Review Article

An account of phytochemicals from *Plumbago zeylanica* (Family: Plumbaginaceae): A natural gift to human being#

Abstract

The semi-climbing sub-shrub *Plumbago zeylanica* (family: Plumbaginaceae) is a widely accepted ethnomedicine around the world including India, Pakistan, Bangladesh, Sri Lanka, and Australia. The plant is credited with potential therapeutic properties including antiatherogenic, cardiotonic, hepatoprotective, and neuroprotective properties. The present review highlights the various medicinal and pharmacological aspects along with recent updates on phytochemical contents of the plant.

Key words:
Medicinal plants, phytochemicals, Plumbaginaceae, Plumbago zeylanica

Introduction

The plant *Plumbago zeylanica* belongs to family Plumbaginaceae of genus *Plumbago* that consists of 10–20 flowering plants species. The *P. zeylanica* (White Leadwort) plant is native to warm temperate-tropical regions of the world and grows wild in India (especially in Bengal, Uttar Pradesh, and South Indian states) and Sri Lanka.[1] *P. zeylanica* is supposed to be originated in South-East Asia.[2,3] A mature evergreen plant can reach up to 6 feet in length; however, proper pruning and pot size can limit the size of plant [Figure 1]. The plant needs full sun to partial shade with intermediate to warm temperature ranges. It has been used by rural and tribal people for hundreds of years as traditional medicine.[4] The generic name *P. zeylanica* has been derived from the Latin words *plumbum* (lead) and *agere* (to resemble) referring the ability of plant sap to create lead-colored stains on skin.[5] Historic mention of *P. zeylanica* has been traced to the Vedic times. As per *Charaka* (1500 B.C.), the name *Chitraka* (Hindi) denotes one that renders the discoloration to skin, when applied topically. (http://www.ayurvedaconsultants.com/herb_consult.aspx?commonName=CHITRAK).

Scientific Classification

Kingdom: Plantae
Phylum: Tracheophyta
Class: Magnoliopsida
Subclass: Caryophyllidae
Superorder: Plumbaginanae
Order: Plumbaginales
Family: Plumbaginaceae
Genus: *Plumbago*
Species: *Zeylanica*

Common names

The plant *P. zeylanica* is commonly known as White Leadwort, while other vernacular names are as follows: Chitraka (Hindi-Uttar Pradesh), Telhidak angouba (Manipur), Chittiramoolam karimai (Tamilnadu), Vellakoduveli (Malayalam), Chitramulika (Karnataka), Safaid-sitarak (West Bengal), Ogni (Orissa), Chitrmulam (Andhra Pradesh), etc.

Botanical Description

The plant *P. zeylanica* is an evergreen small perennial shrub which grows to a height of about 3–4 feet. The leaves are simple, alternate, oblong, spirally arranged, hairy margin, thick, and flashy, 4–10 cm long, pointed at the tip. The flowering occurs from September to November. The flowers

Access this article online	
Website: http://www.cysonline.org	Quick Response Code
DOI: 10.4103/2229-5186.99564	

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are white in color, 10–25 cm long.[6] Inflorescence is terminal raceme, bracts ovate to lanceolate, flowers bisexual, regular, pentamerous, sweet-scented; calyx is green, about 1 cm long and covered with long-stalked glandular hairs. Corolla is white with five petal-like lobes, with a slender tube and spreading limb. The flower calyx has glandular hairs which secret a sticky mucilage that is capable of trapping and killing insects.[7,8] The fruits are like a small cocklebur with glue on the soft spines and they will stick to anything. Fruit an oblong capsule, apex acute with 5 furrows, 1-seeded, seed oblong, 5–6 mm long, reddish brown to dark brown. The roots are stout, cylindrical, friable, blackish red in color, with a pungent odour.

Medicinal properties

P. zeylanica is very popular throughout India and Asia as a remedy for skin diseases, infections, and intestinal worms. The plant has been found significant in different clinical conditions, especially inflammation, leprosy, scabies, ringworm, dermatitis, ulcers, hemorrhoids, and hookworm.[9]

All parts of the plant are used, but the roots have fascinated the chemists and biologists due to tremendous pharmacological properties. The pulped roots or aerial parts are reported abortifacient, while powdered bark, root or leaves are used to treat gonorrhoea, syphilis, tuberculosis, rheumatic pain, swellings, and wound healing.[10] Root decoction with boiled milk is swallowed to treat inflammation in the mouth, throat, and chest. A paste of the root in vinegar, milk, and water is considered significant against influenza and black water fever, while root infusion is taken orally to treat shortness of breath.[11] In Ayurvedic and Unani system of medicines, the plant has been described for significant anticancer,[12,13] antitumor,[14] anti-inflammatory,[15] antioxidant,[16,17] antimycobacterial,[18] and antimicrobial activities.[19-21] The plant is also effective against rheumatic pain, sprains, scabies, skin diseases, and wounds. The roots of the plant and its constituents are credited with potential therapeutic properties including antiatherogenic, cardiotonic, hepatoprotective, neuroprotective, and central nervous system stimulating properties.[22] Plant extract shows potent mosquito larvicidal activity against the larvae of *Aedes aegypti*.[23,24] Hexane extracts of *P. zeylanica* show activity against canine distemper virus.[25] Acetone extract of *P. zeylanica* also effects on chromosomal aberrations induced by ethinylestradiol in cultured human lymphocytes[26] [Table 1].

