A Systematic review on Banaba

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Abstract:
Lagerstroemia speciosa is commonly known as "Pride of India" belonging to the Lythraceae family. *Lagerstroemia speciosa* or Banaba is a medicinal tree traditionally used to lower blood sugar in the body. Its high content of corosolic acid makes it an effective anti - diabetic drug. Banaba is also recommended for kidney, bladder problems and hypertension. Leaves of the species have been traditionally used over thousands of years as folkloric treatment by the native Indians and Americans for illness, ailments particularly for lowering blood sugar levels and weight loss. The flower extracts of the species has some pharmacological properties like antioxidant and anti- microbial activities, whereas fruit extracts reported anti-nociceptive, anti-diarrhoea and cytotoxic activities. Research on leaf extracts reveals that anti-bacterial, anti-viral, anti-inflammatory, anti-obesity, anti-fibrotic, anti-diabetic, xanthine oxidase inhibition, diuretic, decongestant activities and roots are applied for treating mouth ulcers. In addition to that bark is used to relieve the abdominal pains. The species also has essential metals like sodium, potassium, iron, zinc and magnesium which were clinically proved. This review article is focused on pharmacognostical, phytochemical and pharmacological parameters of banaba leaves.
Key words: *Lagerstroemia speciose* leaves, phytochemical, pharmacological parameters.

Introduction

The family Lythraceae [1] consists of about 24 genera and nearly 500 species wide spread in the temperature regions. In India it is represented by 11 genera and about 45 species. This data shows that *Lagerstroemia speciosa* is spread all over the world. *Lagerstroemia speciosa* is belongs to the family Lythraceae. The genus Lagerstroemia was first described by Carlos Linnaeus. Indians commonly called it as "Pride of India" and also called as giant crape myrtle[2], queen's crape myrtle and banaba by Philippines. This tree is widely distributed in Philippines, India and Malaysia. Traditionally, leaves, bark and roots of *Lagerstroemia Speciosa* have been used in folk medicines and are remedy for various illness and ailments. Leaves have been used to treat diabetes mellitus [3] and serve as diuretic and decongestant. The red-orange leaves have high levels of corosolic acid that can reduce blood sugar. Its fresh leaves are also used as emergency tincture of wounds and sanitizing the surface of the skin.

Roots are used for treating mouth ulcers and bark is used as stimulant, relief of abdominal pains and febrifuge. Philippines consume the leaves of the *Lagerstroemia Speciosa* as herbal tea for lowering blood sugar level and reducing body weight. Because of its "insulin like principle" is used as a remedy for diabetes. Recently, Glucosol^{TM} and Banabamin herbal products have been developed from *Lagerstroemia Speciosa* as an anti-diabetic drug.

The leaves are arranged opposite, or almost opposite, to one another. They are simple, elliptical, and oblong with entire (not lobed) margins. The leaf blade is 5-10 cm long,and has prominent veins, especially on the dorsal side. Mature leaves are leathery in texture. Jarul flowers are borne in large, erect terminal clusters from late April to June. In some trees flowering extends to July- August. Older flowers occur at the base and younger ones towards the tip. Flowers are up to seven cm wide.

Plant profile[1-9]:

Synonyms:

- *Adambea glabra* .
- *Lagerstroemia augusta*
- *Lagerstroemia flos-reginae*
- *Lagerstroemia macrocarpa*
- *Lagerstroemia major*
- *Lagerstroemia munchausia*
- *Lagerstroemia plicifolia*
- *Lagerstroemia reginae*
- *Munchausia speciose*.

Taxonomical classification:

- Kingdom: Plantae
- Subkingdom: Tracheobinata
- Superdivision: Spermatophyta
- Division: Magnoliophyta
- Class: Magnoliopsida
- Subclass: Rosidae
- Order: Myrtales
- Family: Lythraceae
- Genus: Lagerstroemia L
- Species: *Lagerstroemia speciosa* L

Vernacular names:

- English :- Pride of India, Queen Crape Myrtle
- Bengali :- Jarul
- Hindi :- Jarul
- Marathi :- Tamhan, Jarul, Motha Bondara
- Assamese :- Ajhar
- Telugu :- Banaba

Description:

Lagerstroemia speciosa is a medium-large-sized evergreen tree grows up to 25 m high. The leaves are opposite, leathery, oblong to ovate in shape, glaborus with short petiole, and measures 10-20 cm x 5-7.5 cm. The flowers are in large terminal panicle, regular in shape, varying from pink to purple in color, measure 5.0-7.5 cm wide. The calyx is in green ribbed tube with 6 leathery sepal lobes and 6 lilac purple petals with wavy margins up to 3.5 cm long, attached between the sepals by short claws. The stamens are numerous, with purple filaments and golden yellow anthers. The pistil is simple with a long purple style of up to 5 cm long, a dark green stigma and a superior ovary. The fruit is hard woody, subglobose, measures about 2.5 cm long. The seeds are winged [12, 13].

