Ethnomedical and Pharmacological Potentials of *Plumbago zeylanica* L- A Review

Kumar Ganesan¹, Sharmila Banu Gani²

¹ Department of Biochemistry, Faculty of Medicine, International Medical School, Management and Science University College, Shah Alam- 40100, Selangor, Malaysia
² Department of Zoology, NKR Government Arts College for Women, Namakkal, Tamilnadu 637 001, India

**ABSTRACT**

*Plumbago zeylanica* L. (Plumbaginaceae) (PZ) commonly called as Doctorbush is a semi climbing sub shrub used to effective against anaemia, rheumatic pain, dysmenorrhoea, leprosy, ulcers and elimination of intestinal parasites. In Ayurvedic system of medicine, the roots of the plant and its constituents are credited with potential therapeutic properties including cardiotonic, neuroprotective and CNS stimulating properties. The aim of this review is to provide comprehensive information on the traditional uses, phytochemistry, pharmacological actions and toxicity study of *Plumbago zeylanica* L to explore their therapeutic potential and future research opportunities. All the relevant information of PZ was collected through MEDLINE/PUBMED. The evidence presented in this review has showed that PZ has great potential to be integrated into conventional medical practice for the treatment of various metabolic diseases, hepatotoxic, diabetes, inflammation, cancer and other disease complications. Future research on PZ would provide much knowledge about pharmacological uses and socio-economic impact.

**Keywords**: *Plumbago zeylanica*, Pharmacology, Phytochemistry, Toxicity, Bioactive compounds.

**INTRODUCTION**

The usage of medicinal plants is increasing worldwide. According to the World Health Organization (WHO), approximately 80% of the world’s population currently uses herbal medicines directly as teas, decocts or extracts with easily accessible liquids such as water, milk, or alcohol.¹ In fact, most of the plants produce a various bioactive molecules making them for various types of diseases. The medicinal plants and its active principles have been continued to play a
dominant role in the maintenance of human health since ancient times. Over 50% of all modern clinical drugs are synthesised from natural product origin. Natural products play on important role in drug development in the pharmaceutical industry. There are many reports on the use of medicinal plants in traditionally used by either tribal people or indigenous population.

**BOTANICAL DESCRIPTION**

Plumbago is a genus of 15-20 species of Angiosperms in the family Plumbaginaceae. The family Plumbaginaceae consists of 10 genera and 280 species. The genus Plumbago includes 3 species, namely Plumbago indica L. (P. rosea L.), P. capensis L., and P. zeylanica L., which are distributed in several parts of India. Among these species Plumbago zeylanica grows all districts of plains in Tamilnadu, Andra Pradesh, Karnataka and Kerala, common, wild or in cultivation due to its more therapeutic uses.

Plumbago zeylanica (PZ) commonly called as Doctorbush or Ceylon Leadwort is a semi climbing sub shrub that grows throughout Asia, Australia, Africa and Ceylon and widely used in ethnomedicine. It is branched evergreen shrub growing up to 2 meters. The leaves are dark-green, ovate 30 cm long and 15 cm wide. The flowers are white in thick racemes, individuals around 1cm across, flowering throughout the year.

**Classification**

Kingdom: Plantae  
Order: Caryophyllales  
Family: Plumbaginaceae  
Genus: Plumbago  
Species: Zeylanica  
Sanskrit Synonyms: Agni, Vahini

**Regional names:**

English: Lead wort, Ceylon lead wort  
Hindi: Chira, Chitra  
Gujarati: Chitrakmula  
Kannada: Chitrakmula, Bilichitramala  
Malayalam: Vellakeduveli  
Punjabi: Chitra  
Bengali: Chita  
Tamil: Kodiveli, Chitramoolam  
Telugu: Chitramulam

**ETHNOPHARMACOLOGICAL & TRADITIONAL USES**

In Ayurvedic and Unani system of medicines the whole plant has been described for significant effective against anaemia, rheumatic pain, sprains, dysmenorrhoea, carbuncles, scabies, leprosy, contusion of the extremities, inflammation, ulcers and elimination of intestinal parasites. The roots of the plant and its constituents are credited with potential therapeutic properties including antiatherogenic, cardiotonic, neuroprotective and central nervous system stimulating properties.

