AN OVERVIEW OF LAGERSTROEMIA SPECIOSA

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ABSTRACT

Lagerstroemia speciosa, commonly known as banaba, is a plant native to Southeast Asia that has garnered attention for its potential pharmacological properties. Research suggests that various parts of the banaba plant, including leaves and bark, possess bioactive compounds with medicinal value. One of the most studied compounds found in banaba is corosolic acid, which has demonstrated promising effects on blood glucose levels, making it a subject of interest in the management of diabetes mellitus. Additionally, banaba extracts have shown antioxidant, anti-inflammatory,Activity against arthritis, Activity against fibrosis, Inhibition of xanthine oxidase, Activity against microorganisms, Activity against pain perception, Activity against cell toxicity, Activity against obesity, Activity against viruses, and hypolipidemic properties in preclinical studies, indicating potential benefits for cardiovascular health. Moreover, banaba has been investigated for its antimicrobial and wound-healing properties. While further clinical studies are needed to confirm and elucidate its therapeutic potential, Lagerstroemia speciosa holds promise as a source of pharmacologically active compounds with various health benefits.

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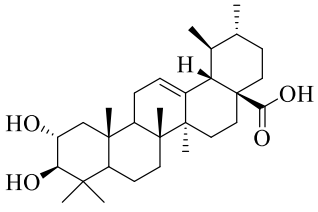
Introduction

Lagerstroemia plants belong to the family Lythraceae within the rosids, a group of core eudicots. With approximately 56 species globally, they inhabit regions from tropical to northern temperate zones**[1-2].** Originating from China, Lagerstroemia is primarily found in provinces such as Yunnan, Guizhou, Sichuan, Guangdong, Guangxi, and along the eastern coast of Fujian, totaling 24 discovered species in these areas**[3-4].** Renowned for their long-lasting summer blooms, vibrant colors, and diverse flower types, Lagerstroemia species are favored as woody ornamental plants. They exhibit adaptability to various habitats, making them ideal for landscaping with minimal susceptibility to pests and diseases. Additionally, they have a rich history of use in Chinese gardens and offer industrial, medicinal, and environmental benefits. As awareness of environmental and health issues grows, Lagerstroemia's significance in air purification and disease treatment is increasingly recognized, leading to a surge in research interest both nationally and internationally. Bibliometrics, a statistical method, proves invaluable in organizing and summarizing vast literature datasets. By extracting and correlating information such as keywords, sources, authors, and publication dates, bibliometrics aids in identifying research directions, dynamics, and hotspots. In this study, scientific literature on Lagerstroemia sourced from the Web of Science (WOS) core collection databases underwent analysis using VOSviewer and CiteSpace visualization software to delineate the field's research status, hotspots, and trends, offering valuable insights for Lagerstroemia studies globally**[5-8].**

Chemical structure of Lagerstroemia



Corosolic acid

Botanical description and Active constituents

It is a deciduous tropical tree renowned for its vibrant flowers, capable of reaching heights between 9 to 18 meters with spreading branches spanning 9 to 12 meters. The bark is grayish or brown, thin, smooth, and often mottled, peeling off in irregular pieces. Its leaves are oblong, lanceolate, or elliptic, measuring 10 to 20 centimeters long and 3.8 to 7.5 centimeters wide, featuring a dark green, leathery texture, and turning orange-red in the fall. The calyx is turbinate, approximately 1.6 centimeters long, covered in white or ferruginous tomentum, ribbed with stout ridges numbering between 12 to 24. The petals, usually numbering 6 to 7, are purple, suborbicular, or round-ovate, with crumpled edges, and spreading stamens shorter than the style. Flowers are striking, ranging from pink to purple, measuring 5 to 7.5 centimeters across, typically arranged in large panicles, sometimes up to 30 centimeters long. Flowering typically occurs in May, with fruits resembling nuts. The ellipsoid or sub-globose capsules measure 2 to 3.2 centimeters long and 1.6 to 2.5 centimeters wide, with minutely apiculate tips. The seeds, winged and glabrous, measure 1.25 to 1.45 millimeters wide and 6.45 millimeters long, exhibiting a pale brown color.

