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Phytochemical constituents and pharmacological activities of *Lagerstroemia floribunda* Jack. (Kedah bungor): A Review

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ABSTRACT

This is the first report on review of *Lagerstroemia* species which includes the detailed description on phytochemistry and its pharmacological research. Despite being rich in important phytochemicals and having possible medicinal value there is no enough information available on this plant. *Lagerstroemia floribunda* Jack also known as Thai crape myrtle and kedah bungor, is a species of flowering plant in the Lythraceae family. This delightful ornamental plant is native to subtropical and tropical South-East Asia, from southern China to Myanmar, Thailand, Cambodia, Indo-China and Peninsular Malaysia. The phytoconstituents of *Lagerstroemia floribunda* includes 23-hydroxyursolic acid, alphitolic acid, ursolic acid, dihydro-β-cyclopyrethrosin, sesamin, β-sitosterol, clauslactone-K, betulinic acid, lingueresinol, ent-isolariciresinol. Some of the researches that are being carried out on this plant include total phenolic contents and antioxidative activity of its flowers. This review will help to provide detailed information on recent researches done on this plant.

INTRODUCTION

Despite this scientific era, herbal medicine still plays an important role as an alternative medicine, without much scientific method based evidence backed up. Unlike the modern medicine - which stand on a very stiff foundation of evidence-tested pharmaceutical drugs and laboratory-tested data, in utter vice versa, herbal medicines extended its scope including fungal, bee products, minerals, shells and animal parts as well. In terms of nations, it also shows its glow in Europe. Example, in Germany, herbal medications are dispensed by apothecaries (e.g.: Apotheke). The prescribed drugs are sold alongside with essential oils, herbal extracts, or herbal teas. Some avid herbal medicine lovers, even fond of utilizing this alternative drug as their medication of choice in their daily lives far more extent compared with modern medications. Whereas in India (well-known with its herbal medication tradition), herbal remedy is so taken spotlight that distinct department has been officially set up by its government – AYUSH Ministry, due to its overwhelming demand by its people (Herbalism, 2015).

Most of the plants around us possess therapeutic properties and has been utilized by human beings in treating arrays of diseases since time immemorial, devoid of the basic knowledge of the scientific mechanism and action physiologically. Thus, similar to the much explored plants with medical purposes, *Lagerstroemia floribunda*, equally possess the hidden therapeutic action in curbing several of diseases and health related symptoms.

Lagerstroemia floribunda, also known as Thai crape myrtle and kedah bungor, is a species of flowering plant in the Lythraceae family (Figure 1). This delightful ornamental plant is native to subtropical and tropical South-East Asia, from southern China to Myanmar, Thailand, Cambodia, Indo-China and Peninsular Malaysia. It's the provincial tree of Saraburi Province in Thailand.

Reaching a height of 15mn, this tree is famous for its showy and long lasting flowers. The crown has a spreading, round

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Fig. 1: Parts of *Lagerstroemia floribunda.*

form held on sinewy, fluted stems and branches with a mottled appearance that arises from having bark that is grey or grayish-brown shedding throughout the year. The leaves are simple, opposite or nearly-opposite, elliptic-lanceshaped, with a pointed or long pointed tip. Having smooth surface and densely brownish hairy beneath.

Flowers are borne in large panicles at the end of branches. They are small, pink-purple, fading to white. Fruit is an elliptic capsule with many oblong, winged and small seeds. Its flowering period falls between May-August, about 4 months in duration, which would color up the surrounding with its spectrum of hues.

Seeds sown into well-drained, sandy compost at any time of the year, and covered thinly with sand or grit and kept moist. Its optimum temperature is between 20-25°C. Germination is within 4 to 6 weeks although some varieties may take very much longer. Planted out in the open ground in the tropics or in a large container elsewhere, the seeds are urged to be kept at minimum 15°C (Plant E-Database, 2015, Anonyms, 2015).