In Indian system of medicine, the plant has been recommended for the treatment of various ailments such as dyspepsia, piles, diarrhoea, skin diseases and used in formulations of a number of ayurvedic compounds. It is said to increase digestive power and improve appetite. The roots of Plumbago species have been demonstrated to possess immunosuppressive and antitumor activities.

Ethnopharmacological studies carried out by many studies have indicated that PZ has an effect of antidiarroheal activities, antiallergic, insecticidal, antidiabetic, hepatoprotective, hypolipidaemic, anti-inflammatory, antitumour activity, antibacterial, antifungal, antimicrobial and oral treatment for complaints related to infections of the urinary tract. PZ has been extensively studied for the inhibition of proliferation of variety of cell...
lines and animal models and cytotoxic for tumor cell activities.

The present review aims to describe PZ has been pharmacologically tested and shown to be proving as potential healer and highlight the main medicinal properties with a view to focus future studies on this plant.

**PHARMACOLOGICAL ACTIONS**

Pharmacological studies on PZ has been reviewed and a detailed information of dose range tested, type of extract used, the model used, controls, duration of the study as well as their pharmacological results are given in the table 1.

**Antidiabetic Activity**

Pharmacological studies carried out by Olagunju et al. have indicated that PZ has antihyperglycemic effect on diabetic induced animals. The ethanol extract of PZ root on key enzymes of glycolysis and muscle hexokinase, phosphofructokinase, pyruvate kinase lactate dehydrogenase activities were diminished in diabetic rats.

**Hypocholesterolemic Action**

Pharmacological and Clinical studies carried out by Sharma et al. indicated that PZ extract has hypolipidaemic and antiatherosclerotic activities. Plumbagin, an active principle isolated from PZ brings about a definite regression of atherosclerosis and prevents the accumulation of cholesterol and triglycerides in liver and aorta. “Panchcole” an Ayurvedic formulation containing PZ as one of its chief ingredients has been advocated to produce hypolipidaemic effect.

**Anti-Inflammatory Activity**

The plant has been used for anti-inflammatory properties. Three medicinal plants namely Phyllanthus emblica, PZ and Cyperus rotundus were used to analyse two models of acute inflammation and result showed that PZ reduce the oedema while the combination of P. emblica compared to aspirin. Also PZ brought to suppress the activation of NF-kappa B in tumor cells and prevented Graft Versus Host Disease-induced mortality in mice.

**Anticancer Activity**

The methanolic extract of PZ root and pure compound 3β-hydroxyyp-20(29)-ene-27, 28-dioic acid (PZP) isolated from PZ have anti-invasive properties and antitumour activity. Both compounds were noted to have the ability to induce apoptosis and found to release of cytochrome c, activation of caspase-3 and cleavage of PARP leading to DNA fragmentation, followed by effectiveness in human promyelocytic leukemia cells, NB4. This action inhibits STAT3 activation pathway through the induction of SHP-1 and mediate the sensitization of STAT3 and chronically activate ERK1/2 and inhibit Akt activity in cancer cells.

**Antimicrobial Activity**

The plant has been used for antibacterial, antifungal and antimicrobial activities. The ethanol, ethyl acetate and acetone extracts of PZ have the highest inhibitory effects against Helicobacter pylori using the agar diffusion and dilution methods at the pH 1-7, having synergistic and action against Mycobacterium intracellulare, M. smegmatis, M. xenopoei and M. Chelonei. The antimicrobial potential of PZ have been described in various pathogenic
bacteria\textsuperscript{40,42,58,59} like Staphylococcus aureus\textsuperscript{66} and E.coli\textsuperscript{61} and regulate gastrointestinal flora.\textsuperscript{67}

Aqil and Ahmad\textsuperscript{68} & Ahmad and Aqil\textsuperscript{69} investigated a broad-spectrum antibacterial activity against different bacteria and the most promising plant fraction of PZ (ethyl acetate fraction) confirmed killing of test bacteria at the lower level compared to its Minimum Inhibitory Concentration. In addition the root contains Anti-methicillin-resistant Staphylococcus aureus (MRSA) activity.\textsuperscript{70} The antimicrobial properties of compounds such as neoisoshinanolone and 1-epineo-isoshinanolone separated from the crude petroleum ether extract of roots of PZ.\textsuperscript{71}

