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A Review on Lagerstroemia Indica: A Potential Medicinal Plant

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Abstract: Lagerstroemia indica contained alkaloids, cardiac glycosides, tannins, saponins, sterols, triterpenes, anthraquinones, reducing compounds, flavonoids (flavanones/ dihydroflavonols and chalcones) and phenolic glycosides (strosides A–C). Lagerstroemia indica showed anti-inflammatory, analgesic, antipyretic, antioxidant, anticancer, antimicrobial, anti-Alzheimer's, antidiabetic, hepatoprotective and antithrombin effects. The current review discussed the chemical constituents and pharmacological effects of Lagerstroemia indica.

Keyword: Lagerstroemia indica, pharmacology, constituents

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I. INTRODUCTION

Two thirds of the new chemicals identified yearly were extracted from higher plants. 75% of the world's population used plants for therapy and prevention. In the US, where chemical synthesis dominates the pharmaceutical industry, 25% of the pharmaceuticals are based on plant-derived chemicals[(1)]. Recent pharmacological studies showed that medicinal plants possessed wide range of pharmacological effects included central nervous, cardiovascular, antioxidant, reproductive, gastrointestinal, antidiabetic, anticancer, anti-inflammatory, analgesic and antipyretic, nephro and hepato-protective, antiurolithiatic and diuretic, antimicrobial and antiparasitic, antiprotozoal, molluscicidal and insecticidal[(2-26)]. *Lagerstroemia indica* contained alkaloids, cardiac glycosides, tannins, saponins, sterols, triterpenes, anthraquinones, reducing compounds, flavonoids (flavanones/ dihydroflavonols and chalcones) and phenolic glycosides (strosides A–C). *Lagerstroemia indica* showed anti-inflammatory, analgesic, antipyretic, antioxidant, anticancer, antimicrobial, anti-Alzheimer's, antidiabetic, hepatoprotective and antithrombin effects. The current review will highlight the chemical constituents and pharmacological effects of *Lagerstroemia indica.*

Plant profile:
Synonyms:
Lagerstroemia chinensis, Lagerstroemia elegans, Lagerstroemia indica var. alba, Lagerstroemia minor, Lagerstroemia pulchra, Murtughas indica and *Velaga globosa*[(27)].
Taxonomic classification:
Kingdom: Plantae, **Subkingdom**: Viridiplantae, **Infrakingdom**: Streptophyta, **Superdivision**: Embryophyta, **Division**: Tracheophyta, **Subdivision**: Spermatophytina, **Class**: Magnoliopsida, **Superorder**: Rosanae**, Order**: Myrtales, **Family**: Lythraceae, **Genus**: *Lagerstroemia*, **Species**: *Lagerstroemia indica*[(28-29)].
Common names:
Arabic: Ward el-kahwa, Zahar kahwa katheb, Brenjik, Lailak hindi, Hinna hindi; **Barazil**: escumilha; **Bengali**: chhotojarul, purus, farash; **Chinese**: ziwei; **Engliash**: crape-myrtle, crepeflower, crepe-myrtle, rose of India; **French**: Lilasd'été, Lilas des Indes, Myrte de crêpe; **German**: chinesischeKräuselmyrte; **Hindi**: Farash, Harsingar, Phurush, Saoni, Sawani, Telingachina; **Italian**: Albero di San Bartolomeo, Lagerstremia; **Russian**: Indijskaia siren, Lagerstremiia indijskaia; **Spanish**: Árbol de Júpiter, Crespón, Espumilla, Júpiter, Lila de lasIndias, Lila del sur, Melindres; **Swedish**: lagerströmia; **Turkish**: Oyaağacı[(30)].
Distribution:
The plant is distributed in **Asia**: China, Korea, Japan, Taiwan, Cambodia, Laos, Philippines, Thailand and Vietnam. It is also widely cultivated as an ornamental plant in tropical and subtropical areas[(28, 30-31)].
Description:
Usually a shrub, to 7 m. Leaves: petiole short or 0; lamina elliptic or oblong, pubescent on veins beneath. Flowers showy, pink, white or purple. Calyx hairless, not ribbed. Petals 6, with a long claw and fringed limb. Stamens c. 40. Capsule 0.8-1.2 mm long[(32-33)].
Traditional uses:
The plant had a long history of folkloric medical uses included: blood pressure control, urinary dysfunctions, to control the cholesterol levels, as analgesic, in treatment of diarrhea, to facilitate bowel movement, and in the

treatment of diabetes. Seeds were used as narcotic. Bark was used as stimulant and febrifuge. Leaves and flowers were used as purgative. The root was used as an astringent, detoxicant and used as diuretic and gargle[28, 31, 34].