Taxonomical Classification (GBIF, 2015)

Kingdom Plantae – plantes, Planta, Vegetal, plants
Subkingdom-Viridaeplantae – green plants
Division Tracheophyta – vascular plants, tracheophytes
Class- Magnoliopsida
Order- Myrtales
Family- Lythraceae – loosestrife
Genus- Lagerstroemia L.
Species - *floribunda*

Morphology

Stems: terete, subalate, glabrous, puberulous, pubescent, tomentose
Leaves: subopposite, subalternate, alternate, subsessile or petiolate
Flowers: actinomorphic, campanulate to turbinate, flexibly 5-7-merous
Floral tube: leathery, with broad to narrow ribs or ridges
Sepals: deltate (narrowly to broadly), sometimes subtended
Petals: 6 (-12), rose, purple, or white, crinkled, slenderly clawed
Stamens: dimorphic, monomorphic (rare)
Filaments: thin, subequal
Style: long-exserted
Stigma: capitate
Ovary: globose to oblong, 3-6-loculed
Fruit: dry, indurate capsules, loculicidally dehiscent, 3-6-valved
Seeds: numerous, obpyramidal, unilaterally winged from raphe
Cotyledons: rolled
Height: 5.0 - 25.0 meters
Cultivation: Ornamental, Wild

Lagerstroemia floribunda is a tree, which usually grows up to 25 metres in height. The bole is usually crooked, and can be free of branches for more than half of its height. It often branches from low down; it can be 60 cm in diameter, often fluted and sometimes with small buttresses.

Having attractive wood textures, the tree is often harvested from the wild for this very reason. The wood is used locally and also traded for quite a fortune. It is ordinarily grown as an ornamental in parks and gardens, wherein the multihued of its flowers would color up the surrounding (Anonyms, 2016).

Phytochemical Constituents of Lagerstroemia Species

In *Lagerstroemia floribunda*, there were ten constituents found. These ten constituents were isolated and their structures were identified as 23-hydroxyursolic acid (1), alphitolic acid (2), ursolic acid (3), dihydro-β-cyclopyrethrosin (4), sesamin (5), β -sitosterol (6), clauslactone-K (7), betulinic acid (8), linguerisinol (9), ent-isolariciresinol (10) respectively.

Besides, sugars and proteins can also be found in a lesser concentration in the leaves of *Lagerstroemia speciosa*. Secondary metabolites that present were anthraquinone glycosides, flavonoids, and saponins.

Six new monomeric and dimeric ellagitannins (flosin A and B, and reginin A, B, C and D), and three new ellagitannins (lagerstannins A, B and C) from the aqueous acetone leaf extract of *Lagerstroemia speciosa* has been isolated and identified.

Lagerstroemia speciosa leaves were extracted with aqueous acetone, causing the isolation of seven ellagitannins, ellagic acid, ellagic acid sulphate and four methyl ellagic acid derivatives, including corosolic acid, gallic acid, 4-hydroxybenzoic acid, 3- O-methyl protocatechuic acid, caffeic acid, p-coumaric acid, kaempferol, quercetin and isoquercitrin.

It was found that the red leaves contained more corosolic acid than the green leaves and other plant parts such as petals, roots and seeds are obtained by assessment done on corosolic acid content in *L. speciosa*. It was due to cyanidin 3-O glucoside, identified in the species for the first time. The contents of corosolic acid and cyanidin 3-O-glucoside was determined scientifically having a sizeable correlation.

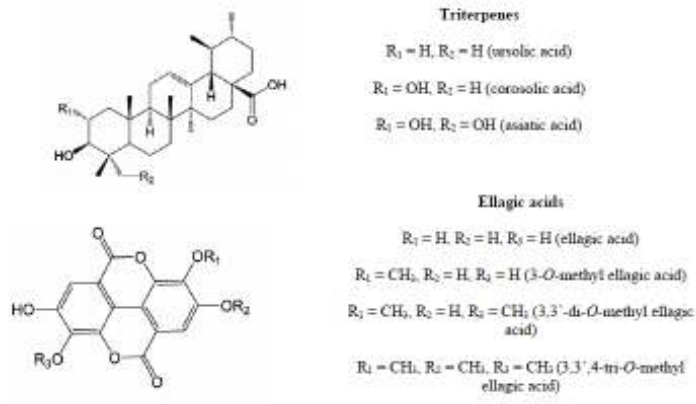

Fig. 2: Triterpenes and ellagic acids (isolated from leaves of *Lagerstroemia speciosa*).