**Antimalarial Activity**

The root of the PZ has been used for a potential of antimalarial properties and to treat fever or malaria.\textsuperscript{72,73} The study was examined in vitro for antimalarial properties against Plasmodium falciparum. Malaria is normally transmitted to people by mosquitoes infected with the malaria parasite. Avoiding the bites of Anopheles mosquitoes is the best way to prevent Malaria. On the other hand, the highest Larvicidal potential was found in methanol extracts of PZ roots against Anopheles aegypti and A.stephensi.\textsuperscript{74,75} The hexane and chloroform extracts of PZ also found to have highest larvicidal activity against Anopheles gambiae.\textsuperscript{76} It shows that the plant has high larval mortality of mosquito species.

**Abortifacient & Antifertility Activity**

Azad Chowdhury et al.\textsuperscript{77} and Edwin et al.\textsuperscript{78} investigated that the acetone and ethanol extracts of PZ were most effective to interrupt the estrous cycle and exhibited a prolonged diestrous stage of the estrous cycle resulting to a temporary inhibition of ovulation. Also in human, PZ acts as family planning agents\textsuperscript{79,80} and anti-implantation agents that appear to interfere with progesterone synthesis or utilization.\textsuperscript{81,82}

**PHYTOCHEMISTRY**

A raw phytochemical analysis with thin layer chromatography of crude extracts of PZ showed the presence of alkaloids, phenols and flavonoids.\textsuperscript{70} Phytochemical screening of various parts of PZ revealed to produce lineolic acid, palmitic acid, nonylnonanoate, stigmasterol acetate, lupeol acetate, friedelinol, lupeol, lupanone, sitosterone and stigmasterol.\textsuperscript{32,83-86}

The leaves, stems and roots of PZ exists with abundant amounts of elements like four macro-elements (Na, K, Ca and Mg), five essential microelements (Zn, Fe, Mn, Cr and Co), and eight other elements (Mo, Sb, Bi, Cd, Sr, Pb, Cd and As) respectively were detected by inductively Coupled plasma atomic emission spectrometry (ICP-AES). Many anticancer and antioxidant drugs usually possess these elements.\textsuperscript{87} The aerial parts contain plumbagin, isoshinanolone, plumbagic acid, beta-sitosterol, 4-hydroxybenzaldehyde, trans-cinnamic acid, vanillic acid, 2, 5-dimethyl-7-hydroxychromone, indole-3-carboxaldehyde isolated by column chromatography.\textsuperscript{88} The dichloromethane extract of aerial parts contain beta-sitosterol, beta-sitosteryl-3beta-glucopyranoside, beta-sitosteryl-3-beta-glucopyranoside-6’-O-palmitate, lupenone, lupeol acetate, plumbagin and trilinolein.\textsuperscript{59} In addition, the natural active compound Plumbagin isolated from different plant part of PZ by RP-HPLC\textsuperscript{89} along with synthesis of the binaphthoquinone, 3, 3’-biplumbagin [90]. Plumbagin was quantified by reverse phase HPLC and UV detection,\textsuperscript{91} liquid chromatography coupled with tandem mass spectrometric.\textsuperscript{92}

The root of PZ contains a numerous bioactive products such as two plumbagic acid glucosides [3’-O-beta-glucopyranosyl
plumbagic acid and 3'-O-beta-glucopyranosyl plumbagic acid methylester, along with five naphthoquinones (plumbagin, chitranone, maritinone, elliptinone and isoshinanolone), and five coumarins (seselin, 5-methoxyseselin, suberosin, xanthyletin and xanthoxyletin) respectively.

Kamal et al. isolated a number of compounds such as plumbagin, droserone, isoshinanolone and a new naphthalenone, 1,2(3)-tetrahydro-3,3'-biplumbagin from the phenolic fraction of PZ. A variety of compounds have been isolated from various parts of PZ includes naphthoquinones, such as plumbagin, droserone, isoshinanolone and the new variant, 1,2(3)-tetrahydro-3,30-biplumbagin; metroterpenes, such as bakuchiol and 12-hydroxyisobakuchiol; C-glucosylflavonoids and saponaretin.