Active constituents found in Lagerstroemia include ellagic acid derivatives, ellagitannins, lagerstroemin, flosin B, and reginin A, which may enhance glucose transport. Additionally, lagertannins, beta-sitosterol, stigmasterol, campesterol, and certain olefins are present in L. speciosa leaves and extracts. Other compounds isolated from leaves include lageracetal (1,1-Dibutoxybutane), 1-pentanol, ellagic acid, and corosolic acid, a triterpene. Amino acids, pyrogallol tannins, and lipids are also reported in L. speciosa leaves. The neutral fraction of hot ethanol leaf extracts contains nonacosane, hentriacontane, tritriacontane, and esters of various fatty acids.

The bark of L. speciosa contains similar constituents to its leaves, including ellagic acids, beta-sitosterols, and corosolic acids. Seeds contain various fatty acids such as caprylic, lauric, myristic, palmitic, stearic, arachidic, behenic, lignoceric, oleic, and linoleic acids, along with 9-keotoctadec-cis-11-enoic acid. Seed extracts also contain antibacterial compounds like nonanedioic acid, 12-acetyloxy-9-octadecenoic acid, and 16-methyl-heptadecandic acid.

Stem parts of L. speciosa and related species contain ellagic acid, campesterol, stigmasterol, and beta-sitosterol. Flowers are rich in Delphinidin-3 arabinoside, petunidine-3-arabinoside, mulvidin-3-arabinoside, gallic acid, methyl gellate, and ellagic acid. The active principles identified include corosolic acid, lagerstroemin, and lagertannins**[9]**.

Pharmacological Properties:

Activity against diabetes" and "actions to lower blood sugar levels"

a) In a study conducted by Custer C. Deocaris et al. in 2005, the hypoglycemic effects of an 80% ethanol extract of banaba leaves that underwent irradiation were investigated on diabetic mice treated with alloxan. The researchers observed a notable decrease in blood glucose levels within a span of 1.5 hours.
b) William et al. (2003) conducted a study on the anti-diabetic properties of an 80% w/w aqueous ethanol leaf extract from Lagerstroemia speciosa, standardized to 1% corosolic acid (marketed as GlucosolTM). In a randomized clinical trial involving individuals with Type II diabetes, it was observed that GlucosolTM, when formulated in soft gel capsules, resulted in a 30% reduction in blood glucose levels, whereas a 20% decrease was seen with the dry powder-filled hard gelatin capsule formulation. This suggests that the soft gel formulation may have superior bioavailability compared to the dry powder formulation.
c) In 2009, Amornnat Thuppia and colleagues investigated the hypoglycemic properties of a water extract derived from Lagerstroemia speciosa leaves in both normal and streptozotocin (STZ)-induced diabetic rats. Their findings indicated that the water extract from Lagerstroemia speciosa leaves could effectively lower fasting blood glucose levels in STZ-induced diabetic rats.
d) In 2009, Barun Kanti Saha et al. conducted research on the hypoglycemic properties of a hot water extract derived from the leaves of Lagerstroemia speciosa in rats with chemically induced diabetes. The findings from these studies strongly indicate that the notable hypoglycemic effects of the Lagerstroemia speciosa extract on diabetic rats were likely due to its ability to inhibit gluconeogenesis and enhance glucose oxidation through the pentose phosphate pathway.**[10-13]**

Activity against obesity
a) In 1999, Suzuki et al. investigated the anti-obesity potential of a 5% hot water extract obtained from banaba leaves. The findings indicated that banaba exhibited favorable effects on obese female KKA Y mice. **[14-16]**

Activity against viruses
a) In 2013, Nutan et al. conducted a screening for the anti-HIV properties of aqueous and 50% ethanol extracts derived from the leaves and stems of banaba using in vivo reporter gene-based assays. They discovered the novel anti-HIV potential of banaba attributed to the presence of Gallic acid and ellagic acid, which inhibit reverse transcriptase and HIV protease.**[17]**

b) Choi HJ et al. in 2010 examined the anti-human rhinovirus (HRV) activity of orobol 7-O-D-glucoside (O7G), isolated from Lagerstroemia speciosa leaves, using HeLa cells. O7G exhibited broad-spectrum anti-HRV effects against both group A and group B HRV strains.**[15]**

Activity against cell toxicity
a) In 2012, Fatema Nasrin et al. assessed the cytotoxic effects of methanol extracts obtained from Lagerstroemia Speciosa leaves and barks using the brain shrimp lethality bioassay method. Their findings revealed significant cytotoxic potential associated with the methanol extract of L. Speciosa leaves.**[17]**

