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PHYTOCHEMISTRY AND MEDICINAL PROPERTIES OF *LAGERSTROEMIA SPECIOSA* (LYTHRACEAE) EXTRACTS: A REVIEW

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ABSTRACT: *Lagerstroemia speciosa*, commonly known as jarul, is one of those precious medicinal herbs of Lythraceae that are still included in un-utilized herbs in spite of the variety of useful pharmacological properties it possesses. Extracts of *Lagerstroemia speciosa* have anti-diabetic, hypoglycemic, antioxidant, anti-inflammatory, anti-obesity, xanthine-oxidase inhibitors, antibacterial, antiviral, cytotoxic, anti-fibrotic, antinociceptive, antidiarrhoeal and other activities. Here, we have reviewed all the reported phytochemistry and pharmacological properties of the plant and its phytoconstituents.

Keywords: *Lagerstroemia speciosa*, Phytochemistry, Pharmacological activities, Other activities

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INTRODUCTION: Medicinal plants have been used in virtually all cultures as a source of medicine, and they are also considered as rich resources of ingredients which can be used in drug development and synthesis [1]. These plants are frequently used in traditional medicine to treat different diseases in different areas of the world [2]. It is observed by UNESCO in 1996 that the use of traditional medicine and medicinal plants in most developing countries, as a basis for the maintenance of a good health [3]. *Lagerstroemia speciosa* (Jarul) is a kind of medicinal plant.

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The Lagerstroemia genus belongs to the Lythraceae family, Myrtales order containing more than 50 species [4]. It is originally endemic to south-east Asia, Indian subcontinent and Northern parts of Australia [5]. Banaba is widely distributed in the Philippines, India, and Malaysia. The fruits are subglobose capsule type, and they are 2-3.2 cm long [6]. Banaba extracts possess potent antiobesity effect, without any adverse effect. The extracts are also known to have antioxidant effects and anti-gout [7]. Corosolic acid, an active ingredient in these extracts displays a potential anti-diabetic activity [8 - 12] as well as anti-oxidant, anti-inflammation, and hypertension properties [13].

It is widely cultivated as an ornamental plant in tropical and subtropical areas. It is a small to medium-sized tree growing to 20 m tall, with smooth, flaky bark. The leaves are deciduous, oval to elliptic, 8-15 cm long and 3-7 cm broad, with an

acute apex. The flowers are produced in erect panicles 20 - 40 cm long, each flower with six white to purple petals 2 - 3.5 cm long. Banaba also has a long history of folkloric medical applications that include blood pressure control, urinary dysfunctions (helps ease urination), controls the cholesterol levels, treatment of diarrhea, facilitates bowel movement, Diabetes and as analgesic [14]. The following is a comprehensive and up-to-date review of the distribution, phytochemistry, and pharmacological properties of *Lagerstroemia speciosa* with an urge of further advancements in the medicinal uses of the herb worldwide.

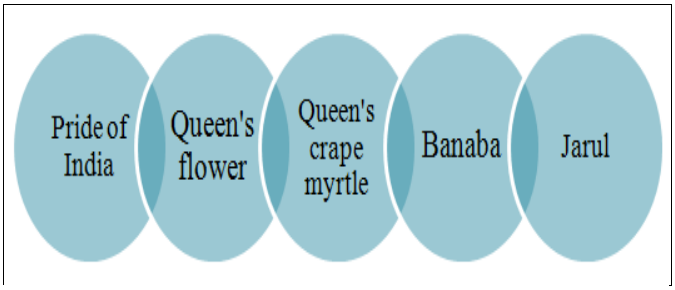


FIG. 1: COMMON NAMES OF *LAGERSTROEMIA SPECIOSA*

Binomial Name: *Lagerstroemia speciosa* L. Pers.

Synonyms: *Adambea glabra* Lam., *Lagerstroemia augusta* Wall, *Lagerstroemia macrocarpa* Wall, *Lagerstroemia flos-reginae* Retz., *Lagerstroemia major* Retz., *Lagerstroemia minor* Retz., *Lagerstroemia munchausia* Willd, *Lagerstroemia plicifolia* Stokes, *Lagerstroemia reginae* Roxb., *Munchausia speciosa* L., *Adambea hirsute* Lam., *Lagerstroemia hirsute* (Lam.) Willd.