Traditional uses

The roots were used as astringent, stimulant and febrifuge, it was also used for stomach problems. Tea of the leaves was used in the treatment of diabetes mellitus and for weight loss. The leaves, flowers and barks were used as purgative. Leaf decoction or infusion was used for bladder and kidney inflammation, dysuria and other urinary dysfunctions, for cholesterol deduction, hypertension and diabetes. Poultice of the leaves was used as remedy for malaria, headache and cracked heeling by application over the lesions. Decoction of the bark was used for gastrointestinal tract disturbance, stomachache, haematuria and depression. The seeds were used as narcotic [9, 14-16].

Parts used

The roots, leaves and barks [9, 17].

Phytochemical review(17-25)

Tahakashi et al. (1976) identified *β*-sitosterol, stigmasterol, campesterol and 5 kinds of olefins by gas chromatogphy. They also separated a new tannin namely, lagertannin (3,4-di-O-methyl-4'-O-α-D-glucosyl ellagic acid) from the leaves of *L. speciosa*. They (1977) isolated two known ellagic acid derivatives, namely 3,3',4-tri-O-methyl ellagic acid and 3-O-methyl ellagic acid from the leaves of *L. speciosa.* They also synthesized 3, 4-di-O-methyl ellagic acid, previously reported as the aglycon of lagertanin.

They have (1979) examined hot ethanoic extract of leaves of *L. speciosa* by gas chromatography-mass spectrometric analysis. From the neutral fraction, they identified nonacosane, hentriacontane, tritriacontane, olefins ($C_{24}H_{48}$ and $C_{26}H_{32}$), and ethyl esters of palmitic, daturic, stearic, arachidic, and behenic acid. From the alkaloid fraction, lasubine II was isolated along with 4 other alkaloids of m/e 223, 248, 248, and 278 having base peaks at m/e 149.

Tanaka et al. (1992) isolated three ellagitannins namely, Lagerstannins A, B and C from the leaves of *L. speciosa* (L.) Pers. On the basis of chemical and spectroscopic evidence, their structures were established as 2,3,4,6-bis-O- (S)-hexahydroxydiphenoyl-D-gluconic acid, 2,3,5-O-(SR)-flavogalloyl-4,6-O- (S)-hexahydroxy diphenoyl-D-gluconic acid and 5-O-galloyl-4,6-O-(S)- hexahydroxy diphenoyl-D-gluconic acid respectively.

Manalo et al. (1993) isolated and identified sixteen amino acids, pyrogallol tannins and lipids from the leaves of *L.speciosa*. They also conducted preliminary toxicity studies which indicated presence of the active constituents in the crude and tannin-free spray-dried extracts which was responsible for the blood sugar lowering activity. They also reported that the amino acids constituted insulin-like principle responsible for the hypoglycemic activity.

Okada et al. (2003) isolated a new triterpenoid from the leaves of *L. speciosa* (L.) Pers. They established the new compound as 3β, 23-dihydroxy-1-oxo- olean-12-en-28-oic acid.

Ragasa et al. (2005) reported 31-norlagerenol acetate along with known compounds like 24-methylenecycloartanol acetate, largerenol acetate, tinotufolins C and D, lutein, phytol, sitosterol and sitosterol acetate from the leaves of *L. speciosa.*

Zong et al. (2006) screened constituents with hypoglycemic activity from *L. speciosa* leaves. The components of extracts of *L. speciosa* leaves were separated by HP-20 resin, solvent extraction, PTLC and PHPLC. They found that the corosolic acid, ursolic acid and total triterpene had the hypoglycemic effect.