Parts used

Roots, bark, leaves and flowers[5].

Chemical constituents:

Lagerstroemia indica contained alkaloids, cardiac glycosides, tannins, saponins, sterols, triterpenes, anthraquinones, reducing compounds, flavonoids (flavanones/ dihydroflavonols and chalcones) and phenolic glycosides (strosides A–C). The plant contained protein 22.53, carbohydrate 37.25 and ash 12.23 g% on dry weight. Mineral analysis showed that the plant contained high potassium, calcium, magnesium, phosphorous, sodium and sulphur[35-42].

The phenolic derivatives isolated from *Lagerstroemia indica* stem were included:

stroside A,B and C, 9,9'-dihydroxy-3,4-methoxylenedioxy-3'-methoxy [7-*O*-4'-8-5']- neolignan, pterospermin A, (2*R*,3*S*)-dihydrodehydroconiferyl alcohol, gochidioboside, 7*S*,8*R*-dihydrodehydrodiconiferyl alcohol 4-O-*β*-D-glucopyranoside, hovetrichoside A, hovetrichoside B, (1'*S*,2'*R*)-guaiacyl glycerol, carthamoside B5, (+)-(7*S*,8*S*)-guaiacylglycerol 8-O-*β*-D- glucopyranoside, D-*threo*-guaiacylglycerol 8-*O*-*β*-D-(6'-*O*-galloyl) glycol pyranoside, alatusol A, ficusol, evofolin-B, and marphenol C[38].

The total anthocyanin content of *Lagerstroemia indica* was 36.22 mg/kg[43]. Triterpenes: lagerindiside, quadranoside, betulinic acid, 3b-acetoxyolean-12-en-28-acid, arjunolic acid 28-O-glucopyranoside, hederagenin, arjunolic acid, oleanolic acid, maslinic acid, and 3b,23-dihydroxy-1-oxo-olean-12-en-28-oic acid were isolated from the stems of *Lagerstroemia indica*[31]. Pentacyclic triterpenoids were isolated from the leaves of *Lagerstroemia indica* and identified as 7-oxo-3 beta-hydroxy-5,20(29)diene-24-norlupane, lup-20(29)-ene-1 beta,2 3 beta-triol, 21-hydroxylupa-1,12-dien-3-one, and lageflorin[44]. Biphenyl and biphenyl ether quinolizidine N-oxide alkaloids were also isolated from the plant[35, 39]. Decamine, decinine, decodine, dihydroverticillatine, lagerstroemine and lagerine alkaloids were isolated from *Lagerstroemia indica*. 5-epi-dihydrolyfoline and its sterioisomer, dihydrolyfoline, along with lagerine were isolated from the aerial parts of *Lagerstroemia indica* [39, 45]. The total flavonoids identified in the 80% ethanolic extract of *Lagerstromia indica* was 27.71mg/g dry weight, these included: luteolin-6-arabinose-8-glucose 2.53, luteolin-6-glucose-8-arabinose 0.30, apigenin-6-arabinose-8-glactose 0.43, apigenin-6-rhamnose-8-glucose 0.49, apigenin-6-glucose-8- rhamnose 3.13, luteolin-7-glucose 0.86, naringeen 0.80, hisperidin 4.86, rutin 0.92, apigenin-7-O-neohespiroside 0.33, kampferol-3,7-dirhamnoside 1.51, quercetrin 1.54, rosemarinic 0.13, quercetin 0.22, naringenin 0.30, kampferol-3-(2- *p*-comaroyl) glucose 1.18, hespertin 0.31, kampferol 0.23, rhamnetin 0.06, apigenin 0.13, apigenin-7-glucose 1.25, acacetin 18.88 6.20 mg/g dry weight. The total Phenolics identified in the 80% ethanolic extract of *Lagerstromia indica* was 64.75 mg/g dry weight. Phenolic compounds isolated from the 80% ethanolic extract of *Lagerstromia indica* included: pyrogallol 3.10, gallic acid 0.03, 4-amino-benzoic acid 0.08, protocatchuic acid 0.80, catechin 0.37, catechol 1.43, epicatechin 0.15, *p* -hydroxy benzoic acid 0.66, chlorogenic acid 0.27, vanillic acid 0.99, caffeic acid 0.13, *p*- coumaric acid 0.53, ferulic acid 0.29, iso-ferulic acid 0.56, vanillic acid 17.40, α-Coumaric acid 0.70, benzoic acid 3.65, ellagic acid 31.48, 3,4,5,-methoxy-cinnamic acid 1.24, cinnamic acid 0.03, and salycilic acid 0.68 mg/g dry weight. The total carotenoids identified in the 80% ethanolic extract of *Lagerstroemia indica* was 112.22 mg/g[46].