The various fractions of petroleum ether, chloroform, ethyl acetate and n-butanol extracts of PZ root provided difuranonaphthoquinones, analysed by MS and 1H and 13C NMR spectroscopic data. Plumbagin reacted with lanthanide salts to produce five new lanthanide (III) complexes, characterized by different physicochemical methods such as elemental analyses, UV-visible, IR and 1H NMR, Electro Spray Ionization Mass Spectrum, and Thermogravimetric analysis. Neo- and 1-epineo-isoshinanolones along with plumbagin separated from the crude petroleum ether extract of PZ roots, analysed by using NMR, IR and Mass Spectroscopy.

TOXICITY STUDY

The root of PZ has been reported to be a powerful poison when given orally or applied to ostium uteri, causes abortion. But the methanol root extract of PZ in rabbits produced a limited toxic effect and did not produce any overt signs of toxicity in skin and possible in vivo protective effect against cyclophosphamide-induced genotoxicity and oxidative stress in mice. Moreover the acute toxicity studies of PZ in albino rats revealed that the oral LD50 of the drug is 65mg/kg body weight and in the dead animals, the post mortem revealed a profuse bleeding in the viscera. The active compound of PZ, Plumbagin may have potential as a compound in synthetic insecticides.

BIOACTIVE COMPOUNDS

Plumbagin

Plumbagin (2-methyl-5-hydroxy-1,4-naphthoquinone) is a yellow crystalline bioactive phytoconstituent present in the roots isolated from PZ by soxhlet apparatus followed by silica gel column chromatography, cold maceration followed by preparative Thin layer chromatography techniques, Thin Layer Chromatography and column chromatography, normal-phase liquid chromatography, reverse-phase liquid chromatography, and liquid chromatography-tandem mass spectroscopy (LC-MS/MS).

Structure of Plumbagin

Plumbagin, an active compound have a potential of anticarcinogenic and antioxidant, cardioprotective, antimicrobial, antibacterial, antifungal, antimalarial, antifertility, anti HIV activity, anti-atherosclerotic and potentiate phagocytosis in the human white blood cells. Plumbagin has a potential of anticancer properties and studies on mouse embryonic fibroblast cells suggest that
the cytotoxic action of plumbagin may be due to apoptotic cascade through the generation of reactive oxygen species (ROS).\textsuperscript{128}

Plumbagin is known to produce reactive oxygen species (ROS) such as superoxide anion and hydrogen peroxide.\textsuperscript{129-133} Plumbagin generates ROS through multiple mechanisms depending upon cell types, can produce ROS via the redox cycling,\textsuperscript{130} the leakage of the mitochondrial respiratory chain,\textsuperscript{134} or the depletion of intracellular glutathione levels.\textsuperscript{132,133} The generation of ROS by plumbagin may account for its cytotoxic or apoptotic effects.\textsuperscript{135}

Plumbagin can also as a radiosensitizer modulate the effects of radiation in the treatment of tumor.\textsuperscript{136} The anticancer effect of plumbagin has been postulated to come true by disrupting microtubule polymerization through tubulin binding and inducing apoptosis.\textsuperscript{137,138} In addition, plumbagin does not exert an apoptotic effect on normal cells and therefore may have potential as a chemotherapeutic agent.\textsuperscript{139,117,140}

Plumbagin has also observed to have oxidative effects in prokaryotic cells lacking superoxide dismutase (SOD), due to its antimicrobial activity\textsuperscript{141} and prevent the development of antibiotic resistant mutants in bacteria through mutagenic mechanisms,\textsuperscript{51} but plumbagin itself did not have mutagenic effect; it rather reduced the mutagenic effects of other mutagens in Salmonella typhimurium suggesting a plumbagin associated antimutagenic activity.\textsuperscript{139} Indeed, the fact that plumbagin acts as an antigenotoxic and antioxidative agent\textsuperscript{142,22,143} as well as anticarcinogenic agent.\textsuperscript{124,117,132}