Bai et al. (2008) identified seven ellagitannins, lagerstroemin, flosin B, stachyurin, casuarinin, epipunicacortein A and 2,-D-glucose,2,3-(S)- hexahydroxy diphenoyl α/β D-glucose, 3-O-methyl-ellagic acid 4'-sulfate, ellagic acid, and four methyl ellagic acid derivatives, 3-O-methyl ellagic acid, 3,3'-di-O-methyl ellagic acid, 3,4,3'-tri-O-methyl ellagic acid and 3,4,8,9,10- pentahydroxy dibenzo [b,d]pyran-6-one along with corosolic acid, gallic acid, 4-hydroxybenzoic acid, 3-O-methyl protocatechuic acid, caffeic acid, p- coumaric acid, kaempferol, quercetin and isoquercitrin by the bioassay- directed isolation from the leaves of *L. speciosa* (L.) Pers. The ellagitannins exhibited strong activities in both stimulating insulin-like glucose uptake and inhibiting adipocyte differentiation in 3T3-L1 cells.

Hou et al. (2009) investigated potential antidiabetic activity of ethyl acetate extract of the leaves of *L. speciosa* by α-amylase and α-glucosidase inhibition assay. They isolated six pentacyclic triterpenes (oleanolic acid, arjunolic acid, asiatic acid, maslinic acid, corosolic acid and 23-hydroxyursolic acid) from the leaves. They found that the α-glucosidase inhibitory activity of ethyl acetate extract was due to corosolic acid.

Phung et al. (2009) isolated corosolic acid and ursolic acid from the leaves of *L. speciosa* (L.) Pers by various chromatography methods. Their structures were identified by ESI-MS and NMR experiments including 1D-NMR (1H,13C) and 2D-NMR (HSQC, HMBC and COSY).

Pharmacological review(26-50)

Antidiabetic activity

Garcia (1941) reported distribution and deterioration of insulin like principle in the leaves of *L. speciosa.* He reported that hypoglycemic principle of leaves was thermostable and lowered the blood sugar upon oral administration, while large doses given orally produced no toxic effects or convulsions. He also reported that the old leaves and ripe fruits of the Banaba contained the maximum amount of hypoglycemic principle in the form of 100 cc. 20% decoction. He also reported that 20 g. of old leaves or fruits had a hypoglycemic activity equivivalent to 6-7.7 units of insulin. He found that activity of the mature leaves, young leaves and flowers ranged from 4.4 to 5.4 units of insulin per 100 cc. 20% decoction, i.e., about 70% of the activity of the old leaves or fruits.

Bunag et al. (1960) studied effect of insulin and extract of leaves of *L. speciosa on* duodenal motility in dogs under morphine-chloralose anesthesia. They found that the duodenal motor response to insulin and to extract of leaves of *L. speciosa was* increased markedly in all dogs.

Garcia et al. (1987) carried out pharmaceutico-chemical and pharmacological studies on a crude drug from *L. speciosa*. They isolated *β*-sitosterol from the petroleum ether extract of leaves of *L. speciosa* by column chromatography and thin layer chromatography. They found good diuretic activity of petroleum ether extract of leaves of *L. speciosa* in Sprague Dawley rats at a dose of 300mg/kg.

Mishra et al. (1990) studied hypoglycemic activity of alcoholic extract of the leaves of *L. speciosa* (L) Pers. on mild alloxan induced diabetes in albino rats. They observed significant hypoglycemic activity of extract at a dose of 250 mg/100g body weight as compared with tolbutamide 20 mg/kg body weight in albino rats. They also reported that the hypoglycemic effect was persistent even after two weeks of discontinuation of treatment.

Murakami et al. (1993) screened 23 extracts of medicinal plants including Banaba to study their effect on glucose transport activity on ehrlich ascites tumour cells. They isolated two triterpenoids corosolic acid and maslinic acid from Banaba leaves which showed significant glucose transport activity.

Kakuda et al. (1996) studied the hypoglycemic effects of *L. speciosa* using hereditary diabetic mice (Type II, KK-AY/Ta Jcl). They reported that the level of serum insulin, the amount of urinary excreted glucose and plasma total cholesterol level were lowered in mice fed with hot water extract of Banaba leaves.

Hamamoto et al. (1999) evaluated effect of Glucosol (an extract from *L. speciosa* containing 1% corosolic acid) on blood glucose in streptozotocin- induced diabetic rats and control rats. They found that the blood glucose level was significantly lowered at 90 min. after Glucosol administration.

Liu et al. (2001) studied the effects of extracts of the leaves of *L. speciosa*. (Banaba) on glucose transport and adipocyte differentiation activity in 3T3-L1 cells. They found that the extract showed unique combination of a glucose uptake stimulatory activity, the absence of adipocyte differentiation activity and effective inhibition of adipocyte differentiation induced by insulin plus 3- isobutyl-1-methylxanthine (IBMX) and dexamethasone (DEX) (IS-IBMX-DEX) in 3T3-L1 cells. Thus, Banaba extract might be useful for prevention and treatment of hyperglycemia and obesity in type II diabetics.