Twenty five compounds were isolated from the aqueous methanol leaf extract of *Lagerstroemia indica* included p-methoxygallic acid methyl ester, gallic acid, 3-O-methylgallate, tellimagrandin, nilocitin, 1,3-di-O-galloyl-4,6-hexahydroxy diphenoyl-β4 C1-glucopyranose, 2,3-hexahydroxydiphenic acid-α/β-glucoside, isovitexin, vitexin, iso-orientin, orientin, astralagin, rutin, apigenin-7–O-4 C1-β-D-glucoside, catechin, epicatechin, luteolin-7-O-4 C1-β-D-glucoside, 3- methoxyellagic acid, ellagic acid, apigenin, kaempferol, luteolin and quercetin[47] .

However, the constituents of ethanol and hexane extracts of *Lagerstroemia indica* and *L. loudonii*, included *γ*-sitosterol , (Z)-9-octadecenamide (oleamide), phytol, *α*-tocopherol, squalene, n-hexadecanoic acid, linolenic acid, 5-hydroxy methyl furfural, phytol, acetate, campesterol, ethyl *α*-d-glucopyranoside, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, linoleic acid, 24-methylenecycloartanol, cis-11-eicosenamide, stigmast-5-en-3-ol,oleate, *γ*-tocopherol, hexadecanamide, octadecanamide, octadecanoic acid, stigmasterol, glycerol ß-palmitate, hexadecanoic acid ethyl ester and pentacosane[48].

Analysis of *Lagerstroemia indica* leaves polysaccharides showed that polysaccharides consisted of xylose (1.921%), arabinose (0.520%), ribose (0.620%), rhamnose (25.74%), mannitol (0.392%), sorbitol (2.430%), fructose (0.426%), mannose (46.58%), glucose (16.15%) and galacturonic acid (5.21%)[42].

Pharmacological effects:

Anti-inflammatory analgesic and antipyretic effects:

The anti-inflammatory effect of *Lagerstroemia indica* whole plant 80% ethanol extract was studied using *in vitro* and *in vivo* experiments . In an *in vitro* study, the increased cytokine concentrations (IL-2, IL-4, IL-5, IL-13, and TNF-α) in Jurkat cells with the using of house dust mites extract were inhibited by *Lagerstroemia indica* extract, and it also suppressed the increased expression of IL-6 after treatment with mite extract of EoL-1 cells and THP-1 cells. The extract significantly inhibited leukocytosis and eosinophilia in bronchoalveolar lavage fluid and lung tissue samples in ovalbumin-induced asthmatic mice. The extract also inhibited the increased mucus secretion, blocked the production of reactive oxygen species, and blocked the protein expression of IL-5 in bronchoalveolar lavage[(49)].

The anti-inflammatory effect of *Lagerstroemia indica* fruits extracts was determined in LPS-induced RAW 264.7 cells and in protective effects in reflux-esophagitis in rats. The anti-inflammatory effect of *Lagerstroemia indica* extracts was measured by NO production inhibitory activity and the expression of pro-inflammatory protein such as iNOS, COX-2 and NF-kB on lipopolysaccharide (LPS)-induced Raw 264.7 cells. The NO production and iNOS, COX-2 and NF-kB expression increased by LPS were inhibited by *Lagerstroemia indica* extracts. In reflux-induced esophagitis, the oral administration of *Lagerstroemia indica* extracts decrease contradistinction to the reflux-esophagitis control[(50)].

The anti-inflammatory activities of 19 phenolic derivatives isolated from *Lagerstroemia indica* stem were evaluated through the measurement of the production of NO in murine microglia BV2 cells stimulated by bacterial pathogen, LPS. (2*R*,3*S*)-dihydrodehydroconiferyl alcohol compound significantly inhibited LPS-stimulated NO production with IC_{50} values of 14.6 μM, which displayed more activity than L-NMMA. Evofolin-B compound showed the inhibitory activity with an IC_{50} of 22.0 μM in BV-2 cells without cell toxicity. However, other compounds (pterospermin A, alatusol A, ficusol, evofolin-B and marphenol C) exhibited week NO production activity in the murine microglia BV-2 cell line[(38)].

The anti-inflammatory effect of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B), 100 mg /Kg bw, was studied using carrageenan induced oedema in rat paw. Both extracts possessed anti-inflammatory activity[(42)].