"Panchcole," an Ayurvedic formulation containing *P. zeylanica* as one of its chief ingredients, has been advocated to produce hypolipidemic effect.[27] An herbal preparation "*yogaraj guggal*," derived from the root, is being used in the treatment of arthritis, rheumatism, and related diseases. The roots, root barks, and seeds are used medicinally as a stimulant, caustic, digestion, antiseptic, antiparasitic, and also for killing intestinal parasites.[28] *P. zeylanica* products are traded worldwide as Ayurvedic and Homeopathic medicine.[1,29]

Figure 1: Plant *Plumbago zeylanica*

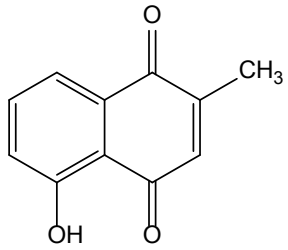
Table 1: Pharmacological properties of *Plumbago zeylanica*

P. zeylanica extract	Activity	References
Methanol extract (80%)	Skin diseases	[11]
Alcoholic extracts	Antibacterial activity	[19]
Ethanolic root extract	anti-inflammatory activity	[34]
Ethyl acetate extract	Antiarthritic activity	[35]
Dichloromethane	anti inflammatory effects	[84]
Hexane extract	Antiviral activity against	[25]
Aqueous leaf extract	Antifungal activity	[85]
Alcoholic extract (root)	Antibacterial activity	[44]
Ethanol extract (50%)	Dopaminergic activity	[22]
Acetone extract	Antifertility activity	[38]
Ethanol extract (70%)	Anti-inflammatory activity	[50]
Petroleum ether extract	Antifertility activity	[36]
Petroleum ether, aqueous extract	Anti-inflammatory and antinociceptive activities	[37]
Chloroform extract	Antigonorrhoeal activity	[52]
Methanolic extract	Hepatoprotective activity	[57]
Petroleum ether extract	Anti bacterial activity	[45]
Ethanol extract	Hyperglycaemic activity	[47]
Ethanolic extract (50%)	Hyperlipidaemic	[27]
Ethanolic extract	Wound healing	[33]
Ethanol extracts	Antiplasmodial activity	[55]
Hexane extract	Antioxidant properties	[9]

The roots and leaves of *P. zeylanica* contain plumbagin, a major component that constitutes about 0.03% of dry weight of the roots, which has been identified as significant bioactive component related to several pharmacological activities, e.g., antitumor,[30-32] antimicrobial, anticancer, wound healing,[33] anti-inflammatory and altered T-cell proliferative activities,[34,35] and antifertility actions.[36-40] It is also a powerful irritant. In small doses, it exhibits sudorific and stimulates the central nervous system;

large doses may cause death due to respiratory failure and paralysis. Plumbagin has also shown antibacterial activity against both gram-positive and gram-negative bacteria,[41-46] antihyperglycemic,[47] insecticidal,[48,49] antiallergic,[50,51] and antigonorrhoeal activity.[52] Besides, it has been also found active against certain yeasts and fungi[53,54] and protozoa.[55] It has also demonstrated significant hyperglycemia, hypolipidemic, and antiatherosclerotic effects in rats[56-61] [Table 2].

Table 2: Pharmacological properties of plumbagin



Plumbagin

Antibacterial activity	[42]
Antitumour activity	[31]
Antifertility activity	[39]
Antitumor and antifertility activities	[32]
synergistic activity	[18]
Anticoagulant activity	[59]
Hypolipidaemic and antiatherosclerotic	[56]
GST activity	[16]
Oxidative stress	[86]
Antibacterial activity	[20]
Blood coagulation activity	[61]
Anti-*Helicobacter pylori* activity	[41]

Phytochemicals isolated from *P. zeylanica*

Based on the literature reports, several naphthoquinones, binaphthoquinones,[62-66] coumarins,[67] di-phenyl sulfone,[68] carboxylic acids and esters,[69] meroterpenes,[70] triterpenoids,[71,72] amino acids,[73] anthraquinones,[74] steroids,[75] steroid glucosides,[67] sugars,[76] and other compounds[77-81] (recently four other compounds one naphthoquinone and three difuranonaphthoquinones) have been isolated and characterized from our laboratory.[82,83] All compounds are cited in [Table 3].

While concluding, the author only likes to repeat the same statement present somewhere else.

"With the increasing loss of much of the world's forests, particularly in the tropics, the potentially remarkable properties of plant constituents not yet discovered and threatened with extinction could be forever lost. If this occurred, many future drugs and other useful plant products would remain undiscovered and the often surprising chemical structures produced by the genetic diversity of plants might not be envisioned by future chemists."