Hayashi et al. (2002) reported three glucose transport enhancer compounds namely ellagitannins, lagerstroemin, flosin B and reginin A by bioassay-guided fractionation of the aqueous acetone extract of the leaves. These compounds increased glucose uptake of rat adipocytes and could be responsible for lowering the blood glucose level.

Hattori et al. (2003) isolated lagerstroemin, an ellagitannin from the leaves of *L. speciosa* (L.) Pers. In rat adipocytes, the ellagitannins increased the rate of glucose uptake and decreased the isoproterenol-induced glycerol release. It also increased the Erk activity expressing human insulin receptors in Chinese hamster ovary cells. These insulin-like actions were accompanied by the increased tyrosine-phosphorylation of the β-

subunit of the insulin receptors. Thus, lagerstroemin was considered to cause its insulin-like actions by a mechanism different from that employed by insulin.

Schmandke (2005) reported a review on the hypoglycemic effect of extract from *L. speciosa* (Banaba) leaves. He discussed the insulin-like glucose uptake-stimulatory and adipocyte differentiation-inhibitory activity of 1,2,3,4,6-penta-O-galloyl-D-Glucose (PGG).

Deocaris et al. (2005) tested hypoglycemic activity of irradiated and non- irradiated Banaba leaves on alloxan treated diabetic mice. They found that gamma irradiated Banaba leaves led to effective extraction of corosolic acid or tannins. They also found that irradiated Banaba leaf extract mixed with insulin was found to have a higher hypoglycemic activity in comparison with the mixtures of non-irradiated banaba leaf extract and insulin.

Zong and Xia (2006) found that the total triterpenes promoted glucose metabolism and fat content control in 3T3-L1 cells.

Yamada et al. (2008) found that the corosolic acid (20-100 μM) decreased gluconeogenesis dose-dependently in perfused liver and in isolated hepatocytes of rat and reported that corosolic acid also increased glucokinase activity in isolated hepatocytes without affecting glucose-6-phosphatase activity suggesting the promotion of glycolysis.

Takagi et al. (2008) studied specific direct action of corosolic acid on blood glucose level and hydrolysis of disaccharide in the small intestine of mice and results showed that it reduced blood glucose level significantly within 60 min. after administration of the sucrose ($P<0.01$).

Keawpradub and Purintrapiban (2009) found that the methanol fraction of leaves of *L. speciosa* stimulated glucose uptake in a dose-dependent manner in cell based radioactive assay using L8 muscle cells. They also found that the extract enhanced insulin-stimulated glucose transport. These results suggested that action of extract of leaves of *L. speciosa* might be mediated primarily via the synthesis of new transporters and involved both insulin-dependent and independent pathways.

Antiobesity activity

Suzuki et al. (1999) reported antiobesity activity of water extract of *L. speciosa* leaves on female KK-Ay mice.

Antioxidant activity

Unno et al. (1997) studied antioxidant activity of hot water extract of leaves of *L. speciosa* in a linoleic acid antioxidation system, a potent radical scavenging action on 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals and superoxide radicals (O_2) generated by a hypoxanthine (HPX)/ xanthine oxidase (XOD) system. Extract was reported to possess *in vitro* lipid peroxidation of rat liver homogenate induced by tert-Bu hydroperoxide (BHP) in a dose dependent manner.

Kajimoto et al. (1999) reported an anti-oxidant activity of hot-water extracts of 15 kinds of commercial tea including *L. speciosa* and isolated and identified polyphenols as gentisic acid, gallic acids, catechin, and resorcinol in Banaba tea.

Chen et al. (2006) evaluated antioxidant activity of the different polar solvent extracts of leaves of *L. speciosa* and reported that methanol extract showed stronger antioxidant power and higher extraction yield and total phenolic content than other extracts.

Priya et al. (2008) studied *in vitro* antioxidant activity of the successive extracts (ethyl acetate, ethanol, methanol and water) of the leaves of *L. speciosa*.

Liu et al. (2008) reported antioxidant activity of stems, seeds and leaves of *L. speciosa*. The antioxidant activities of different solvent (water, alcohol and acetone) extracts were evaluated by DPPH and linoleic acid assay and showed that water extracts of the seeds showed the highest antioxidant activity.