The analgesic effect of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B), 100 mg /Kg bw, was studied using an electric current as noxious stimulus applied to the rat's tail. Extract A of *Lagerstroemia indica*. possesses higher analgesic activity and more potent than extract B, with 68% and 54% analgesic activity, respectively of that of the standard dipyron-metamizole[(42)].

The antipyretic effect of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B), 100 mg /Kg bw using intramuscular injection of 1 mg /100g bw of 44% yeast suspension in rats. Extract A of *Lagerstroemia indica*. possessed antipyretic activity, it showed potency after one hour (65%) then it increased after two hours reaching 88%, while the potency of extract B was 35% after one hour then increased to 62% after two hours of treatment as compared to the reference drug, acetaminophen[(42)].

Antioxidant effects:

The antioxidant activity of *Lagerstroemia indica* Linn. f. alba (Nichols.) Rehd and *Lagerstroemia indica* flowers was evaluated by DPPH radical scavenging, ABTS radical scavenging and FRAP assay. *Lagerstroemia indica* flowers possessed good antioxidant activity *in vitro*. The ethyl acetate extract of *Lagerstroemia indica* Linn. f. alba (Nichols.) Rehd showed the highest antioxidant activity, it possessed higher DPPH radical scavenging activity (IC_{50}= 7. 4 μg / ml), ABTS radical scavenging activity (IC_{50}= 1. 8 μg / ml) and ferric reducing antioxidant power (=2664. 7 μmol / g)[(51)].

Both models of DPPH and ABTS revealed high antioxidative activities of *Lagerstroemia indica* (70% acetone in water) at the 50 ppm. In the result of DPPH (1,1-diphenyl-2-picryl-hydrazyl) scavenging radical activity, the acetone extract of *Lagerstroemia indica*. branch were higher than 73% at the 50 ppm. ABTS radical cation decolorization activity of acetone extract were higher than 78% at the 50 ppm[(52)].

The antioxidant potential was assessed using ABTS activity, DPPH radical scavenging activity and metal chelating activity. Highest TEAC value 7.946 ± 0.04 mMtrolox for ABTS assay was possessed by aqueous extract of leaves. The maximum metal chelating activity 60.302 ± 0.93 was recorded for petroleum ether extract of fruit. The highest value of % DPPH° (92.92 ± 0.08 %) was caused by aqueous extract of bark[(42)].

The antioxidant activity of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B) was studied by determination of blood glutathione (mg %). Extract A of *Lagerstroemia indica* (100 mg /Kg bw) induced highly significant antioxidant activity than extract B. The potent antioxidant activity of *Lagerstroemia indica* extracts might be attributed to its phenolic compounds[(42)].

Anticancer effects:

Two of the phenolic derivatives isolated from *Lagerstroemia indica* stem showed cytotoxicity against four cell lines: A549 (non-small cell lung carcinoma), SK-OV-3 (ovary malignant ascites), SK-MEL-2 (skin melanoma), and HCT-15 (colon adeno carcinoma) with IC_{50} of 16.59, 16.64, 17.26 and 8.83μM for lagerindiol and 6.51, 9.13, 11.38 and 5.87 μM for pterospermin A, against the four cell lines respectively[38].

Ten triterpene glycoside isolated from stems of *Lagerstroemia indica* were tested for anticancer effects, by determining their inhibitory effects on four human tumor cell lines (A549, SK-OV-3, SK-MEL-2, and HCT15). Two of the ten compounds (betulinic acid and 3b-acetoxyolean-12-en-28-acid) showed potent cytotoxicity with IC_{50} 3.38- 6.29 μM[31].

Antimicrobial effect:

The antimicrobial effect of the methanol extract of *Lagerstroemia indica* leaves was evaluated against (*Staphylococcus aureus* (ATCC 8095), *Salmonella enteritides* (ATCC 13076), *Escherichia coli* (ATCC 25922), *Listeria monocytogenes* (ATCC 15313) and *Candida albicans* (ATCC 10231) using disk diffusion and broth microdilution methods. The methanol extract of *Lagerstroemia indica* leaves exhibited antimicrobial activity against all the tested microorganisms. Purification of the methanol extract of *Lagerstroemia indica* leaves yielded one pure active compound, '4-methoxy apigenin-8-C-β-D-glucopyranoside; cytisoside. The minimum lethal concentration of the compound against *Candida albicans* was (MLC= 32 μg/ml), *Staphylococcus aureus* (MLC=16 μg/ml), *Salmonella enteritides* (MLC= 16 μg/ml), *Escherichia coli* (MLC= 16 μg/ml), and *Listeria monocytogenes* (MLC= 16 μg/ml)[53].