A theme

With the globe facing synthetic chemical hazards in environment and health, it is a sense to experiment herbal

Table 3: Phytochemicals isolated from *Plumbago zeylanica* Linn

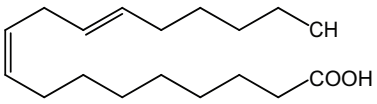
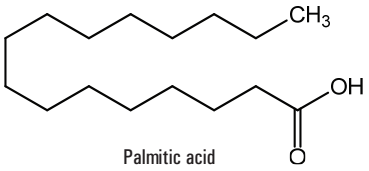
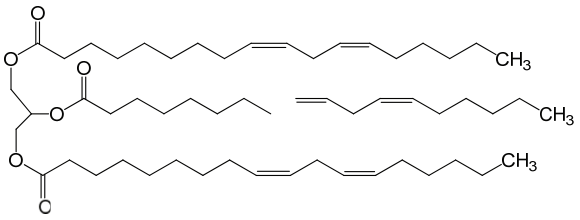
Compounds name	References
Fatty acids and esters	
 Lineleic acid	[87]
 Palmitic acid	[87]
 Trilinolein	[12]

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Table 3: (Continued)

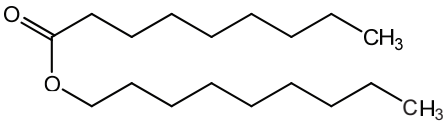
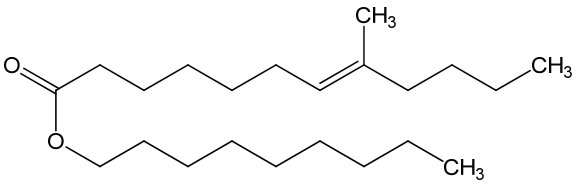
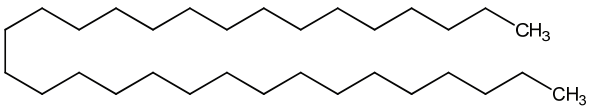
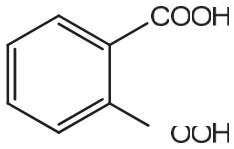
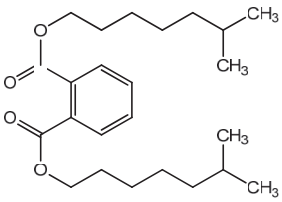
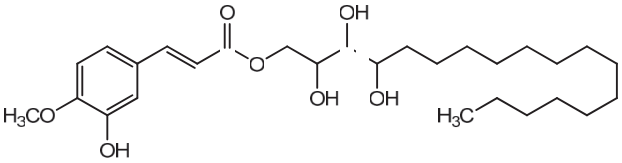
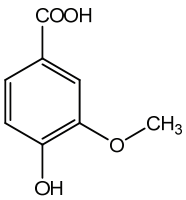
Compounds name	References
 Nonyl nonanoate	[75]
 Nonyl 8-methyl-dodec-7-enoate	[75]
 Hentriacontane	[57]
 1,2-Benzenedicarboxylic acid	[69]
 Diisooctyl phthalate	[69]
 Gugultetrol-18-ferrulate	[84]
 Vanillic acid	[88]

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Table 3: (Continued)

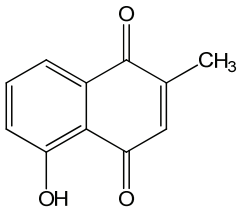
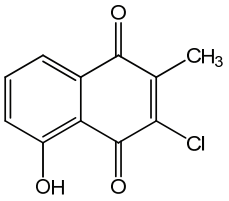
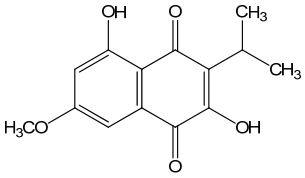
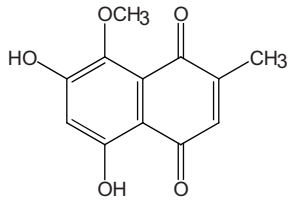
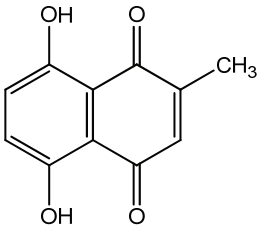
Compounds name	References
Naphthoquinones:	[89]
	[75]
Plumbagin	[90]
	[91]
3-chloroplumbagin	
	[63]
3,8-dihydroxy-6-methoxy-2-isopropyl-1, 4-naphthoquinone	
	[63]
5,7-dihydroxy-8-methoxy-2-methyl-1, 4-naphthoquinone	
	[62]
2-methylnaphthazarin	

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Table 3: (Continued)