Activity against bacteria
a) In 2013, LMV Laruan and colleagues investigated the phytochemical composition and antibacterial properties of a methanol extract obtained from Lagerstroemia speciosa (L.) Pers. using a modified Kirby-Bauer technique. Their research revealed significant antibacterial efficacy of the extract against E. coli, Staphylococcus aureus, and Pseudomonas aeruginosa. **[18]**

Activity against inflammation
a) Priya et al. (2008) investigated the anti-inflammatory properties of ethyl acetate and ethanol leaf extracts derived from Lagerstroemia Speciosa. They evaluated these extracts using carrageenan-induced acute inflammation and formalin-induced chronic paw edema assays. The ethyl acetate extracts demonstrated a significant reduction in inflammation in a dose-dependent manner, whereas such effects were not observed with the ethanol extract in both acute and chronic inflammatory models. **[19]**
b) The evaluation of potential anti-inflammatory activities by plant extract utilized the carrageenan-induced paw edema model as described by Winter et al. (2022) **[20]**

Activity against pain perception
a) In 2010, Ahosan Morshed et al. investigated the antinociceptive properties of a chloroform extract obtained from the bark of Lagerstroemia speciosa. They utilized an acetic acid-induced gastric pain model in Swiss albino mice for screening. Their findings indicated that Lagerstroemia speciosa exhibited significant antinociceptive activity. **[21]**

Activity against microorganisms
a) Asish Bhaumik et al. in 2014 investigated the bioactive compounds present in methanol, ethanol, and chloroform extracts derived from the

fruit of Lagerstroemia speciosa using the agar well diffusion method. They employed bacterial cultures including Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa, Escherichia coli, and fungal cultures including Aspergillus niger, Aspergillus flavus, and Candida albicans. Their findings revealed that all the extracts demonstrated moderate to good antimicrobial activity against the tested microorganisms. **[22]**

b) In 2013, Pavithra G. M. et al. investigated the antimicrobial properties of a methanol extract obtained from the flowers of Lagerstroemia speciosa using the agar well diffusion method. Their research revealed that the extract effectively inhibited all tested microorganisms, including 5 isolates of Streptococcus, 5 isolates of Staphylococcus aureus, Candida albicans, and Cryptococcus neoformans.**[23]**

c) Seed extracts from Lagerstroemia speciosa were evaluated for their antibacterial effects against various bacterial strains. Certain fractions of these seed extracts exhibited significant antibacterial activity against both Gram-positive and Gram-negative bacteria. **[24]**

d) The antimicrobial activity of methanolic extracts from Lagerstroemia speciosa leaves and barks was assessed against 11 Gram-positive bacteria, Gram-negative bacteria, and 3 fungi using the disk diffusion method. The average inhibition zones for the methanolic leaf and bark extracts (500µg/disc) were found to be 10-20 mm and 12-21 mm, respectively. The antibacterial and antibiofilm activities of Lagerstroemia speciosa leaf extracts were investigated against clinical strains, including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Salmonella typhi, using the well diffusion technique. Additionally, the antibacterial efficacy against common foodborne pathogens, such as Listeria monocytogenes and Bacillus cereus, was tested at concentrations ranging from 250 to 1000 µg/ml. The antibiofilm assay was conducted against P. aeruginosa using concentrations from 250 to 1000 µg/ml with the cover slip method. The alcoholic extract exhibited minimal antibacterial activity, while all other extracts showed negligible effects. At higher concentrations (1000µg/ml), the methanolic and ethanolic extracts inhibited P. aeruginosa biofilms by 93.0±2% and 91±2%, respectively. **[25-26]**

e) The antibacterial activity of ethanol and water extracts from Lagerstroemia speciosa leaves was evaluated using the plate agar diffusion method against both Gram-positive and Gram-negative bacteria. The Minimum Inhibitory Concentrations (MIC) for the ethanol and water extracts against Staphylococcus aureus were 14 mm and 15 mm, Bacillus subtilis were 12 mm and 15 mm, Pseudomonas aeruginosa were 14 mm and 17 mm, and Escherichia coli were 16 mm and 17 mm, respectively. The water extract demonstrated the highest efficacy. **[27]**

