Int. J. Pharm. Investigation, 2022; 12(2) : 113-116

Review Article

Phytochemistry and Pharmacological Activities of *Plumbago indica* L.: An Overview

Bhatia Hemant*, Kumar Dinesh, Ahuja Dharmendra
Faculty of Pharmaceutical Sciences, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, INDIA.

ABSTRACT

Plumbago indica L. is a remedial herb species in the genus of *Plumbago* described by Linnaeus of the species of Plantarum, extensively in the hot and humid areas to use in the conventional structure of herbs. The distinct division of that plant is used to heal rheumatism, menstrual irregularities, tumors, leprotic infections, acquired immune disease, numbness, immobility, swollen glands, eczema, conjunctivitis, flatulence, extravagated, piles, anorexia, etc. The plant contains a variety of Phyto-constituents including sugars, alkaloids, flavonoids, steroids, phenols, and gums. Numerous categories of research were supported out in distinct kingdoms on the pharmacology of that remedial herb. Methodologically and biologically demonstrate data were concluded on that paper to clear the way for well-founded convenience detailed sources and invigorate further research.

Keywords: *Plumbago indica* L., Phytochemical analysis, Pharmacological agents, Medicinal herbs, Phyto-constituents.

Correspondence

Mr. Hemant Bhatia
Research Scholar, Faculty of Pharmaceutical Sciences, Jayoti Vidyapeeth Women's University, Jaipur-303122, Rajasthan, INDIA.

Email id: hemantpharma618@gmail.com

DOI: 10.5530/ijpi.2022.2.21

INTRODUCTION

Plumbago indica L. syn. *Plumbago rosea* L. is a category of flowering plant distributed in parts of South-East Asia, region, the Arabian Peninsula, Europe, Malaysia, Indonesia, Africa, China, and India. *Plumbago indica* L. has a vast area of pharmacological interest against numerous infectious conditions. *Plumbago indica* L. is universally used in conventional techniques such as in herbalism, Siddha, Perso-Arabic, and Homeopathy and also in unrestricted generic formulations of the farmer's populations.[1-3]

Common name – Chitraka (in Ayurvedic), Sheetraj, Chita (in Unani), Chitraka, Chitrakamool (Trade Name).

MORPHOLOGY

Plumbago indica L. is an ayurvedic remedial plant and it is an evergreen perpetual herb or shrub that grows and spread in warm lush climates up to a height of 1.5meters. It remains stem erect or branched from the base. Leaf parts of *Plumbago indica* L. are alternate, simple, and oval to elliptic, 8-13cm long, plane, glossy with wavy margins, and have a pointed base. Flowers are bisexual, intense red, 3-5cm long, forming very long-winded, lax spine, and axillary slender reaching 60 cm. The calyx is a tiny, tube-like formation along with ribs covered by prescribed glands with red color. *Plumbago indica* L. precise with inflorescent throughout a complete year without fruit.[4-5]

CHEMICAL CONSTITUENTS AND MEDICINAL PROPERTIES

Plumbago indica L. herb part root carry *Plumbagin in* as active constituent along with other isolated compounds from other parts of the herb including *plumbagin*, dihydroflavinods, (stem), Chitanone (leaves), glucose, and steroids from flowers, fruits, seeds respectively. Plumbagin shows several pharmacological activities against bacterial infections, antitumor, cardioprotective with several therapeutic effects. *Plumbagin* additionally acts as an irritant. Therefore, produce stimulant action such as the fast release of the secretions in the central nervous system at low doses and may cause death due to collapse of respiration and paralysis at a high level of doses. Historically as per data reported. Showed anti-implantation and abortion studies reported in animals (rat) due to toxic effects of *Plumbagin*. Because of its toxic effects, it is a life-threatening exercise. Reported *in-vitro* studies declare that *Plumbago indica* L. have an agent which interferes with mutagenicity.[6-8]

EXPERIMENTAL PHARMACOLOGY

Anti-fungal activity

Methanol extract showed strong antifungal activity with zone inhibition of (10.0-27.0) mm while the greatest antifungal activity was found against *C. albicans*, *B. lastomyces dermatitides*, *and Trichophyton spp*. and Microsporum spp *C. albicans* the more sensitive against fungal strain with the methanol extract of *Plumbago indica* L.[9]