Botanical Description: *Lagerstroemia speciosa* is a small to medium-sized tree growing to 20 m tall, with smooth, flaky bark. The leaves are deciduous, oval to elliptic, 8 - 15 cm long and 3 - 7 cm broad, with an acute apex.

The flowers are lilac in color. They are produced in erect panicles 20 - 40 cm long, each flower with six white to purple petals 2 - 3.5 cm long. These flowers are used as traditional medicine by practitioners for many purposes and are found almost in every place in the world.

FIG. 2: LEAVES AND FLOWER OF *L. SPECIOSA*

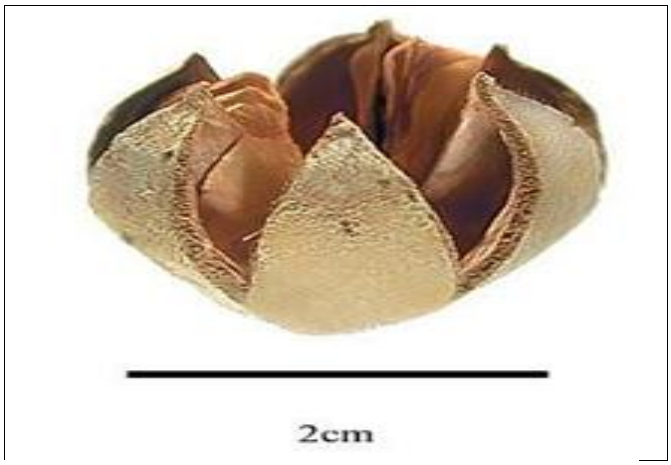


FIG. 3: FRUIT OF *LAGERSTROEMIA SPECIOSA*

Scientific Classification:

Kingdom: Plantae
Subphylum: Euphyllophytina
Infraphylum: Radiatopses
Subclass: Magnoliidae
Superorder: Rosanae
Order: Myrtales
Suborder: Lythraceae
Family: Lythraceae
Tribe: Lagerstroemia
Genus: *Lagerstroemia*
Species: *L. speciosa*

Phytochemical Constituents: Various impressive works have just been done so far to distinguish and disengage the concoction constituents from various concentrates of *Lagerstroemia speciosa*. *Lagerstroemia speciosa* leaves and fruits include ellagitannins and related compounds. Leaf extract contains alanine, isoleucine alpha-aminobutyric acid, and methoeonine. By using bioassay-directed separation process, seven ellagitannins, Lagerstroemia, flosin B, stachyurin, casuarinin, casuariin, epipunicacortein A, and 2, 3-(S)-hexahydroxydiphenoyl-α/β-d-glucose, alongside one ellagic acid sulfate, 3-O-methyl-ellagic acid 4′-

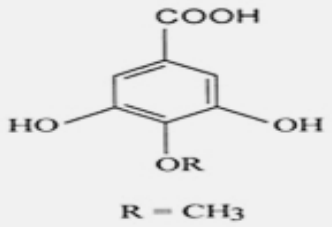
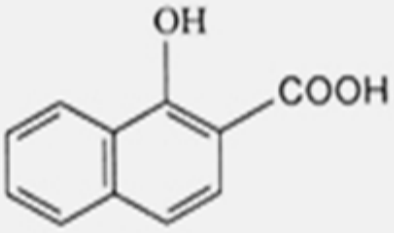
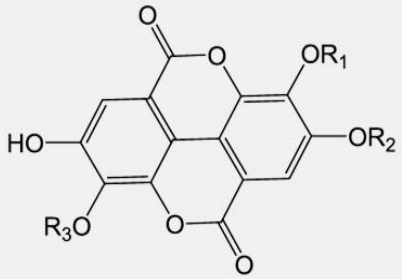
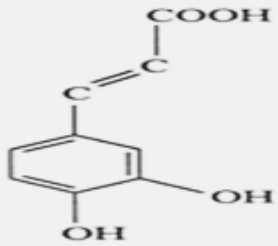
sulfate, ellagic acid, and four methyl ellagic acid derivatives, 3-O-methylellagic acid, 3,3′-di-O-methylellagic acid, 3,4,3′-tri-O-methylellagic acid, and 3, 4, 8, 9, 10-pentahydroxydibenzo[b,d]pyran-6-one were discovered.