To date, more than 40 compounds including triterpenes, tannins, ellagic acids, glycosides and flavones have been identified scientifically from the leaves of *L. speciosa*. Recent studies reported four triterpenes (ursolic acid, corosolic acid, asiatic acid and alphitolic acid), eight ellagic acids, one coumarin and one neolignan (Figure 2). Out of the 14 compounds identified, four are new to the genus and family, and one new to the species (Chan et al., 2014; Laruan et al., 2013; Woratouch et al., 2011; Niranjan et al., 2010; Rahman et al., 2011; Lou Xu, 2004).

Traditional Uses

Stomach Problems: The roots are used to treat stomach problems.

Weight Loss: Tea of the leaves is used against diabetes mellitus and for weight loss. The tea is therapeutic against ailments such as diabetes, kidney- and urinary problems. The taste is pleasant and smooth; in Japan it is known as "slimming tea."

Lower Blood Sugar: The leaves are able to lower blood sugar. It helps the body handling glucose and is as such also effective in weight loss and against obesity. The hypoglycemic (blood sugar lowering) effect is similar to that of insulin (which induces glucose transport from the blood into body cells) (*Lagerstroemia Speciosa*).

Pharmacological Uses

Total phenolic contents and antioxidative activity

The results of this study indicated that ethanolic extract of *L. floribunda* and *L. speciosa* have high inhibitory effect on MMP-2 and MMP-9 with high antioxidative activity. Therefore, these Thai flowers may be good sources for natural antioxidant products for anti-aging agent (Kolakul et al., 2013).

Antibacterial activity

It has been proven that the leaves of *Lagerstroemia speciosa* is having antibacterial activity. The leaves extracts were tested with *Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa and Escherichia coli*, and ampicillin being the standard. According to zone of inhibition, the water extract appears to be more efficacious than the ethanol extract (Ambujakshi et al., 2009).

Meanwhile, its flowers inevitably, been reported to exhibit antibacterial activity. By using methanol extract of flowers, it was tested against *S. mutans* and *S. aureus* using the agar well diffusion assay. The flower extract at 100 µl per well and 20 mg/ml concentration gives zones of inhibition ranging from 1.8−2.5 cm and 2.3−2.8 cm, respectively (Pavithra et al., 2013).

Antiviral activity

Anti-human rhinovirus (HRV) activity has been tested in HeLa cells. O robol 7-O-D glucoside (O7G) isolated from *Lagerstroemia speciosa* leaves showed broad-spectrum anti-HRV activity towards HRV of groups A and B.

It was found that, the inhibitory concentration (IC50) of O7G ranged from 0.58−8.80 µg/ml and the cytotoxic concentration (CC50) was more than 100 µg/ml. The very compound possesses great potentials to be developed into a potent anti-human rhinovirus agent (Choi et al., 2010).

Anti-inflammatory activity

By using the carrageenan-induced acute inflammation and formalin-induced chronic paw oedema assays, the anti-inflammatory activity of ethyl acetate and ethanol leaf extracts of *Lagerstroemia speciosa* had been examined.

Both the acute and chronic inflammatory models, the ethyl acetate extract enormously alleviated inflammation in a dose-dependent manner, which was not speculated in the ethanol extract (Priya et al., 2008).

Anti-Gout activity

Lagerstroemia speciosa is having the function against gout (metabolic arthritis) since its leaves contain Valoneic Acid Dilactone (VAD). This acts as an inhibitor of xanthine oxidase to lower uric acid levels.

The action of VAD is stronger than Allopurinol (brand names: Aloprim®, Zyloprim®) and is without the side effects commonly associated with this drug (Chan EWC et al., 2014).

Anti-diarrhoeal activity

With castor oil-induced diarrhea, the anti-diarrhoeal activity test was run on young swiss-albino mice. The test reflected a delay of the diarrhoea from one to two hours, in the usage of ethanol fruit extract of *Lagerstroemia speciosa* at 500 mg/kg body weight.

The anti-diarrhoeal activity was similarly competent to the standard drug of loperamide at 50 mg/kg of body weight with latent period of two hours. At 500 mg/kg body weight, the extract shown a drop in frequency of defecation (Rahman et al., 2011).