Plumbago indica roots extract with ethanol indicate antifungal activity against *Aspergillus niger* and *C. albicans*.[10]

The active constituents *Plumbagin* was reported as fungicidal against *C. albicans* with MIC and MFC values 0.78 and 1.56µg/mL.[11]

Anti-Acne Activity

The MIC of *Plumbago indica* roots extraction with acetone against *P. acnes, S. epidermidis*, and *M. furfur* was found to be 600, 200, and 300µg/mL.[12]

The anti-acne activity showed by acetone extract of *Plumbago indica* (*in gel* formulation) was investigated against *P. acnes, S.epidermidis*,

Copyright © 2022 Author(s) *et al.* Exclusive Licensee Phcog.Net. Distributed under a Creative Commons Attribution License (CC BY 4.0).
This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

and yeast by well diffusion method has potential activity against acne-causing microorganisms.[13]

As Table 1 contains the taxonomical classification of *Plumbago indica* L. Figure 1 shows morphological characters of *Plumbago indica* L. A: flowers, B: roots. *Plumbago indica* L.

Antimicrobial activity

Methanolic extracts of *Plumbago indica* was showed antimicrobial activity with zone inhibition ranging 7.0-25.0mm against *Staphylococcus aureus, Salmonella typhi*, and *Salmonella paratyphi* with MIC was found 31.25-125µg/mL with the use of ciprofloxacin as a standard.[14]

PPE (Plumbago derivative-rich *Plumbago indica* extracts) was not less than 13.0%w/w contains and shows antimicrobial effects against *Propionibacterium acnes, Staphylococcus aureus*, and *Staphylococcus epidermidis* by micro-dilution assay method, and its stability was determined quarterly when stored in a well-closed container at temperature 4±2°C in dried powder form which is to be protected from light.[15]

With the use of the Disc Diffusion Assay method of *Plumbago* release dynamic antimicrobial action against methicillin-resistant *Staphylococcus aureus*. *Plumbago* reported high specificity with the DNA *gyrase* binding site with a high affinity and a minimum energy barrier of - 7.651kcal/mol after molecular docking.[16]

Table 1: Taxonomic profile: *Plumbago indica L.*

Kingdom	*Plantae*
Synonym(s)	*Plumbago rosea* L.
Kingdom	*Plantae*
Subkingdom	*Viridiplantae*
Infrakingdom	*Streptophyta*
Superdivision	*Embryophyta*
Division	*Tracheophyta*
Subdivision	*Spermatophytina*
Class	*Magnoliopsida*
Superorder	*Caryophyllanae*
Order	*Caryophyllales*
Family	*Plumbaginaceae*
Genus	*Plumbago* L.
Species	*Plumbago indica* L.

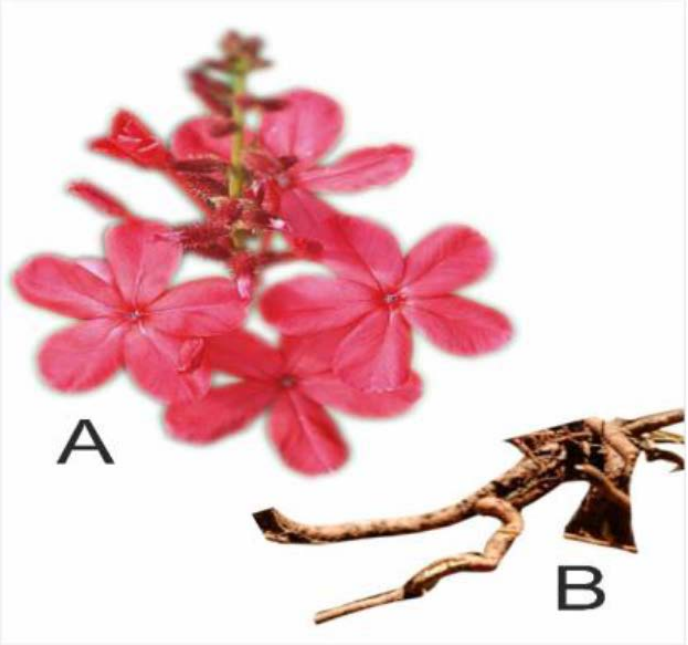

Figure 1: *Plumbago indica* L.[3]
A: flower; B: roots"