f) The antimicrobial properties of Lagerstroemia speciosa flower extracts were investigated against Gram-positive bacteria (Bacillus cereus, Bacillus megaterium, Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus), Gram-negative bacteria (Escherichia coli, Pseudomonas aeruginosa, Salmonella paratyphi, Salmonella typhi, Shigella boydii, Shigella dysenteriae, Vibrio mimicus, Vibrio parahemolyticus), and fungi (Saccharomyces cerevisiae, Aspergillus niger). The methanolic crude extract exhibited antimicrobial activity against all tested microorganisms. The largest inhibition zone, measuring 19 mm, was observed for the carbon tetrachloride-soluble fraction against Staphylococcus aureus. **[28]**

g) The antibacterial activity of the methanolic extract from Lagerstroemia speciosa leaves was studied against Escherichia coli, Salmonella typhimurium, Staphylococcus aureus, and Pseudomonas aeruginosa. The extract exhibited significant antibacterial efficacy against Escherichia coli (15 mm), Staphylococcus aureus (10 mm), and Pseudomonas aeruginosa (10 mm), but showed no activity against Salmonella typhimurium. **[29]**

h) The antimicrobial effects of Lagerstroemia speciosa bark extract were examined using the time-kill curves assay. The extract demonstrated a concentration-dependent bactericidal effect against both B. spizizenii ATCC 6633 and A. anitratus. Significant reduction in bacterial counts was observed when exposed to twice the Minimum Inhibitory Concentration (2MIC) level. B. spizizenii ATCC 6633 exhibited greater susceptibility to the extract compared to A. anitratus. **[30]**

i) Various extracts from the fruits of Lagerstroemia speciosa (at concentrations of 50, 100, and 150 µg/ml) were evaluated for their antimicrobial activity using the paper disc diffusion method. Most of the extracts exhibited activity against all tested bacteria with MIC values ranging from 15-39 µg/ml for S. aureus, 16-38 µg/ml for E. coli, 15-39 µg/ml for P. aeruginosa, and 14-39 µg/ml for B. subtilis. Additionally, the extracts demonstrated activity against all tested fungi, with MIC values ranging from 16-38 µg/ml for A. niger, 18-39 µg/ml for A. flavus, and 16-38 µg/ml for C. albicans. **[31]**

j) The Lagerstroemia speciosa fruit extract's ability to inhibit cell-to-cell communication, expression of virulence genes and factors, and biofilm formation was studied in Pseudomonas aeruginosa strain PAO1. The findings indicated that the fruit extract led to the downregulation of quorum sensing-related genes (las and rhl) and their corresponding signaling molecules, N-acylhomoserine lactones, without impacting the growth of P. aeruginosa PAO1. Significant reductions in virulence factors, including Las A protease, Las B elastase, and pyoverdin production, were observed. Moreover, the application of the extract to P. aeruginosa PAO1 biofilms increased the susceptibility of the bacteria to tobramycin. **[32]**

k) The anti-human rhinovirus activity of orobol 7-O-d-glucoside, extracted from Lagerstroemia speciosa, was assessed in Hela cells using a cytopathic effect reduction method. Orobol 7-O-d-glucoside exhibited broad-spectrum anti-human rhinovirus activity with IC50 values ranging from 0.58 to 8.80 microg/ml. The CC50 value for orobol 7-O-d-glucoside was greater than 100 microg/ml. **[33]**

l) The antiviral efficacy of quercetin 7-glucoside, isolated from Lagerstroemia speciosa, was examined against human rhinovirus 2 (HRV2) using a cytopathic effect reduction method. Quercetin 7-glucoside demonstrated potent anti-HRV2 activity by diminishing the cytopathic effect formation. Additionally, it hindered virus replication during the initial stages of infection through indirect interaction with virus particles. **[34]**

m) The aqueous and 50% ethanolic extracts from the leaves and stems of Lagerstroemia speciosa were examined for their anti-HIV activity using in vitro reporter gene-based assays. All extracts demonstrated a dose-dependent inhibition of HIV-1 infection in TZM-bl and CEM-GFP cell lines, with IC50 values ranging from 1 to 25 μg/ml. **[35]**