Cytotoxic activity

Prominent cytotoxic activity has been exhibited through the brine shrimp (*Artemia salina*) lethality bioassay, using ethanol fruit extract of *Lagerstroemia speciosa*. Lethal concentration (LC50) was 60 µg/ml and LC90 was 100 µg/ml (Rahman et al., 2011).

Anti-obesity activity

It has been observed that significant reduction of body weight and parametrial adipose tissue weight in obese female KK-AY mice when fed with a hot water *Lagerstroemia speciosa* leaf extract.

Blood glucose levels and serum lipids were relatively similar between the control diet and test diet groups, however, the triglyceride content in the liver declined, affirming the anti-obesity activity of *Lagerstroemia speciosa* (Suzuki et al., 1999).

Anti-fibrotic activity

Studies on the effect of ethanol leaf extract of *Lagerstroemia speciosa* on male albino Wistar rats with liver fibrosis induced by carbon tetrachloride (CCl_4) was carried out. Thoroughly mixed with an equal volume of corn oil, liver fibrosis was induced twice weekly by administration of CCl_4 at a dose of 1 ml/kg body weight.

Liver fibrosis extent was assessed by hydroxyproline content in the liver, level of aspartate transaminase, alanine transaminase, alkaline phosphatase and bilirubin in the serum, and by histological studies. The hydroxyproline content in the liver, serum enzyme levels and total bilirubin declined by oral administration of the extract at 100 mg/kg body weight.

The CCl_4-deranged liver showed improvement escorted by administration of the extract, affirming anti-fibrotic effect was of pivotal action (Prabhu et al., 2010).

Xanthine oxidase inhibition

Valoneic acid dilactone, which was extracted from aqueous leaf extract of *Lagerstroemia speciosa*, shown potent inhibitory effect on xanthine oxidase (XOD), bearing potential in preventing and treating hyperuricemia.

Stronger than that of allopurinol, a clinical drug, the inhibitory effect was non-competitive one. XOD is the critical enzyme in hyperuricemia as it catalyses the oxidation of hypoxanthine to xanthine and subsequently uric acid (Chan *et al*., 2014).

Biological Activity of Lagerstroemia Genus

Antidiabetic

Tomonori *et al* used *Lagerstroemia speciosa* **(**Banaba) leaf extracts for various studies involving animal and human studies as well as *in vitro* systems, indicated that the plant exert antidiabetic and antiobesity effects. The corosolic acid as well as ellagitannins is responsible for these effects. Other polycyclic terpene acids such as oleanolic acid and valoneic acid may also contribute to the antihyperglycemic effects. The corosolic acid provides Banaba to exhibit properties that are beneficial in addressing various factors involved in glucose regulation and metabolism, including the enhanced cellular uptake of glucose, improved insulin sensitivity, decreased gluconeogenesis, and inhibited intestinal hydrolysis of sucrose, thereby lowering blood glucose levels. Furthermore, decreased serum cholesterol and triglycerides have been observed in response to corosolic acid.

Based on the studies conducted to date, no adverse effects have been reported in animals using either corosolic acid or standardized Banaba extracts (Tomonori et al., 1997).

Guy *et al* showed that the *Lagerstroemia speciosa* (Banaba) water extract exhibited an insulin-like glucose transport inducing activity. Coupling HPLC fractionation with a glucose uptake assay, gallotannins were identified in the Banaba extract as components responsible for the activity, not corosolic acid. Penta-O-galloyl-glucopyranose (PGG) was identified as the most potent gallotannin. A comparison of published data with results obtained for PGG indicates that PGG has a significantly higher glucose transport stimulatory activity than Lagerstroemin. Chen et al. have also shown that PGG exhibits anti-adipogenic properties in addition to stimulating the glucose uptake in adipocytes. The combination of glucose uptake and anti-adipogenesis activity is not found in the current insulin mimetic drugs and may indicate a great therapeutic potential of PGG (Guy et al., 2007).