Antifertility Activity

Plumbago indica showed a percentage pre-implantation loss of 40% and 50% against control at doses of 200 and 400mg/kg b/w. *Plumbago indica* and *A. lanata* at a focus of 10% have shown no motility. Both *Plumbago indica* and *A. lanata* possess no motility of spermatozoa in rats within 60 sec at a concentration use 10%.[17]

Acetone extracts of *Plumbago indica* stem possess activity in female albino rats at doses 200 and 400mg/kg. The anti-ovulatory activity was reversible when discontinuing extract and showed significant estrogenic and anti-estrogenic activity.[18]

Analgesic Activity

Methanolic extract of *Plumbago indica* has been shown significant suppression of pain response by using the acetic acid-induced writhing method at dose concentration 250mg/kg and 500mg/kg in young Swiss-albino mice.[19]

Aqueous extracts of *Plumbago indica* were estimated with a dose of 300mg/kg body weight; carrageenan-induced paw volume showed analgesia 68.29% and 45.2% find out by Eddy's hot plate method.[20]

Antimalarial activity

In vitro antimalarial activity of *Plumbago indica L.* was claimed in *Plasmodium* berghei-infected mouse model at the dose level of 25mg/kg BW administrated daily up to 4 days was safe and produced antimalarial activity.[21]

Antibacterial activity

MIC of methanolic extract was found to be 20µg/mL on both *Escherichia coli* and *Klebsiella pneumonia*, while aqueous extract had a Microbial Inhibitory concentration of 10 and 20µg/mL of *Escherichia coli* and *Klebsiella pneumonia*.[22]

Ethanolic extracts (80%) possess activity against *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa*, MIC is 6.25mg/mL for *Bacillus subtilis* and 12.5mg/mL for *Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa*.[10]

Plumbagin was exhibited activity against *Staphylococcus aureus* with MIC and MBC/MFC value 1.56 and 25.0µg/mL.[11]

Antimycobacterial activity

Using a pure and safe composition of the recombinant version of MtbThyX, a structural arrangement of the associated compound obstructs its activity leads to cell death. *Plumbago* quashes mycobacterial cells by targeting with a vital enzyme named ThyX, required for their abidance.[23]

Antioxidant Activity

In vitro antioxidant activity possess by methanolic extracts of *Plumbago indica* by using 2,2-diphenyl-1-picrylhydrazyl in a test construct by the method Oyaizu along with Hydroxyl radical scavenging activity.[24]

Hepatoprotective Activity

The alcoholic root extract of *Plumbago indica* was afforded remarkably safe against paracetamol-induced hepatocellular injury treated with 200mg/kg and 400mg/kg of body weight with reference drug-Silymarin (100mg/kg).[25]

Anti-influenza Activity

Methanolic and ethanolic extracts of *Plumbago indica* exhibited 100% depletion in both concurrent and post treatment evaluation at concentration 10mg/mL, 5mg/mL and 1mg/mL.[26]

Cardioprotective Activity

After Plumbagin treatment of animals, repossess the heart weight and body weight and ameliorated by plumbagin treatment, from doxorubicin-induced damage.[27]

Plumbagin increased activities of creatine kinase and cardiac troponin and restored the level of lipid peroxide markers, increased anti-oxidative enzymes, decreased pro-inflammatory cytokines by oral administration.[28]

Free radicals scavenging (oxidative stress) was controlled by plumbagin by decreasing ROS and lipid peroxide levels in animals with heart injuries, with redox imbalance by injury by transcription factors NF-kB and Nfr-2. Pro-inflammatory cytokine expressions were remarkably quashed by plumbagin treatment.[29]

Macrofilaricidal Property

That property *Plumbago indica* was reported against Setariadigitata, an ailarial parasite of cattle with an inhibitory concentration range from 0.02 and 0.05mg/mL.[30]

Antifertility Activity

Acetonic and Ethanolic extracts exhibit antifertility activity with doses 200 and 400mg/kg measured on estrogenic activity in rats and confirmed by histopathology study of the uterus.[18]

Ethanolic extract of *Plumbago indica* roots shows the anti-implantation effect with loss of 40 percent and 50 percent against control dose at a concentration of 200mg/kg and 400mg/kg body weight which recommended percentage defeat was 30 percent and 40 percent at 200mg/kg and 400mg/kg body weight.[17]