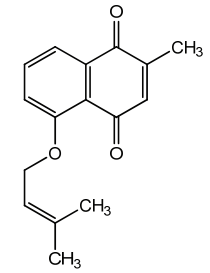
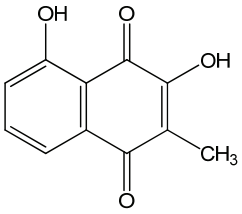
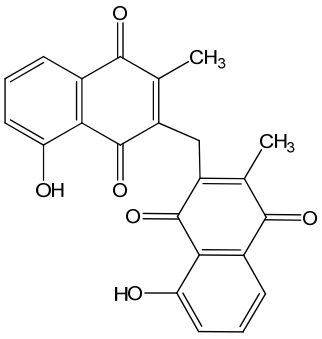
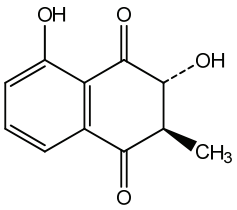
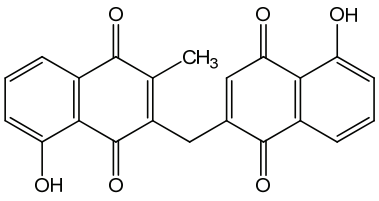
Compounds name	References
 2-methyl-5-(3'-methyl-but-2'-enyloxy)- [1,4]naphthoquinone	[82]
 Droserone	[66,74]
 Methylene-3,3'-diplumbagin	[62]
 Dihydrosterone	[92]
 Isozeylanone	[93]

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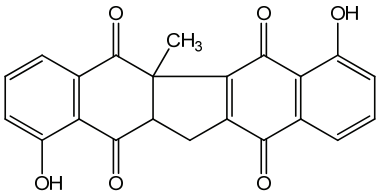
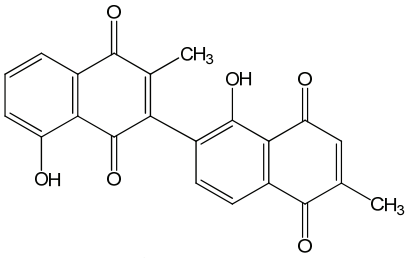
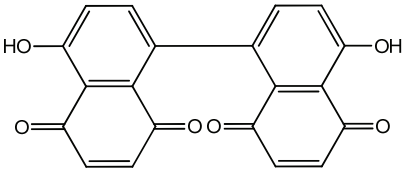
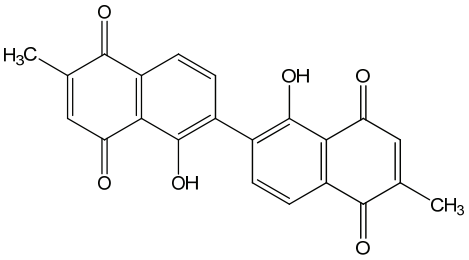
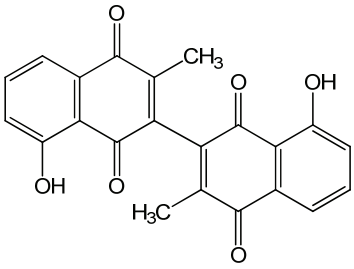
Table 3: (Continued)

Compounds name	References
 Zeylanone	[93]
 Chitranone	[64]
 Maritinone	[62]
 Elliptinone	[66]
 3,3-diplumbagin	[94]

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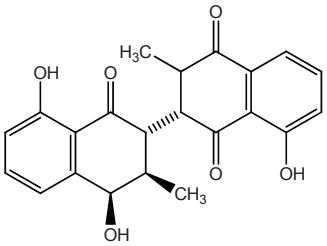
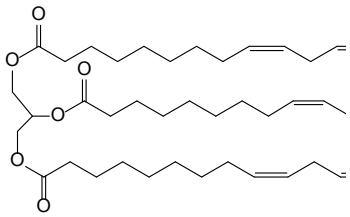
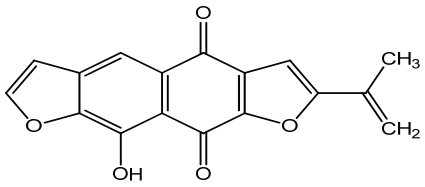
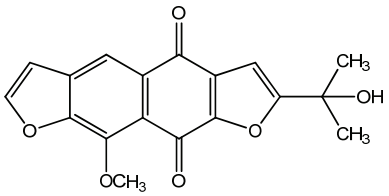
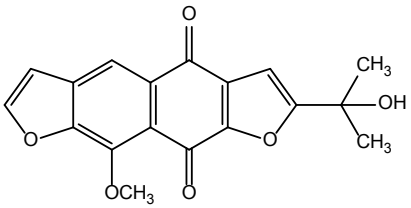
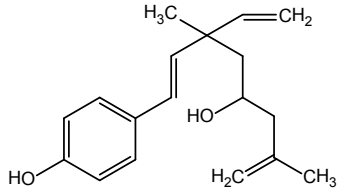
Compounds name	References
 1,2(3)-Tetrahydro-3,3'-biplumbagin	[95]
 1,2(3)-Tetrahydro-3,3′-biplumbagin	[65]
 9-hydroxy-2-isopropenyl-1,8-dioxa-dicyclopenta[b,g]naphthalene-4,10-dione	[83]
 2-(1-hydroxy-1-methyl-ethyl)-9-methoxy-1,8-dioxa-dicyclopenta[b,g]naphthalene-4,10-dione	[83]
 2-(1-hydroxy-1-methyl-ethyl)-9-methoxy-1,8-dioxa-dicyclopenta[b,g] naphthalene-4,10-dione	[83]
Meroterpenes	
 12-hydroxyisobakuchiol	[70]