Antioxidant

Kranjanasurat and Sripanidkulchai investigate the total phenolic content, antioxidant activity and MMP-2 and -9 inhibitory effects in fibroblast cell of ethanolic extracts from flowers of *Lagerstroemia floribunda* and *Lagerstroemia speciosa*. The extract of *Lagerstroemia floribunda* and *Lagerstroemia speciosa* gave total phenolic content at 418.50±39.69 and 636.74±44.14 mg gallic acid equivalent (GAE)/g of the extracts. They show the high antioxidative activities with IC_{50} values of 4.31±0.10 and 3.89±0.12 µg/ml and FRAP values at 1.21±0.28 and 1.79±0.26 mg Fe^{2+}/mg. Moreover, the flower extracts inhibited MMP-2 and MMP-9 activities 50% inhibition concentrations on MMP-2 and MMP-9 of *Lagerstroemia floribunda* were 953.07 and 771.07 ppm and 634.60 and 548.40 ppm of *Lagerstroemia speciosa*. The results of this study indicated that ethanolic extract of *Lagerstroemia floribunda* and *Lagerstroemia speciosa* have high inhibitory effect on MMP-2 and MMP-9 with high antioxidative activity. Therefore, these Thai flowers may be good sources for natural antioxidant products for anti-aging agent (Kranjanasurat and Sripanidkulchai, 2014).

Antibacterial

Vivek *et al* carried out the study to investigate the anticariogenic activity of methanol extract of *Lagerstroemia speciosa* (L.) (Lythraceae) leaves. The inhibitory efficacy of methanol extract was tested against 12 oral isolates of *Streptococcus mutans* by Agar well diffusion method. The broth cultures of bacteria were swabbed uniformly on sterile Brain heart infusion agar plates and wells of 6 mm were punched in the inoculated plates. Standard antibiotic and different concentrations of extract were transferred into labeled wells. Zone of inhibition was measured after incubation. The extract caused a concentration dependent inhibition of cariogenic isolates. Inhibition caused by standard antibiotic was higher than the methanol extract. Preliminary phytochemical analysis showed the presence of saponins, glycosides, tannins and terpenoids. The result of the present study reveals that methanol extract showed significant inhibitory activity against cariogenic isolates. The inhibitory efficacy of extract against cariogenic isolates could be due to the presence of these metabolites. In suitable form, the leaves could be used to treat dental caries (Vivek et al., 2012).

Antiviral

Choi et al tested anti-HRV activity of O7G using a cytopathic effect (CPE) reduction method, which exhibited broad-spectrum anti-HRVs activity with a 50% inhibitory concentration (IC50) ranging from 0·58 to 8·80 µg ml−1. The 50% cytotoxicity concentration (CC50) of O7G is more than 100 µg ml−1, and the derived therapeutic indices are more than 12. Ribavirin didn't possess antiviral activity against HRV15, HRV3 and HRV5, but exhibited weak antiviral activity against HRV2 and HRV3, and showed strong anti-HRV6 and -14 activities (Choi et al., 2010).

Anti-inflammatory activity

Priya *et al* conducted the *in vitro* antioxidant activity of the successive extracts (ethyl acetate, ethanol, methanol and water) of the leaves of *Lagerstroemia speciosa* L. (Lythraceae) by examining their superoxide, hydroxyl ion scavenging and by measuring lipid peroxidation. The ethyl acetate and ethanol extracts were found to possess greater antioxidant property than the methanol and water extracts. Anti-inflammatory activity of the ethyl acetate and ethanol extracts were examined using the carrageenan-induced acute inflammation and formalin-induced (chronic) paw edema models. In acute and chronic inflammation models, the ethyl acetate extract reduced the paw edema significantly in a dose-dependent manner. Whereas, ethanol extract did not show dose-dependent activity. This result suggests that the anti-inflammatory activity is possibly attributed to its free radical scavenging activity. It was found that ethyl acetate extract reduced the inflammation more significantly than the ethanol extract (Priya et al., 2008).

CONCLUSION

Lagerstroemia floribunda, equally possess the hidden therapeutic action in curbing several of diseases and health related symptoms. It is ordinarily grown as an ornamental in parks and gardens, wherein the multihues of its flowers would color up the surrounding. *Lagerstroemia floribunda* basically consists of carbohydrates and phenolic compounds. The trees bear fruits which prevalently rich in carbohydrate. Since the fruits contain high ratio of seed portion, thus, it does not favoured by animal and human as staple or edible fruit. Yet, the phenolic compounds incorporated within, may contain vast varieties of medical purposes.

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