>)
  Extract : 0.03, 0. 06, 0.39, 0.47
  Rf values (UV<sub>366</sub>)
  Extract : 0.83, 0.22, 0.10, 0.06, 0.03

Scanning
- Densitometer

Spray reagent
- Vanillin – sulphuric acid

Fig : 10
TLC chromatogram of *P. indica* leaves extract

Fig : 11
TLC Densitometer finger print
TLC PROFILE

Sample preparation

Sample detail - P. indica roots

Sample preparation - P. indica roots (5.0g) were extracted with ethanol and concentrated (33.1mg/10ml) 15μl of extract applied to TLC plate.

Adsorbent - Silica gel GF<sub>254</sub>

Solvent system - Benzene : ethyl acetate (3 : 7)

Detection

Direct evaluation - UV<sub>254</sub>nm UV<sub>366</sub>nm

Rf values (UV<sub>254</sub>nm)

Extract : 0.01, 0.05, 0.08, 0.17, 0.27, 0.36, 0.46, 0.65, 0.74, 0.81

Rf values (UV<sub>366</sub>)

Extract : 0.17, 0.10, 0.64, 0.74, 0.81

Scanning - Densitometer

Spray reagent - Vanillin – sulphuric acid

Fig : 12
TLC chromatogram of P. indica roots extract TLC

Fig : 13
Densitometer finger print
HP LC PROFILE

P. indica: Leaves

Sample preparation - *P. indica* leaves (5.0g) were extracted with ethanol (9.4mg/10ml) and purified using Sep-pak C18 cartridge.

Injection volume - 20μl

Apparatus - Waters 501 HPLC pump. SPD 10AV Shimadzu uv-vis detector.

Column - μ Bondapak™ RP18

Solvent system - Methanol : water (1:1)

Flow rate - 0.5ml/min

Detection - 254nm

Description of the HPLC – Chromatogram

**Table 2**: Retention time of main peaks

<table>
<thead>
<tr>
<th>Peak no</th>
<th>Rt (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.52</td>
</tr>
<tr>
<td>2</td>
<td>2.265</td>
</tr>
<tr>
<td>3</td>
<td>2.482</td>
</tr>
<tr>
<td>4</td>
<td>3.347</td>
</tr>
<tr>
<td>5</td>
<td>3.33</td>
</tr>
<tr>
<td>6</td>
<td>4.105</td>
</tr>
<tr>
<td>7</td>
<td>4.323</td>
</tr>
<tr>
<td>8</td>
<td>5.072</td>
</tr>
<tr>
<td>9</td>
<td>6.112</td>
</tr>
<tr>
<td>10</td>
<td>6.568</td>
</tr>
<tr>
<td>11</td>
<td>7.81</td>
</tr>
<tr>
<td>12</td>
<td>10.477</td>
</tr>
<tr>
<td>13</td>
<td>14.608</td>
</tr>
</tbody>
</table>

**Fig: 14**
HPLC chromatogram of leaves
HPLC PROFILE

_P. indica_ : Roots.

Sample preparation - _P. indica_ roots (5.0g) were extracted with ethanol (0.16mg/10ml) and purified using Sep-pak C18 cartridge.

Injection volume - 20μl

Apparatus - Waters 501 HPLC pump. SPD 10AV Shimadzu uv-vis detector.

Column - μ Bondapak™ RP18

Solvent system - Methanol : water (1:1)

Flow rate - 0.5ml/min

Detection - 254nm

Description of the HPLC – Chromatogram

**Table 3** : Retention time of main peaks

<table>
<thead>
<tr>
<th>Peak no</th>
<th>Rt (min)</th>
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</thead>
<tbody>
<tr>
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<td>4.49</td>
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<td>6</td>
<td>5.552</td>
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<tr>
<td>7</td>
<td>6.683</td>
</tr>
<tr>
<td>8</td>
<td>7.19</td>
</tr>
<tr>
<td>9</td>
<td>12.31</td>
</tr>
</tbody>
</table>

**Fig – 15**

HPLC chromatogram of root
REFERENCES