Plumbagin (acetone extract) with the dose levels, 200 and 400mg/kg body weight showed significant estrogenic and anti-estrogenic activity ($p< 0.05$) ($p<0.001$) in female rats.[31]

Anti-inflammatory Activity

Plumbagin suppresses T cell expansion in response to polyclonal mitogen concanavalin A by blocking cell cycle progression induced IL - 2, IL - 4, IL-6, and IFN - γ cytokines. Also suppressed CD69 and CD25 in activated T cells.[32]

Genotoxic Effect

Plumbago indica root ethanolic extract of (EEPIR) serves potential therapeutic effects at concentration 25-100µg/mL induced cell kills and cytotoxic effect at concentrations of ≥500µg/mL *in-vitro.*[33]

Anticancer Activity

Plumbago indica L., Methanolic extraction against brine shrimp nauplii and evaluate LC_{50} and LC_{90} was 5.0µg/mL and 12µg/mL.[34]

Ethanolic extract (50-250µg/mL) reflects cytotoxicity in HE-17 cell lines by using MTT assay.[35]

Plumbagin down the feasibility of human prostate cancer cells (PC-3, LNCaP, and C4-2) with ROS origination and decrease of intracellular GSH levels together with superoxide dismutase 2 (Mn-SOD).[36]

Plumbagin acted as a potent inducer of ROS, proteasome inhibitors causing DNA double-strand break by oxidative DNA base damage and suppression of cellular glutathione.[37]

Plumbagin inhibits tumor development and no sign of toxicity at 200 or 500ppm dose levels decrease Stat3, AKT, PKCE, and COX_2 both primary and castration-resistant prostate cancer in Pten-KO mice as compared with the control group.[38]

Antiproliferative effect

Plumbago indica L. and *P. zeylanica* L., in stomach and breast cancer cell lines, confirmed cell kills by nucleus staining.[39]

Antidiarrhoeal Effect

Plumbagin produces inhibition in smooth muscle contractility and delayed in intestinal motility and; inhibits both cAMP-activated and Ca^{2+} Cl-channels as per mechanism and can be used in the therapy of CT-induced, rotaviral diarrhea and travelers with the inhibition of CaCC–calcium-activated Cl-channels and cystic fibrosis Trans-membrane conductance regulator in both HT-29 cells and mouse colon.[40]

Toxicity study

Plumbago indica root crude extract in hamster's mortality, behavior, histochemical, histopathological replaces with dose at 0, 100, 400, 1000, and 3000 mg/kg orally for 24hr and every day for 7 days assessment. The parameters show differences in hepatic panel tests (ALT and AST) and renal function tests (creatinine and BUN).[41]

CONCLUSION

As per published literature on *Plumbago indica* L. reported a variety of active ingredients with many potential therapeutic uses. Further investigations should be carried out to recognize and establish other potential Phyto-constituents and pharmacological activities.

ACKNOWLEDGEMENT

The authors acknowledge their thanks to the Management, Director, Faculty members, and students of the Department of Pharmaceutical Sciences, Jayoti Vidyapeeth Women's University, Jaipur, India for providing never-ending support and inspiration.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Bennet SSR. Name changes in flowering plants of India and adjacent region. Triscas public. Dehra Dun, India, 1989.
2. https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=504463#null
3. https://www.prota4u.org/database/protav8.asp?g=pe&p=Plumbago+indica+L
4. Kurian A, Sankar MA. Medicinal plants horticulture science series-1, kv peter, New India pub Agency, New Delhi. 2007:143-123.
5. Okeyo JM. Medicinal plants, GH Schmelzer, A Gurib-Fakim (Eds.) PROTA. 2008 473.
6. Eldhose B, Notario V, Latha MS. Evaluation of phytochemical constituents and in-vitro antioxidant activities of *Plumbago indica* root extract. J Pharma Phyto. 2013; 2(4):157-61.
7. Gangopadhyay M, Chakraborty D, Bhattacharyya S, Bhattacharya S. Regeneration of transformed plants from hairy roots of *Plumbago indica* plant cell, Tiss Org Cul. 2010; 102:109-14.
8. Silja PK, Gisha GP, Satheeshkumar. Enhanced plumbagin accumulation in embryogenic cell suspension cultures of *Plumbago rosea* L. following elicitation.