In addition, Plumbagin is a potential beneficial for the treatment of various diseases like diarrhoea, skin rashes, hepatic toxicity, reproductive toxicity and also involved in white blood cell counts enhancement, increase in serum phosphate and acid phosphate level.\textsuperscript{144,127,79,109,145}

Also the research showed that the plumbagin doesn’t have any mutagenic effects in different E. coli strains,\textsuperscript{146,52} Salmonella typhimurium\textsuperscript{147} and reported to induce clastogenic effects in a micronucleus assay\textsuperscript{57} and somatic mutations.\textsuperscript{148}

The anticancer and antiproliferative activity of plumbagin tested in either in vivo or in vitro models are listed in the Table-2. The structure of the plumbagin has been reported to closely resemble the vitamin K and the anticoagulant property of PZ might be similar to coumarin derivative, the haemorrhage may be due to the competitive inhibition of vitamin K activity, needed for the synthesis of clotting factors.\textsuperscript{149} The anticoagulant activity of the PZ was reported after an hour exposure and the effect of PZ on platelets and coagulation profile lead to the development of an antithrombotic drug.\textsuperscript{150,151}

**Seselin**

Seselin (2,2-Dimethyl-1,5-dioxaphenanthrene-6(2H)-one;8,8-Dimethyl-2H,8H-benzo[1,2-b:3,4-b']dipyran-2-one) is an angular pyranocoumarin\textsuperscript{37,152} isolated from PZ.

**Structure of Seselin**

Several biological activities of seselin have been reported as antinociceptive activities in vivo,\textsuperscript{152,153} antibacterial activity,\textsuperscript{154} and antiproliferative effects on several cancer cell lines such as leukemia and lymphoma cells.\textsuperscript{155-157, 37} Also it has been blocked the ear and paw edema in murine\textsuperscript{158, 159} and inhibitory
effects on Ca2+ influx in mast cells and smooth muscle cells.\textsuperscript{160, 161}

**CONCLUSION**

The evidence presented in this review has showed that Plumbago zeylanica L. has great potential to be integrated into conventional medical practice for the treatment and management of various metabolic syndromes, hepatotoxic, diabetes, inflammation, cancer and other disease complications. Development and research on PZ through modern pharmaceutical technologies and analytical protocols is essential to assure its quality, safety and efficacy. It is anticipated that this review will provide some valuable information for ongoing explorations of this fascinating species and its phytochemicals. Future research on PZ would not only provide much needed knowledge on this popular herbal medicine, but would also offer a noticeable socio-economic impact in turning a common weed into beneficial nutraceutical and pharmaceutical products.

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### Table 1. Pharmacological studies and review on *Plumbago zeylanica* L.