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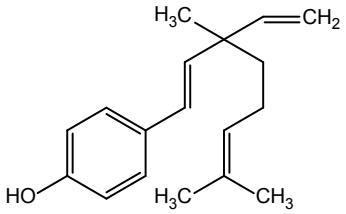
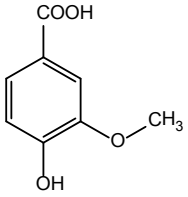
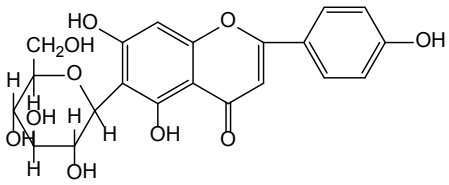
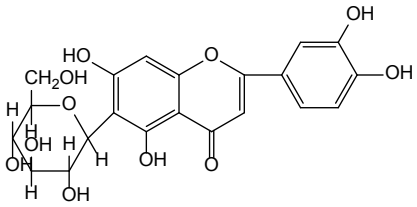
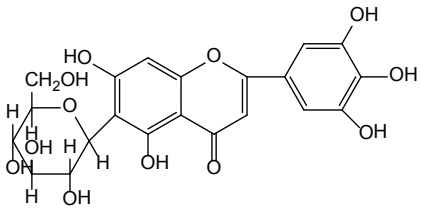
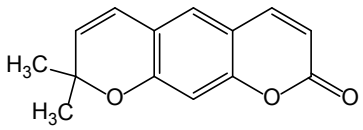
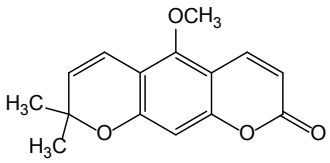
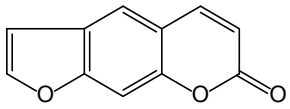
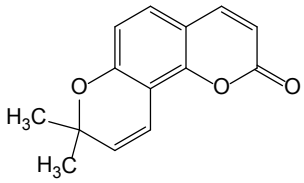
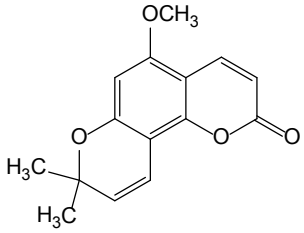
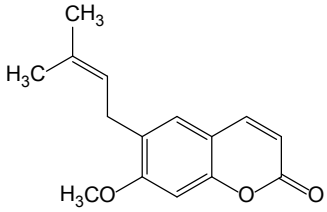
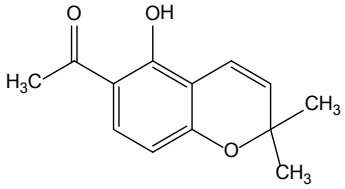
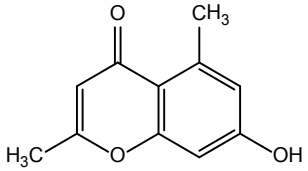
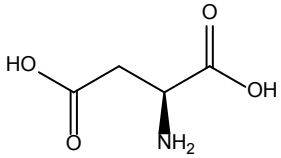
Table 3: (Continued)

Compounds name	References
	[70]
Bakuchiol	
Flavonoid and flavonoid glucosides	
	[96]
2-(2, 4-Dihydroxy-phenyl)-3, 6,8-trihydroxy-chromen-4-one	
	[70]
Saponaretin	
	[70]
Isoorientin	
	[70]
Isoaffinetin	
Coumarins	
	[70]
Xanthyletin	
	[70]
Xanthoxyletin	

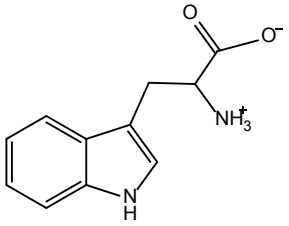
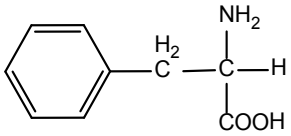
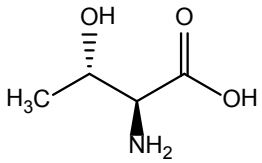
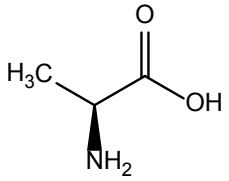
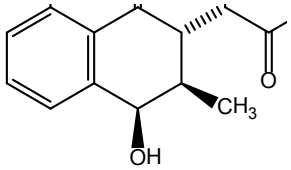
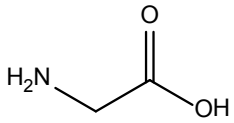
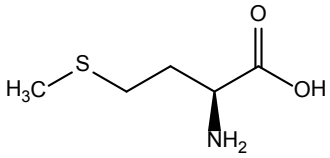
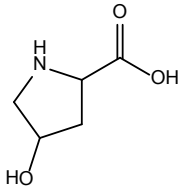
(continued)