Pareek et al. (2010) reported significant antioxidant activity of the hydroalcoholic extract of leaves of *L. speciosa* on different *in vitro* models namely 1,1-diphenyl, 2-picryl hydrazyl (DPPH) assay, Hydrogen peroxide and nitric oxide radical scavenging method, and superoxide radical scavenging by alkaline DMSO method.

Clinical review

Judy et al. (2003) reported the antidiabetic activity of an extract from the leaves of *L. speciosa* standardized to 1% corosolic acid (Glucosol) in the randomized clinical trial involving Type II diabetics.

Fukushima et al. (2006) reported that corosolic acid had a lowering effect on post challenge plasma glucose levels *in vivo* in humans.

Analytical review

Hosoyama et al. (2003) established simple and efficient HPLC method for quantitative determination of valoneaic acid and its derivatives occurring as polyphenols in Banaba extract.

Shao-hong et al. (2005) detected copper, iron, manganese, zinc and selenium by flame atomic absorption spectrophotometer and fluorospectrophotometer.

Zong et al. (2005) reported isolation and identification of ursolic acid from *L. speciosa* leaves using solvent-extraction and thin-layer chromatography.

Zong and Zong (2006) determined 2-α hydroxyl ursolic acid (HUA) in *L. speciosa* hypoglycemic capsules using reversed-phase high-performance liquid chromatography.

Vijaykumar et. al. (2006) determined corosolic acid from the leaves, extracts and dosage form of *L. speciosa* by RP-HPLC and HPTLC methods. They found 0.31-0.38% w/w of corosolic acid in the leaves of *L. speciosa.*

Zong et al. (2007) extracted 2 α-hydroxy ursolic acid from leaves of *L. speciosa* (L) Pers. by the super-high-pressure (SHP) extraction.

Zong et al. (2007) developed TLC/HPLC methods for analysis of corosolic and maslinic acids in the extract of *L. speciosa* leaves.

Mallavadhani et al. (2008) carried out quantitative analysis of corosolic acid from methanolic extracts of different parts of *L. speciosa* by HPTLC, using aluminum plates coated with silica gel 60 F_{254}, with chloroform-methanol (8.5:1.5) as mobile phase. They reported that maximum corosolic acid content (0.89%) was found in the leaves.

Biotechnological review

Zobayed (2000) carried out shoot multiplication and plantlet regeneration from single nodal explants (with two unfolded leaves) of mature trees of *L. speciosa* through *in vitro* culture.

Miscellaneous

Unno et al. (2004) reported that dietary use of the aqueous extract of *L. speciosa* leaves for the prevention and treatment of hyperuricemia. They isolated xanthine oxidase inhibitors namely, valoneic acid dilactone (VAD) and ellagic acid (EA).

Yamaguchi et al. (2006) reported that corosolic acid had anti-inflammatory and hypoglycemic activities. Results demonstrated that corosolic acid ameliorated hypertension, abnormal lipid metabolism, oxidative stress and inflammatory state in SHR-cp rats.

Priya et al. (2007) reported that the ethyl acetate extract at dose levels of 50 and 250 mg/kg showed a dose-

dependent reduction in cisplatin-induced elevations in urea and creatinine concentrations.

Phung et al. (2008) showed that aqueous fraction inhibited α-amylase activity dose-dependently in pre-incubation method where as *n*-hexane fraction did not inhibit α-amylase activity at tested concentration range of 0.05-0.2%.

Lee et al. (2009) found that corosolic acid (2α-hydroxy ursolic acid), an active component of Banaba leaves at concentrations up to 5 μM, significantly stimulated osteoblast differentiation and mineralization without cytotoxicity in mouse.

Ambujakshi (2009) studied antibacterial activity of ethanol and water extracts of leaves of *Lagerstroemia speciosa* (L) pers. against Gram positive and Gram negative bacteria and concluded that all extracts have inhibitory effect, water extract being most effective.

Conclusion

The current review discussed the pharmacological effects of *Lagerstroemia speciosa* which included antimicrobial, antioxidant, anticancer, antidiabetic, hypolipidemic, antiobesity, anti-inflammatory, analgesic, gastrointestinal, diuretic, thrombolytic, cardiovascular, central nervous, inhibition of TNFα production, xanthine oxidase inhibitition, hepatoprotective and nephroprotective effects. The review also highlighted the chemical constituents, toxicity and the recommended doses of *Lagerstroemia speciosa* as a promising medicinal plant for therapeutic purposes as a result of effectiveness and safety.

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