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<td>Concentration</td>
<td>Antioxidant/Activity Tested</td>
<td>Time</td>
<td>Activity</td>
<td>EC50 (µg/ml)</td>
<td></td>
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</tr>
<tr>
<td>Ethanolic extract of root</td>
<td>1mg/L</td>
<td>DPPH (1, 1-Diphenyl-2-picrylhydrazyl), ABTS (2, 2-azinobis-3-ethyl benzothiazoline-6-sulphonic acid diammonium salt)</td>
<td>In-vitro</td>
<td>1 hour Antioxidant activity</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Ethanolic extract of root</td>
<td>100mg/kg</td>
<td>-</td>
<td>Invitro</td>
<td>2 hours Antioxidant activity</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>Methanolic extract of leaves</td>
<td>50,100 mg/ml</td>
<td>Butylated hydroxyanisole</td>
<td>In-vitro</td>
<td>2 hours Antioxidant activity</td>
<td>162</td>
<td></td>
</tr>
<tr>
<td>Methanolic extract of root</td>
<td>0.8–200µg/ml</td>
<td>Guanidine hydrochloride, amantadine, and phosphonoformic acid</td>
<td>coxsackievirus B3 Nancy (CVB3), influenza A virus Hong Kong/1/68 (H3N2), and herpes simplex virus type 1 Kupka (HSV-1)</td>
<td>2 days Antiviral activity</td>
<td>177</td>
<td></td>
</tr>
<tr>
<td>Aqueous extract of plant</td>
<td>0.5 µg/ml</td>
<td>-</td>
<td>Hepatitis B-virus</td>
<td>2 days Antiviral activity</td>
<td>178</td>
<td></td>
</tr>
<tr>
<td>Ethanolic extract of root</td>
<td>250mg/kg</td>
<td>Cholesterol</td>
<td>Rabbit</td>
<td>28 days Hypolipidaemc activity</td>
<td>179</td>
<td></td>
</tr>
<tr>
<td>Ethanolic extract of root</td>
<td>250mg/kg</td>
<td>diet-induced hyperlipidemic rats</td>
<td>Rabbit</td>
<td>28 days Hypolipidaemc activity</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Ethanolic extract of root</td>
<td>250mg/kg bw</td>
<td>-</td>
<td>BALB/C mice</td>
<td>6 weeks Immunomodulatory activity</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cancer cell</td>
<td>Results</td>
<td>References</td>
<td></td>
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<tr>
<td><strong>aqueous root extract</strong></td>
<td>4mg/ml</td>
<td>Decrease in cell viability, apoptosis induction, Generation of ROS, depletion of intra cellular GSH</td>
<td>132</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Turkey egg albumin</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>Balb/c mice</strong></td>
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<tr>
<td></td>
<td><strong>56days</strong></td>
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<tr>
<td></td>
<td><strong>Immunosuppressive activity</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>181</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Chloroform extract of root</td>
<td>100, 200 and 400 mg/kg.</td>
<td>Scopolamine</td>
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<td><strong>Swiss albino mice</strong></td>
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<tr>
<td></td>
<td><strong>10days</strong></td>
<td>Memory Enhancing effect</td>
<td>182</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Table 2. List of studied plumbagin with putative anticancer and antiproliferative tested in either in vivo or in vitro models**

(source: PUBMED, English language).

**Human Prostate cancer cell (PC-3, LNCaP, and C4-2)**

<table>
<thead>
<tr>
<th>Cancer cell</th>
<th>Results</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Prostate cancer cell (PC-3, LNCaP, and C4-2)</td>
<td>Decrease in cell viability, apoptosis induction, Generation of ROS, depletion of intra cellular GSH</td>
<td>132</td>
</tr>
</tbody>
</table>

**Human Melanoma A375.S2**

<table>
<thead>
<tr>
<th>Cancer cell</th>
<th>Results</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Melanoma A375.S2</td>
<td>Reduced amounts of cyclin B1, cyclin A, Cdc2, and Cdc25C and enhanced the levels of inactivated phosphorylated Cdc2 and Cdc25C, increased the activation of apoptosis signal-regulating kinase 1, JNK and extracellular signal-regulated kinase 1/2 (ERK1/2) and finally blocking ERK and JNK</td>
<td>133</td>
</tr>
</tbody>
</table>