According to, one- and two-dimensional NMR and high-resolution mass spectroscopy, the chemical structures of all these constituents were designed. Apart from all these, there are some other known compounds, counting ascorosolic acid, gallic acid, 4-hydroxybenzoic acid, 3-O-methylprotocatechuic acid, caffeic acid, p-coumaric acid, kaempferol, quercetin, and isoquercitrin, were also reported from the plant. Ellagitannins demonstrated strong activities in both reviving insulin-like glucose uptake and hindering adipocyte differentiation in 3T3-L1 cells.

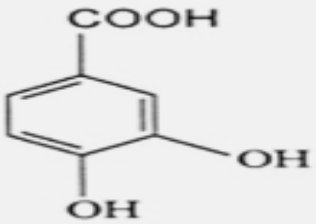
For the moment, ellagic acid derivatives pointed up an inhibitory effect on glucose transport assay. This examination was the first to report an inhibitory impact for methyl ellagic acid subordinates [15]. All parts of the plant, especially old leaves and ripe fruits, contain hypoglycaemic standards having action identical to 6-7.7 units of insulin [16].

Moreover, from leaves of *L. speciosa*, another triterpenoid was isolated along with four known mixes of virgatic acid, corosolicacid, ursolic acid and β-sitosterol glucoside [17]. Pentacyclic triterpenes that areoleanolic acid, arjunolic acid, asiatic acid, maslinic acid, corosolic acid and 2, 3-hydroxyursolic acid were reported from *L. speciosa* leaves [18].

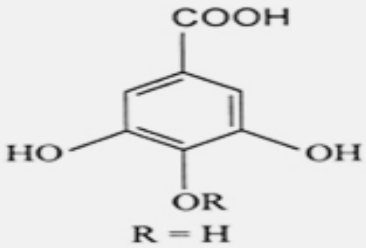
TABLE 1: STRUCTURES OF SOME PHYTOCONSTITUENTS ISOLATED FROM *L. SPECIOSA* [15, 17, 18]

Name of the constituents	Chemical Structure
4- O-methylgallic acid	 $R = CH_3$
1-hydroxy-2-naphthoic acid	
Ellagic acid $R_1 = H, R_2 = H, R_3 = H$ (ellagic acid) $R_1 = CH_3, R_2 = H, R_3 = H$ (3-*O*-methyl ellagic acid) $R_1 = CH_3, R_2 = H, R_3 = CH_3$ (3,3'-di-*O*-methyl ellagic acid) $R_1 = CH_3, R_2 = CH_3, R_3 = CH_3$ (3,3',4-tri-*O*-methyl	
Caffeic acid	

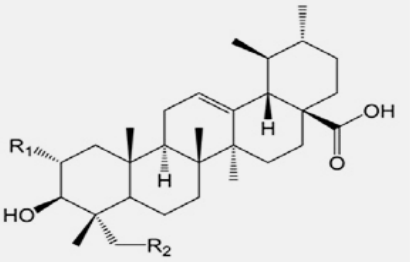
Protocatechuic acid



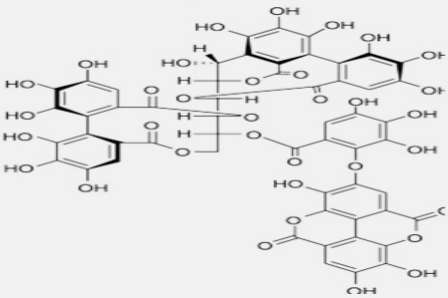
Gallic acid



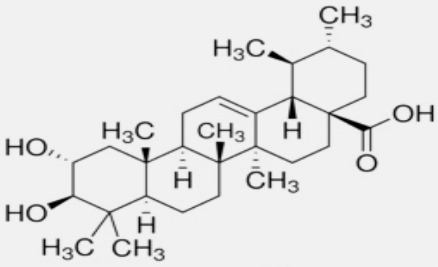
Triterpenes
R_1 = H, R_2 = H (ursolic acid)
R_1 = OH, R_2 = H (corosolic acid)
R_1 = OH, R_2 = OH (asiatic acid)