Plant Cell, Tiss Org Cul. 2014; 119(3): 469-77.
9. Saha D, Paul S. in-vitro screening of antifungal activity of methanol extract of *Plumbago indica* L. against some pathogenic species of fungi. Asian J Res Pharm Sci. 2012; 2(2): 55-57.
10. Valsaraj R, Pushpangadan P, Smitt UW, Adsersen A, Nyman U. Antimicrobial screening of selected medicinal plants from India. J Ethno. 1997; 58(2): 75-83.
11. Paiva SRD, Figueiredo MR, Aragão TV. Kaplan MAC. Antimicrobial activity in-vitro of plumbagin isolated from *Plumbago* species. Memorias do Instituto Oswaldo Cruz. 2003; 98: 959-961.
12. Kaur D, Prasad SB. The anti-acne activity of acetone extract of *Plumbago indica* root. Asian J Pharm Cli Res. 2016; 9(2): 285-287.
13. Kaur D, Prasad SB, Verma S. Formulation and evaluation gel from extract of *Plumbago indica* for acne. Int J Drug Del Tech. 2016; 6(03): 95-98.
14. Saha D, Paul S. Antibacterial activity of Plumbago indica. Turk J Pharm Sci. 2014; 11(2): 217-222.
15. Kaewbumrung S, Panichayupakaranant, P. Antibacterial activity of plumbagin derivative-rich *Plumbago indica* root extracts and chemical stability. Nat pro res. 2014; 28(11): 835-837.
16. Dissanayake DMIH, Perera DDBD, Keerthirathna LR, Heendeniya S, Anderson R., Williams DE, *et al*. Antimicrobial activity of *Plumbago indica* and ligand screening of plumbagin against methicillin-resistant *Staphylococcus aureus*. J Biomo Str Dyn. 2020; 1-12.
17. Savadi RV, Alagawadi KR. Antifertility activity of ethanolic extracts of *Plumbago indica* and *Aerva lanata* on albino rats. Int J Green Pharma. 2009; 3(3).
18. Sheeja E, Joshi SB, Jain DC. Anti-ovulatory and estrogenic activity of *Plumbago rosea* leaves in female albino rats. Ind J Pharma. 2009; 41(6): 273.
19. Paul S, Saha D. Analgesic activity of methanol extract of *Plumbago indica* (L.) by acetic acid-induced writhing method. Asi J Pharm Tech. 2012; 2(2): 74-76.
20. Ittiyavirah S, Jobin KV, Jissa MS, Jomy M, Josmi TJ, Littin B. Anti-inflammatory and analgesic activities of *Plumbago capensis* and *Plumbago indica*. Adv Pharma Toxi. 2012; 13(1).
21. Sumsakul W, Plengsuriyakarn T, Chaijaroenkul W, Viyanant V, Karbwang J, Na-Bangchang K. Antimalarial activity of plumbagin *in-vitro* and in animal models. BMC comp alter med. 2014;14(1):1-6.
22. Bashir SF, Kumar G. Preliminary phytochemical screening and *in-vitro* antibacterial activity of *Plumbago indica* (Laal chitrak) root extracts against drug-resistant *Escherichia coli* and *Klebsiella pneumonia*. Open Agri. 2021; 6(1): 435-444.
23. Sarkar A, Ghosh S, Shaw R, Patra MM, Calcuttawala F, Mukherjee N, *et al*. *Mycobacterium tuberculosis* thymidylate synthase (ThyX) is a target for plumbagin, a natural product with anti-mycobacterial activity. PloS one. 2020; 15(2): e0228657.
24. Eldhose B, Notario V, Latha MS. Evaluation of phytochemical constituents and in-vitro antioxidant activities of *Plumbago indica* root extracts. J Pharma Phyto. 2013; 2(4).
25. Rajasekaran A, Periasamy M. Protective effect of ethanolic root extract of *Plumbago indica* L. on paracetamol-induced hepatotoxicity in rats. African J Pharma Pharmacology. 2011; 5: 2330-4.
26. Chavan RD, Shinde P, Girkar K, Madage R, Chowdhary A. Assessment of anti-influenza activity and hemagglutination inhibition of *Plumbago indica* and *Allium sativum* extracts. Pharma Res. 2016;8(2);105.