**Human nonsmall cell lung cancer cells, A549**

<table>
<thead>
<tr>
<th>Cancer cell</th>
<th>Results</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human nonsmall cell lung cancer cells, A549</td>
<td>Activation of JNK and SP600125 (Aanthra [1,9-cd]pyrazol-6(2H)-one-1,9-pyrazoloanthrone), a specific inhibitor of JNK, decreased apoptosis by inhibiting the phosphorylation of p53 and subsequent increased in the interaction of p53 and MDM2. SP6000125 also inhibited the</td>
<td>117</td>
</tr>
<tr>
<td>Cell Type</td>
<td>Effect</td>
<td>Reference</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Human Peripheral blood lymphocytes</td>
<td>Effective cell growth inhibition, induces apoptosis, generates single-strand of DNA breaks and cytotoxic action</td>
<td>183</td>
</tr>
<tr>
<td>Human Prostate Cancer</td>
<td>Inhibition of both cultured Prostate Cancer cells and DU145 xenografts (a) the expression of protein kinase C epsilon (PKC epsilon), phosphatidylinositol 3-kinase, phosphorylated AKT, phosphorylated Janus-activated kinase-2, and phosphorylated signal transducer and activator of transcription 3 (Stat3); (b) the DNA-binding activity of transcription factors activator protein-1, nuclear factor-kappa B, and Stat3; and (c) Bcl-xL, cdc25A, and cyclooxygenase-2 expression</td>
<td>139</td>
</tr>
<tr>
<td>Human acute promyelocytic leukemia cells</td>
<td>Inhibition of proliferation of NB4 cells, chromosomes condensation and apoptotic body formation, cell proliferation and induce apoptosis of APL cell line NB4 cells.</td>
<td>184</td>
</tr>
<tr>
<td>MCF7 and Bowes cancer cell lines</td>
<td>Inhibition of the proliferation of MCF7 and Bowes cells.</td>
<td>59</td>
</tr>
<tr>
<td>Human hepatoma</td>
<td>Inhibition of the certain glycolytic enzymes and gluconeogenesis.</td>
<td>116</td>
</tr>
<tr>
<td>Human peripheral blood mononuclear cells</td>
<td>involve the regulation of cell cycle progression, interleukin-2 and interferon-production</td>
<td>153</td>
</tr>
<tr>
<td>Cell Type</td>
<td>Effect</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>MDA-MB-231 cells</td>
<td>Inhibitory effect on the protein levels of p-PI3K, p-Akt, p-JNK, p-ERK1/2, MMP-2, MMP-9, VEGF and HIF-1α</td>
<td>50</td>
</tr>
<tr>
<td>Human breast cancer cells</td>
<td>Inactivation of NF-kappaB and Bcl-2</td>
<td>185</td>
</tr>
<tr>
<td>Lung A549 cells</td>
<td>Increased the expression of p53 and phosphorylated p53 (Ser15 and Ser392) and regulates the levels of cell cycle-related molecules in A549 and activates JNK</td>
<td>117</td>
</tr>
<tr>
<td>Human ovarian cancer cells</td>
<td>Bound to the active site of ER-α and inhibit classical ER-α signaling pathways</td>
<td>186</td>
</tr>
<tr>
<td>Cervical cancer cells</td>
<td>Lower dose of radiation in combination with plumbagin could induce apoptosis more effectively and activation of caspase 3 in C33A cells. Induction of apoptosis by irradiation and involves caspase-dependent pathways.</td>
<td>136</td>
</tr>
<tr>
<td>Human promyelocytic leukemia cells</td>
<td>Induced apoptotic cell death and inhibits tumor growth without obvious toxicity and triggering the mitochondria-dependent apoptosis of tumor cells by increasing ROS</td>
<td>53</td>
</tr>
<tr>
<td>Ovarian cancer cells</td>
<td>Induced loss of mitochondrial membrane potential, nuclear condensation, DNA fragmentation, and morphological changes</td>
<td>131</td>
</tr>
<tr>
<td>Human cervical cancer</td>
<td>Induced cell death is through the generation of ROS and subsequent induction of apoptosis caused loss of mitochondrial membrane potential and morphological changes characteristic of</td>
<td>128</td>
</tr>
<tr>
<td>Cell Type</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Human breast cancer cells</td>
<td>Inhibit Akt activity and enhanced the activation of Chk2, resulting in increased inactive phosphorylation of Cdc25C and Cdc2.</td>
<td></td>
</tr>
<tr>
<td>sarcoma-180</td>
<td>Ehrlich ascites model was evaluated and identified as less toxic, justified with the help of LD50 survival studies and study of tumour volume doubling time</td>
<td></td>
</tr>
<tr>
<td>Azoxymethane induced intestinal carcinogenesis</td>
<td>Promising chemopreventive agents for human intestinal neoplasia</td>
<td></td>
</tr>
<tr>
<td>3T3-L1 cells</td>
<td>Activated PI3-kinase and/or PDK1 stimulate Akt activity with Ras–Raf–MEK1/2–ERK1/2 pathway</td>
<td></td>
</tr>
</tbody>
</table>
Plumbago zeylanica L. (Plumbaginaceae)

Pharmacological Actions

- Antifertility
- Antidiabetic
- Anticancer
- Antimalarial
- Anti-inflammatory
- Hypocholesterolemic
- Antimicrobial

Toxicity studies

Global Perspectives
(The Scope for future research)

Bioactive Compounds – Plumbagin & Seselin

Phytochemistry