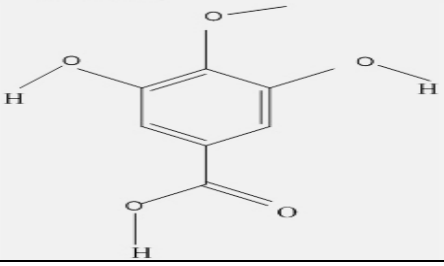
Lagerstroemia



Corosolic acid



4-0 methyl gallic acid



Pharmacological Properties:

Anti-Diabetic Activity: One of the major activities of *Lagerstroemia speciosa*, scientists found is the anti-diabetic property. Diabetes and kidney diseases are often related and the leaves of *Lagerstroemia speciosa* (Lythraceae), have been generally devoured in a different level of treatment of these two diseases. In the 1990s, the prevalence of herbal medicinal therapy started to draw the consideration of researchers around the world.

From that point forward, specialists have directed various *in-vitro* and *in-vivo* experiments that reliably affirmed the anti-diabetic movement of Banaba. Researchers have distinguished distinctive parts of banaba to be in charge of its property.

In a study, researchers took tumor cells as a cell model where the impact of plants was observed, and to do this; methanol extract was collected from the Banaba plant. After that, the corosolic acid was taken from the methanol extract of banaba and appeared to be a dynamic compound against tumor cells. All the more as of late, some other compounds are detected by focusing on water-soluble fractional parts of the exuded liquor. Ellagitannin Lagerstroemin was found to be actively impactful for the activity.

In a different approach, where the selected cell model was 3T3-L1 adipocytes, an insulin-like glucose transport inducing activity was found. Scientists made banaba water extract responsible for the effect. Also, in this research, glucose uptake assay was used as a functional screening method. Again, when HPLC technique was merged with glucose uptake assay, another compound was discovered showing the similar activity not as corrosive acid; named gallotannin. Among all the gallotannin, Penta-O-galloyl-glucopyranose (PGG) was the most significant one. Furthermore, in a compare-contrast overview, PGG results were judged against previously published data.

In this juxtapose analysis; it is found that PGG shows essentially higher glucose transport stimulatory action than Lagerstroemia. Moreover; adipogenesis, the process of fat tissue formation gets disturbed due to the anti-adipogenic action of PGG; in turn, this phenomenon tremendously results in stimulation of glucose uptake in fat cells known as adipocytes [19]. The combination activity of glucose uptake and anti-adipogenesis can improve existed treatment method and in the future, can contribute to effective drug prescription through its great deals of potential therapeutic activities. It is a rare finding and is not seen in any current insulin mimetic drug [20, 21].

Hypoglycemic Activity: The plant *Lagerstroemia speciosa* has demonstrated hypoglycemic activity in different assessments around the globe. Hot water extract showed better impact. In a study, the artificially diabetic condition was created in sample rats by using streptozotocin and was treated with a hot extract of the plant's leaf. The study result showed the tremendous effect of the hot extract on blood sugar level. It suppressed the diabetic condition by decreasing the blood sugar level up to 43.20%. In diabetic condition, glucose- 6-phosphate dehydrogenase gets decreased which in return causes the decline of NADPH amount and subsequently makes cells susceptible to oxidant damage, and thus kidney damage possibility also gets increased [6, 9, 10].

Here, Hot water extract elevates the activeness of shunt enzyme glucose-6-phosphate dehydrogenase (33.81%) and glutathione level (31.25%) and as well as decreases the activity of hepatic gluconeogenic enzymes glucose-6-phosphatase (31.63%) and fructose-1, 6-bisphosphatase (27.40%). Therefore, this study ascribed that hot water extract of *L. speciosa* leaves have a hypoglycemic effect. Being a hot topic of present concern, diabetes and hypoglycemia were always on experimentation. Hence, conducting tests on Banaba's antidiabetic or hypoglycemic activity are huge and frequent. All of these have confirmed these properties of Banaba [22-29].

Free Radical Scavenging: *Lagerstroemia speciosa* L. plant extricate have antioxidant property. It can be useful in forestalling or abating the progress of different oxidative anxiety related to ailments [30]. In an *in vitro* study, a manifestation of free radical scavenging activity of Banaba leaf was seen. This experimentation was conducted with some prominent constituents of Banana leaf extract such as ethyl acetate, ethanol, methanol, and water. Their superoxide, hydroxyl ion scavenging, and lipid peroxidation tests were examined. Among all these, ethyl acetate and ethanol extort showed up drastic antioxidant property than the rest of the two[31].