27. Li Z, Chinnathambi A, Ali Alharbi S, Yin F. Plumbagin protects the myocardial damage by modulating the cardiac biomarkers, antioxidants, and apoptosis signaling in the doxorubicin-induced cardio-toxicity in rats. Env Toxi. 2020; 35(12): 1374-85.
28. Zhang G, Ni X, Zhou Y. Cardio-protective effect of plumbagin and amelioration of pro-inflammatory cytokines through suppression of Na+/K+-ATPase on myocardial ischemia. Pharma Maga. 2021;17(75): 643.
29. Wang SX, Wang J, Shao JB, Tang WN, Zhong JQ. Plumbagin mediates cardio protection against myocardial ischemia/reperfusion injury through Nrf-2 signaling. Medical science monitor: Int Med J Exp clinical Res. 2016;22:1250.
30. Mathew N, Paily KP, Vanamail P, Kalyanasundaram M, Balaraman K. Macrofilaricidal activity of the plant *Plumbago indica/roseain-vitro*. Drug Dev Res. 2002;56(1):33-9.
31. Sheeja E, Joshi SB, Jain DC. Antifertility activity of stems of *Plumbago rosea* in female albino rats. Pharma Bio. 2008;46(12):920-27.
32. Checker, R, Sharma, D, Sandur, SK, Khanam, S, Poduval, TB. Anti-inflammatory effects of plumbagin are mediated by inhibition of NF-kappa B activation in lymphocytes. Int Immuno Pharma. 2009;9(7-8):949-58.
33. Thitiorul S, Ratanavalachai T, Tanuchit S, Itharat A, Sakpakdeejaroen I. Genotoxicity and interference with cell cycle activities by an ethanolic extract from thai *Plumbago indica* roots in human lymphocytes *in-vitro*. Asian Pacific J Cancer Prev. 2013;14(4):2487-2490.
34. Saha, D, Paul, S. Cytotoxic activity of methanolic extract of Plumbago indicaL. (Family: *Plumbaginaceae*). Asian J Pharma Tech. 2012;2(2);59-61.
35. Paul AS, Islam A, Yuvaraj P. Anti-Helicobacter pylori and cytotoxic activity of detoxified root of *Plumbago auriculata*, *Plumbago indica*, and *Plumbago zeylanica*. J Phyto. 2013; 2(3): 4-8.
36. Powolny AA, Singh SV. Plumbagin-induced apoptosis in human prostate cancer cells is associated with modulation of cellular redox status and generation of reactive oxygen species. Pharma Res. 2008;25(9):2171-80.
37. Yin Z, Zhang J, Chen L, Guo Q, Yang B, Zhang W, *et al*. Anticancer effects and mechanisms of action of plumbagin: Rev Res adv Bio Med Res Int. 2020.
38. Hafeez BB, Fischer JW, Singh A, Zhong W, Mustafa A, Meske L, *et al*. Plumbagin inhibits prostate carcinogenesis in intact and castrated PTEN knockout mice via targeting PKCε, Stat3, and epithelial-to-mesenchymal transition markers. Cancer Prev Res. 2015; 8(5): 375-386.
39. Jayanthi M, Gokulanathan A, Haribalan P, Ashakiran K, Kumar CD, Kamal D, *et al*. Plumbagin from two *Plumbago* species inhibits the growth of stomach and breast cancer cell lines. Indl Crops Pro. 2020;146:112147.
40. Yu B, Zhu X, Yang X, Jin L, Xu J, Ma T, *et al*. Plumbagin prevents secretory diarrhea by inhibiting CaCC and CFTR channel activities. Frontiers in Pharma. 2019;10:1181.
41. Camchuen Y, Tesana S, Saowakon N. Toxicological and histopathological effects of *Plumbago indica* root extract in hamsters. Suranaree J Sci Tech. 2021;28(3).

Article History: Submission Date : 15-02-2022; Revised Date : 25-02-2022; Acceptance Date : 17-03-2022.
Cite this article: Hemant B, Dinesh K, Dharmendra A. Phytochemistry and Pharmacological Activities of *Plumbago indica* L.: An Overview. Int. J. Pharm. Investigation. 2022;12(2):113-6.