Table 3: (Continued)

Compounds name	References
 Psoralen	[70]
 Seselin	[67]
 5-methoxyseselin	[67]
 Suberosin	[67]
 2,2- dimethyl-5-hydroxy-6-acetyl chromene	[75]
 2, 5-dimethyl-7-hydroxychromone	[97]
Amino acids and alkaloids	
 Aspartic acid	[73]

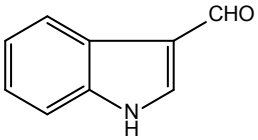
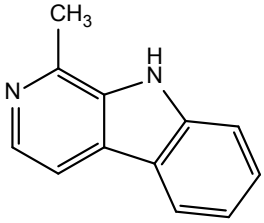
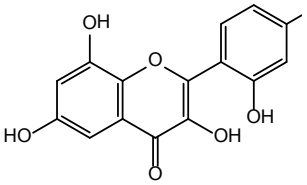
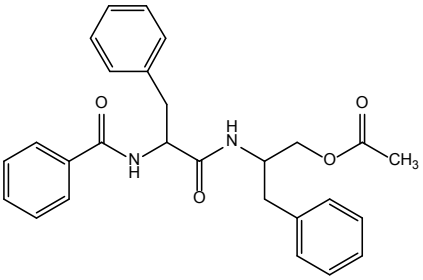
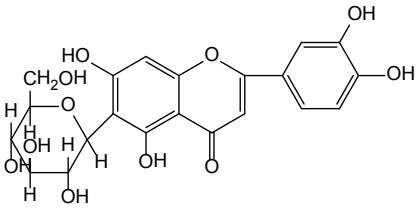
(continued)

Table 3: (Continued)

Compounds name	References
 Tryptophan	[73]
 Tyrosine	[73]
 Threonine	[73]
 Alanine	[73]
 Histidine	[73]
 Glycine	[73]
 Methionine	[73]
 Hydroxyproline	[73]

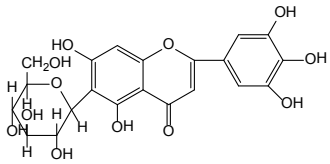
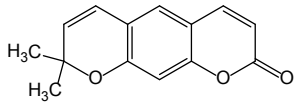
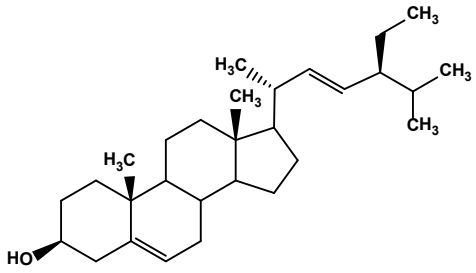
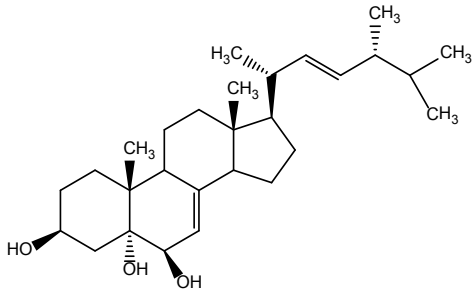
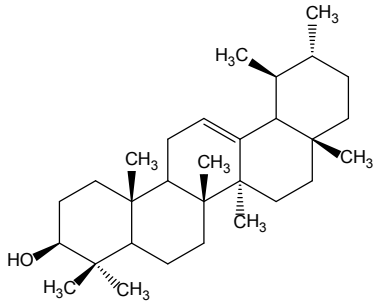
(continued)

Table 3: (Continued)

Compounds name	References
 Indole-3-carboxaldehyde	[97]
 Harman	[98]
 Neoechinulin A	[98]
 *N*-(*N'*-benzoyl-*S*-phenylalaninyl)-*S*-phenylalaninol	[98]
Steroids	
 β-sitosterol	[68]

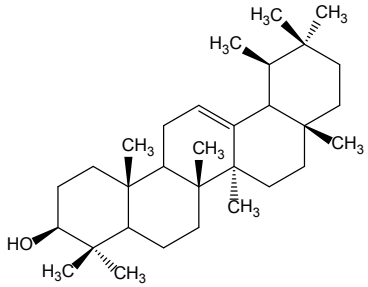
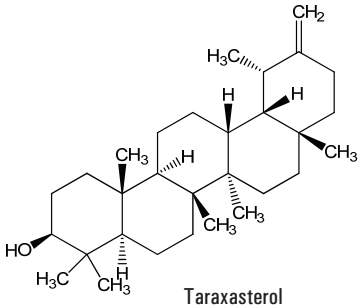
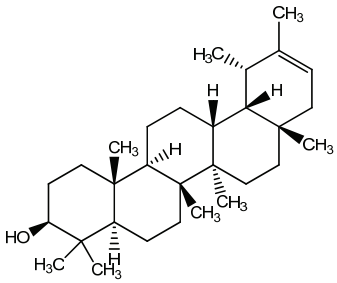
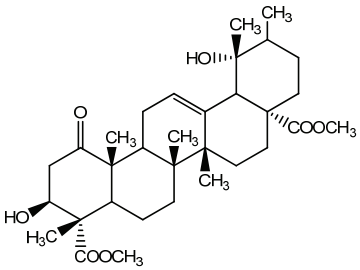
(continued)