Anti-Inflammatory Properties: In case of healing the inflammatory condition, *Lagerstroemia speciosa* plays an important role. In an investigation, it is found that it reduces one of the signs of inflammation. To further illustrate, ethyl acetate and ethanol extracts were collected from the plant, which is also known as Banaba in

Phillippines. In paw edema models, inflammation was induced. To create acute and chronic inflammation, carrageenan, and formalin were used, respectively. In this dose-dependent mannered models, ethyl acetate and ethanol liquor notably decreased paw edema [31].

Anti-Obesity Effect: In 1999, a study was conducted by Kakuda's research group to find out the anti-obesity activity of *Lagerstroemia speciosa*. This experiment was run on some female obese KK-Ay/TaJcl mice. They were fed with 5% banaba water contained food, and control group mice were kept in their regular diet. Here, none of them showed a change in their food intake habit. As a final point, the result showed 10% body weight reduction in the treated group. This plant extract also brought significant changes in lipid profile of every treated mouse's liver. Liver triglyceride level was reduced to 40% in the treated group. The amount of parametrial adipose tissue was reduced to 10% ($P<0.01$) [20].

Xanthine Oxidase Inhibitors: Enzyme always plays a pivotal role in any biological aspect. Xanthine oxidase (XOD) is nothing different in terms of bountiful significant contribution in hyperuricemia, catalyzing the oxidation of hypoxanthine to xanthine and then to uric acid. The plant *Lagerstroemia speciosa* (Linn.) Pers. (Lythraceae), is acknowledged as folk medicine in the Philippines. In a research attempt, bioassay-guided fractionation technique was run where the main objective was to discover the XOD inhibitors from the leaf of this plant.

To do this, two active compounds were collected from the plant's aqueous extract. These compounds are valoneic acid dilactone (VAD) and ellagic acid (EA) among what in a non-competition enzyme substrate (xanthine) binding, VAD showed more well-built effect than a clinical drug called allopurinol. As a result, these outcomes may clarify and bolster the idea of dietary utilization of the aqueous extracts from *Lagerstroemia speciosa* leaves to treat hyperuricemia [7].

Antibacterial Activity: To justify the buzz that *L. species has* potential antibacterial activity, the extracts from the leaf were collected and were vigilantly investigated against *Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa* and *Escherichia coli* where ampicillin was used as a standard. Zone of inhibition, the parameter to understand growth or bactericidal condition was studied. This study revealed that water extract is more efficient than ethanol extract. The inhibitory viability of methanol concentrate of *L. speciosa* leaves was tried against 12 oral isolates of *Streptococcus mutans* utilizing the agar well diffusion technique [32]. The outcome of the test showed noteworthy effects in opposition to cariogenic isolates.

In addition, the measurements of the obtained zone of inhibitions are ranging from 0.0-0.9 cm, 0.8-2.1 cm and 1.0-2.6 cm for extract concentrations of 10, 25 and 50 mg/ml respectively. In another article, it is also found that the flower of *L. speciosa* plant even holds antibacterial characteristics [33]. In that prospect, firstly, they collected methanol extract from the flower. Then they experimented against *S. mutans* and *S. aureus* again using agar well diffusion assay [33]. Here, At 100 µl per well and 20 mg/ml concentration, the liquor repressed the microbes with zones of inhibition going from 1.8-2.5 cm and 2.3-2.8 cm, individually.

Antiviral Activity: To study the antiviral activity of *L. speciosa*, anti-human rhinovirus (HRV) activity was investigated in HeLa cells. To do this, orobol 7-O-D-glucoside (O7G) was isolated from *L. speciosa* leaves. It showed broad-spectrum anti-HRV activity towards HRV of groups A and B [34]. As the outcome of the test, the level of inhibitory concentration (IC_{50}) of O7G came out 0.58-8.80 µg/ml and the cytotoxic concentration (CC_{50}) was more than 100 µg/ml. The compound has awe-inspiring possibilities to be produced into as a weapon against human rhinovirus.