The antimicrobial effect of *Lagerstroemia indica* methanol and aqueous leaf extracts was studied against 5 human bacterial pathogensusing disc diffusion method. The mean inhibitory zones of the methanolic extract against *Staphylococcus auerus*, *Salmonella typhi*, *Klebsiella pneumoniae*, *Proteus vulgaris* and *Pseudomonas aeruginosa* were 12, 12, 13, 20 and 16 mm, while the mean inhibitory zones of the aqueous extract were 8, 6, 9, 5 and 7 mm against the same microorganisms respectively [41].

The antimicrobial activity of the barks, leaves and fruits of *Lagerstroemia indica* extracted by petroleum ether, chloroform, methanol and distilled water was studied against two Gram-positive (*Staphylococcus aureus* and *Bacillus subtilis*), two Gram-negative (*Escherichia coli* and *Pseudomonas aeruginosa*) bacterial strains and two fungal strains (*A. oryzae* and *A. niger*). The maxium antibacterial effect was exerted by petroleum ether extract of the bark (41.33 ± 0.88mm), while, petroleum ether etract of the leaves showed the maximum effect against *Pseudomonas aeruginosa* (49.33 ± 0.66 mm). Chloroform extract of the bark and methanolic extract of the fruit possessed the maximum effect against *Staphylococcus aureus* (31.33 ± 0.88mm) and petroleum ether extract of the bark exerted the maximum effect against against *Bacillus subtilis* (58.33 ± 0.88mm). A significant antifungal activity was exerted by all the extracts of *Lagerstroemia indica* against both fungal strains. The largest zone of inhibition (36 ± 3.21mm) against *A. oryzae* was exhibited by aqueous extract of bark, while the highest antifungal activity against *A. niger* (40.33 ± 0.88 mm) was possessed by chloroform bark extract[42].

Anti-Alzheimer's disease:

Lagerstromia indica 80% ethanolic extract (total extract, 500 mg/kg bw) was evaluated on Alzheimer's disease (AD) induced in rats by Aluminium cholride ($AlCl_3$). Aluminium cholride ($AlCl_3$) caused disturbances in neurotransmitter levels norepinephrine, acetylcholine esterase, dopamine and serotonin. It elevated oxidative stress protein carbonyl (PC) and apoptotic markers caspase -3 with many histological changes included necrosis of cerebral cortex, atrophy, pyknosis of neurons and focal gliosis. Hippocampus of AD rats showed necrosis of pyramidal cells. Treatment of AD rats with total extract of *Lagerstroemia indica* revealed marked improvement of neurotransmitter levels comparing to AD induced rats. Cerebral cortex or hippocampus of AD rats treated with *Lagerstroemia indica* total extract showed only necrosis of some sporadic neurons and pyramidal cells[46].

Hypoglycemic effect:

The hypoglycemic effect of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B), 100 mg /Kg bw, was studied in alloxan (150 mg/ kg bw) induce diabetes mellitus in rats. Extract decreased serum glucose level by 22.5% and 44.9% after 4 and 8 weeks, respectively. Glucose level was decreased by 32.2 % and 58.2% in extract B treated animals after 4 and 8weeks, respectively in comparison with metformin, which decreased glucose level by 46.2% and 66.4% after 4 and 8weeks, respectively[42].

Hepatoprotective effects:

The hepatoprotective activity of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B) was studied in carbon tetrachloride induced hepatotoxicity in rats. Both extracts showed significant reduction (51.9, 57.2 and 14.1 µ /l for extract A and 65.2, 63.2 and 18.5 µ /l for extract B) in AST, ALT and ALP respectively, compared to the control. The hepatoprotective effects of extract A was comparable to that of silymarin[42].

Antithrombin activity:

A chromogenic bioassay was utilized to determine the antithrombin activity of methylene chloride and methanol extracts prepared from 30 plants of central Florida. Extracts of *Lagerstroemia indica* demonstrated activity of 80% or higher antithrombin activity using bioassay system[54].

Toxicity:

The median lethal doses (LD_{50}) of water methanol *Lagerstroemia indica* leaves extract free from polysaccharide (extract A), and water methanol extract with polysaccharide (extract B) were studied in mice. The median lethal doses (LD_{50}) of extracts A and B of *Lagerstroemia indica* were 6.5 and 6.8 g/Kg bw respectively[42].

II. CONCLUSION

Lagerstroemia indica showed anti-inflammatory, analgesic, antipyretic, antioxidant, anticancer, antimicrobial, anti-Alzheimer's, antidiabetic, hepatoprotective and antithrombin effects. The current review discussed the chemical constituents and pharmacological effects of *Lagerstroemia indica.*

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