Table 3: (Continued)

Compounds name	References
 Stigmasterol acetate	[75]
 Sitosterone	[75]
 Stigmasterol	[75]
 Ergostadiene-3β,5α,6β-triol	[98]
 α-amyrin	[72]

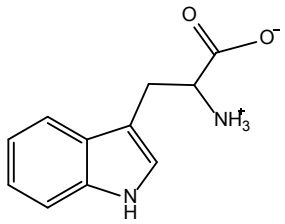
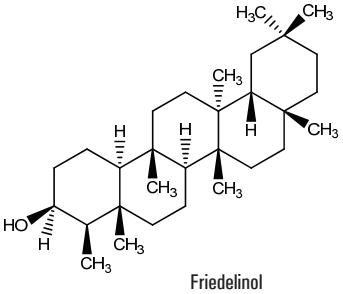
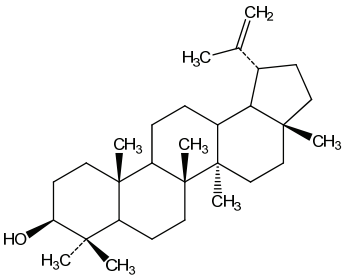
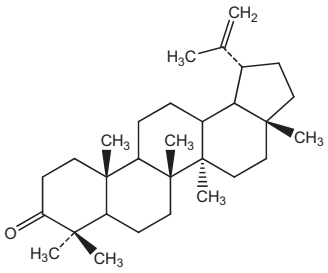
(continued)

Table 3: (Continued)

Compounds name	References
 β-amyrin	[72]
 Taraxasterol	[72]
Taraxasterol  ψ -taraxasterol	[99]
Terpenoids:  1-keto-3 β ,19 α -ainyaroxyurs-12-ene-24,28-dioic acid dimethyl ester	[71]

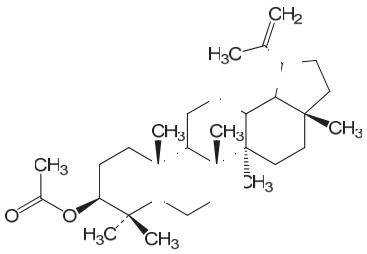
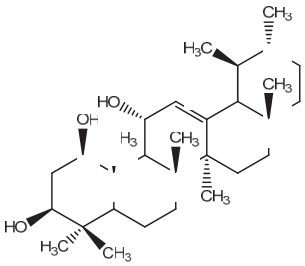
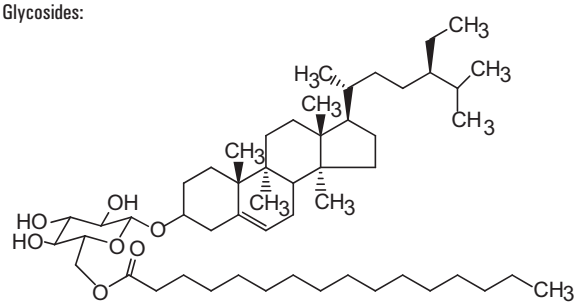
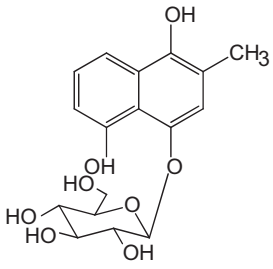
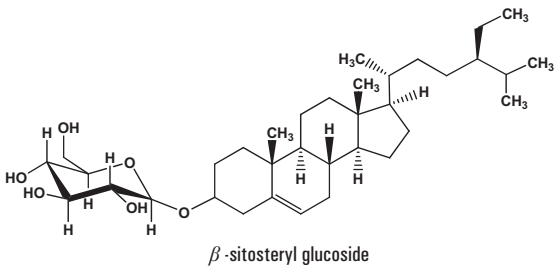
(continued)

Table 3: (Continued)

Compounds name	References
 3-O-β-D-arabinopyranosy derivative	[71]
 Friedelinol	[75]
 Lupeol	[72]
 Lupanone	[75]