Cytotoxic Activity: To evaluate the cytotoxic activity, a study was conducted where pure brine shrimp (*Artemia salina*) was used as a sample. The lethality bioassay and the ethanol fruit extract of *L. speciosa* gave the evidence of prominent cytotoxic activity [35]. Lethal concentration for LC_{50} and LC_{90} were 60 µg/ml and 100 µg/ml, respectively.

Anti-fibrotic Activity: In scientific research, the anti-fibrotic impact of *L. speciosa* was studied. To conduct the research, the livers of male albino

Wistar rats were put in fibrosis condition. Interestingly, here, fibrosis was induced by using carbon tetrachloride (CCl_4) [36]. Initiation period of this fibrosis was twice week by week; every time through repeated overture of CCl_4 at a dose of 1 ml/kg body weight, blended with an equivalent volume of corn oil.

The degree of liver fibrosis was evaluated by the amount of hydroxyl proline in the liver, aspartate transaminase, alanine transaminase, antacid phosphatase and bilirubin in the serum, and by histological changes investigations. Administering the extorted liquor of the plant; orally at a concentration of 100 mg/kg body weight, the exceeded abnormal level of the hydroxyl proline content in the liver, serum enzyme levels, and total bilirubin were deduced. Significant improvisation in the unhinged livers was observed. This affirms its intense antagonistic characteristic to fibrotic impact.

Antinociceptive Activity: In various studies, *Lagerstroemia speciosa* showed antinociceptive or pain relieving effect [36]. In a study; two doses of crude chloroform which were extricated from *Lagerstroemia speciosa* plant leaves were ingested in acetic acid-induced pain in mice model. This chloroform bark extract reduced the number of writhing in mice when it was given at a dose of 250 mg/kg body weight keeping the control to compare. When the dose was increased to 500 mg/kg body weight, the frequency of writhing was reduced to 50.7%. This second level of dose showed the equivalent result to the hindrance seen in standard anti-nociceptive medication, aspirin [37].

Anti-diarrheal Activity: In a study, the anti-diarrheal activity of Banaba was tested. To conduct the study, the diarrheal condition was created using castor oil in young Swiss-albino mice sample. Treating with ethanol extract from the plant fruit extract, consequences were observed. It resulted in 2 hours of delay in the treated group at a dose of 500 mg/kg body weight. Besides, it also reduced the frequency of defecation. Moreover, effect after 50 mg/kg body weight dose was compared to standard drug loperamide [34, 19].

Others Activity: Different substances in little amount were cited as phytol, (Z)- 9-octa-decenamide (oleamide), squalene, n-hexadecanoic Acid, linolenic corrosive, octacosane, tetra-triacontane, and α-tocopherol, a large portion of which are helpful in people; For illustrations, oleamide is a defensive operator against scopolamine induced memory misfortune and is recommended as valuable as a chemopreventive specialist against Alzheimer's ailment and it actuates profound rest and the upregulation of hunger. Squalene is a triterpene essential forever.

In the human body, it is a characteristic and fundamental part utilized for the production of cholesterol, steroid hormones, and Vitamin D. It might likewise be an anticancer substance, as it has chemopreventive action. Phytol is diterpene liquor that can be utilized as an antecedent for making of manufactured types of vitamin E and vitamin K_1. Its hexadecanoic acid or palmitic acid and linolenic acid are sorts of unsaturated fats. Octacosane is an alkane and has been utilized as an ointment. Even it has been used as transformer oil, and anticorrosion operator; parts of the paraffin [38].

CONCLUSION: *Lagerstroemia speciosa* is one of the most near reaching types of the plant right now, which has vast uses in traditional medication. In this regard, pharmacognostical and pharmacological concern on the plant is on significant advances. It additionally requires further developed investigations to assess synthetic, pharmaceutical, and pharmacological explores to build up the medication more institutionalized. This review study reveals the pharmacological properties reported join antioxidant, anti-diabetic, anti-bacterial, antiviral, anti-inflammatory, anti-nociceptive, anti-diarrhoeal, cytotoxic, xanthine oxidase deterrent, antagonistic to fat and against fibrotic works out.

This literature review has also brought a major point into light that clinical studies in human are still not available that may provide evidence of the efficacy of the plant in human. Besides, further study on other parts of *Lagerstroemia speciosa* plant should also be done to unveil its unrevealed latent essential properties that may contribute to drug development.

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CONFLICT OF INTEREST: Nil

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