n) The antiviral properties and potential mechanism of action of the tannin ellagic acid from Lagerstroemia speciosa leaves against HRV2, HRV3, and HRV4 were investigated. Based on 50% inhibitory concentration values, natural ellagic acid exhibited toxicity 1.8, 2.3, and 2.2 times higher towards HRV-2 (38 μg/ml), HRV-3 (31 μg/ml), and HRV-4 (29 μg/ml) compared to ribavirin, respectively. Pre-incubation with 50 μg/ml ellagic acid resulted in a 17% inhibition rate, while continuous presence of ellagic acid during infection significantly increased inhibition to 70%. Treatment with 50 μg/ml ellagic acid notably suppressed HRV-4 infection when added immediately after virus inoculation (0 h) with an 87% inhibition, but showed less than 20% inhibition when added before or after this time point. **[36]**

Inhibition of xanthine oxidase

a) In 2004, Unno and colleagues investigated the impact of an aqueous leaf extract from Lagerstroemia speciosa on xanthine oxidase. Their study revealed that the extract demonstrated inhibitory activity against xanthine oxidase, implying its potential for both preventing and treating hyperuricemia.**[37]**

Activity against fibrosis

a) In 2010, Prabhu VV et al. investigated the impact of ethanol leaf extract derived from Lagerstroemia speciosa on male albino Wistar rats with liver fibrosis induced by carbon tetrachloride (CCl_4). Their study verified the significant anti-fibrotic effect of the extract. **[38]**

Activity against oxidation

a) In 2012, Fatema Nasrin et al. investigated the antioxidant properties of methanolic extracts obtained from Lagerstroemia leaves and barks. Their research revealed noteworthy antioxidant activity in both extracts. **[18]**

b) Syed Junaid et al. in 2013 investigated the antioxidant properties of methanol extract obtained from dried seeds of Lagerstroemia speciosa. Their findings revealed a significant antioxidant activity in the dried seed extract. **[39]**

c) Pavithra G.M. et al., also in 2013, examined the antioxidant activity of methanol extract derived from the flowers of Lagerstroemia speciosa using the DPPH radical scavenging assay. They observed notable antioxidant activity in the flower extracts. **[40]**

d) In 2011, Saumya S.M. et al. evaluated the antioxidant activity of aqueous leaf extract from banaba extract through various assays including TEAC assay and scavenging activities against superoxide, hydroxyl, hydrogen peroxide, and nitric oxide radicals. Their research demonstrated potential antioxidant activity in the banaba leaf extract. **[41]**

Activity against arthritis

a) The anti-arthritic activity of essential oils was assessed using the inhibition of albumin denaturation method. A reaction mixture of 5 ml was prepared, comprising 0.2 ml of egg albumin, 2.8 ml of phosphate-buffered saline (pH 6.4), and 2 ml of various concentrations of essential oils (50, 100, 200, 400, and 800 μg/ml). Buffer and albumin served as controls. The reaction mixture was then incubated at 37°C for 15 minutes followed by 70°C for 5 minutes. After cooling to

room temperature, absorbance was measured at 660 nm using a UV-Visible Spectrophotometer (HITACHI). Diclofenac sodium was used as the reference drug (Shinde, UA 1999). The percentage inhibition of different concentrations of essential oils and the standard drug were calculated using the formula: % inhibition = (A0 – A1 / A0) × 100, where A0 represents the absorbance of the control, and A1 represents the absorbance of the test or standard.**[42]**

Conclusion

In conclusion, Lagerstroemia speciosa, or banaba, exhibits a range of pharmacological properties that make it a promising candidate for medicinal use. The plant contains bioactive compounds such as corosolic acid, which have shown potential in managing blood glucose levels, suggesting a role in diabetes management. Furthermore, banaba extracts display antioxidant, anti-inflammatory,Activity against arthritis, Activity against fibrosis, Inhibition of xanthine oxidase, Activity against microorganisms,Activity against pain perception, Activity against cell toxicity, Activity against obesity, Activity against viruses,and hypolipidemic effects, indicating potential benefits for cardiovascular health. Additionally, its antimicrobial and wound-healing properties suggest broader therapeutic applications. While further clinical studies are necessary to validate these findings and explore the full extent of its medicinal potential, Lagerstroemia speciosa stands out as a valuable natural resource with diverse pharmacological properties that warrant further investigation and consideration in medical research and practice.

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