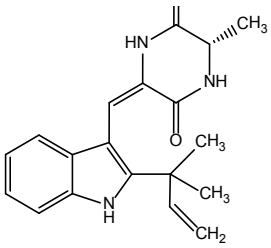
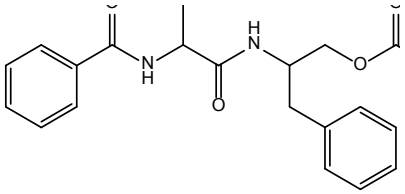
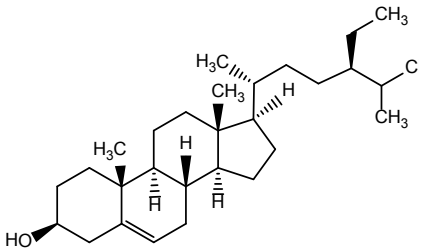
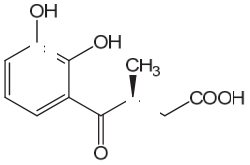
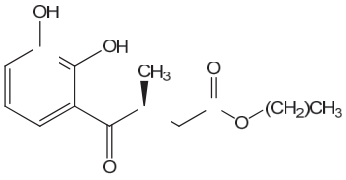
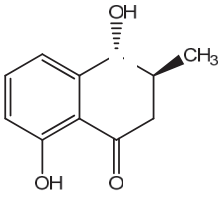
(continued)

Table 3: (Continued)

Compounds name	References
 Lupeol acetate	[12]
	[98]
Glycosides:  β -sitosterol-3 β-glucopyranoside-6'-O-palmitate	[79]
 Hydroplumbagin glucoside	[100]
 β -sitosteryl glucoside	[12]

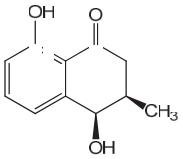
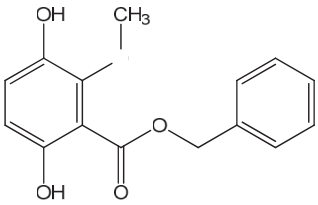
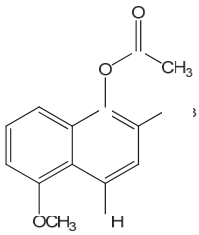
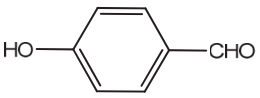
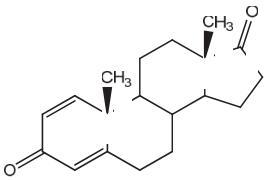
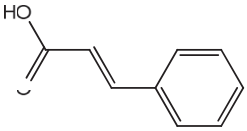
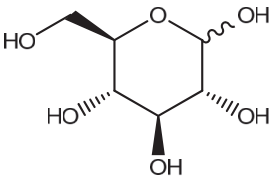
(continued)

Table 3: (Continued)

Compounds name	References
 3′-O- β-glucopyranosyl plumbagic acid	[67]
 1-hydroxy-3-methyl-6-methoxyanthraquinone-8-O-β-D-xylopyranoside	[74]
 3′-*O*- β-glucopyranosyl plumbagic acid methylester	[67]
 Plumbagic acid	[101] [88]
 Plumbagic acid Bu ester	[70]
 Isoshinznolone	[98]

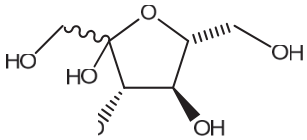
(continued)

Table 3: (Continued)

Compounds name	References
 Isoshinanolone	[70] [65]
 Benzyl 2,5-dihydroxy-6-methoxybenzoate	[75]
 1-acetoxy-4-hydroxy-2-methyl-5- methoxynaphthalene	[94]
 4-hydroxybenzaldehyde	[97]
 Androsta-1,4-diene-3,17-dione	[98]
 Trans-cinnamic acid	[97]
 Glucose	[102]

(continued)

Table 3: (Continued)

Compounds name	References
 Fructose	[102]

source to beat odds in every walks of human life. Also, now-a-days the herbal has become a craze for everyone. The realization is not a new and also not a surprise, rather consistent to following citation from an old Indian spiritual literature.

॥ अमंत्रं अक्षरं नास्ति ॥
Every letter has the potential to become a mantra
॥ नास्ति मूलं अनौषधम् ॥
Every herb has the potential to become a medicine
॥ अयोग्यः पुरुषो नास्ति ॥
Every person has the potential to become a winner
॥ योजकः तत्र दुर्लभः ॥
But rare is the visionary who can transform potential into reality

There is no point to doubt the statement. But before making use of herb in human body, it should be free from contamination and chemically hygienic. Here comes standardization. For these, knowledge of chemicals present is a must. Indian system of medicine has highlighted *Plumbago zeylanica*, having been used medicinally in various forms, viz., it is one main ingredient of *panchkarm*. It is used as ayurvedic catalysis to potentiate the properties of associate drugs. *Panchcole* is an important formulation of which it is a chief constituent. Keeping this in mind, making phytochemical profile of the plant has been resorted to.

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How to cite this article: Kishore N, Mishra BB, Tiwari VK, Tripathi V. An account of phytochemicals from *Plumbago zeylanica* (Family: Plumbaginaceae): A natural gift to human being#. Chron Young Sci 2012;3:178-98.

Source of Support: Nil, **Conflict of Interest:** None declared