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Review article

Medicinal values of a Saiva ritual plant-*Bauhinia tomentosa* L.

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Abstract

Bauhinia tomentosa L. is a small tree that belongs to the *Fabaceae* family and it is distributed in Asia, Africa, North America, and Oceania. *B. tomentosa* is used to treat some diseases including liver inflammation, abscess, tumors, wounds, and hyperlipidemia in ethnomedicines in Asia and Africa. Compounds like phytone, β-cubebene, β-caryophyllene, 3-O-methyl-d-glucose, and phthalic acid have been isolated from leaves of this plant species. This review article aims to analyze, document, and summarize the reported bioactivities of this plant species. A literature review was conducted using electronic databases like the Web of Science, Scopus, PubMed, and Science Direct to identify the relevant published studies from the year 1900 to November 2020. Various parts of *B. tomentosa* exhibited bioactivities such as analgesic, anti-anxiety, antibacterial, anticatatonic, anticonvulsant, antidepressant, antidiabetic, antifungal, anthelminthic, antihyperlipidemic, antinociceptive, antioxidant, antipyretic, anti-ulcerative colitis, motor coordination, nephroprotective, nootropic, and wound healing activities in various assays and animal models. However, no bioactive compound has been isolated from this plant species. It was observed that a daily dose of 3000 mg/kg was safe in animal models. Hence, further phytochemical and bioactivity studies should be conducted to explore more about this plant species. This work analyzed, documented, and summarized the reported bioactivities of *B. tomentosa* that will be very useful for further phytochemical and bioactivities related researches.

Keywords: *Bauhinia tomentosa; bioactivity; cancer; Fabaceae; microbiota; Sri Lanka*

1. Introduction

Bauhinia tomentosa L. is a small tree that grows from 1 to 8 m in height belongs to the *Fabaceae* family (Fig. 1). It is called Thiruvaaththi in Tamil. This plant species is native to Asia (Sri Lanka, Yemen, and India) and Africa (Angola, Burundi, Ethiopia, Kenya, Malawi, Mozambique, Somalia, Sudan, Swaziland, South Africa, Tanzania, Zambia, Zaïre, and Zimbabwe). Anyway, it has been introduced into Asia (Andaman Islands, China, Malaysia, Taiwan, Thailand, and Vietnam), Africa (Cameroon, Gambia, Ghana, Guinea, Nigeria, and Sierra Leone), North America (Cuba, Dominican Republic, Haiti, Puerto Rico, and Trinidad and Tobago), and Oceania (Australia) (Royal Botanic Gardens, Kew, 2020) (Fig. 2). *B. tomentosa* is utilized to treat liver inflammation, abscess, tumors, wounds, hyperlipidemia, bleeding, diabetes, diarrhea, animal bites, helminthiasis, infections, fever, and abdominal, skin, and urinary tract illnesses in ethnomedicines in Asia and Africa (Chopra et al., 1992; Sastri, 1995; Kirtikar and Basu, 2005; Orwa et al., 2009). This plant species is also grown as an ornamental plant in gardens and also used as a hedge. Fiber obtained from the trees are employed to make baskets and timber is utilized as beams for sheds. Further,

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leaves are used to prepare a yellow dye and flowers are used in Saiva rituals in Sri Lanka (Orwa et al., 2009). Compounds like Phytone, β-cubebene, β-caryophyllene, 3-O-methyl-d-glucose, phthalic acid, ethyl pentyl ester, 2-butanone, 3-methoxy-3-methyl, 2,2-dimethylpropionic acid, cyclopentyl ester, 2-hexen-1-ol, 2-ethyl, 5-hydroxy-2,2-dimethylhexan-3-one, pentanoic acid, 2-methyl, butane, and 1-bromo-2-methyl have been isolated from leaves of *B. tomentosa* (Vasudevan et al., 2014; Panda et al., 2019).

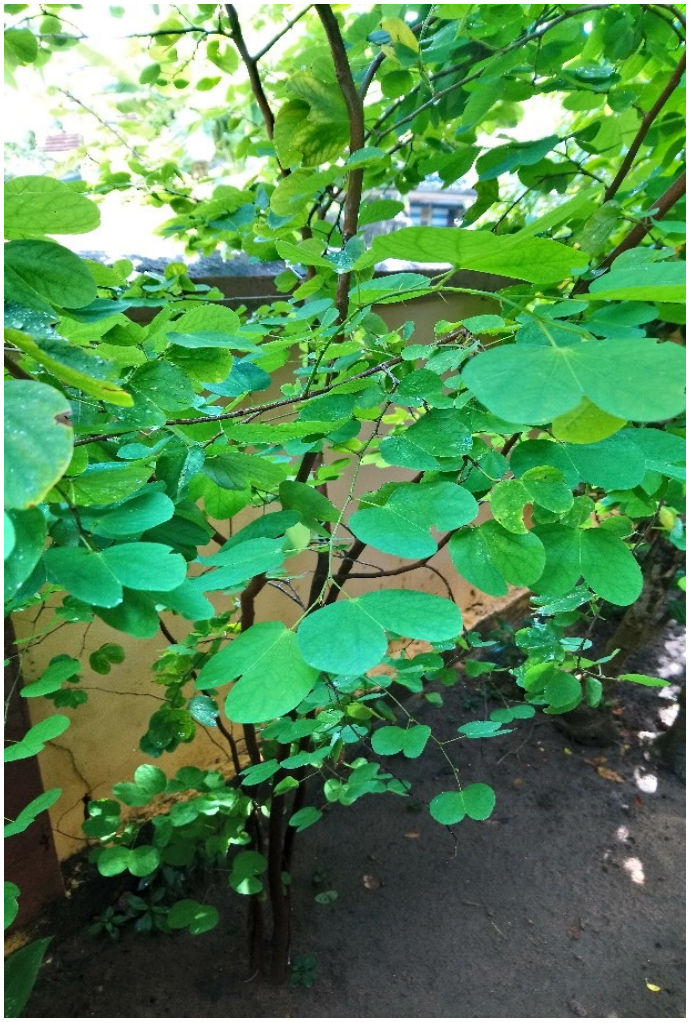

Fig. 1. *B. tomentosa* in a home garden in Batticaloa, Sri Lanka.

Until now, there is no comprehensive systematic review of bioactivities of *B. tomentosa*. Therefore, this review article aims to analyze, document, and summarize the reported bioactivities of this plant species. This work would be useful for further phytochemical and bioactivities related researches.

For this aim, a literature review was conducted using electronic databases namely the Web of Science, Scopus, PubMed, and Science Direct to identify the relevant published studies from 1900 to November 2020. The scientific name (*Bauhinia tomentosa*) was applied as a search term.

2. Bioactivities of *B. tomentosa*

Details of the level of scientific evidence, bioactivity, part used, extract/compound, assay/model, dose/concentration, duration, and reference are presented in Table. So far, only *in vitro* and *in vivo* reported studies are available and the majority of the studies have been conducted in *in vivo* models. Antioxidant activities have both *in vitro* and *in vivo* scientific evidence.

A greater number of researches were carried out to study the antioxidant activities of this plant species (Kannan et al., 2010; Krishnaswamy et al., 2013; Tiwari and Singh, 2013; Banerjee and De, 2014). Leaves unveiled several bioactivities including antibacterial (Mythreyi et al., 2005; Dugasani et al., 2010), anticonvulsant (Risa et al., 2004), anti-anxiety, anticatatonic, antidepressant (Sathya et al., 2011), antidiabetic (Mannangatti et al., 2010a; Devaki et al., 2011; Kaur et al., 2011; Tiwari and Singh, 2013), anti-ulcerative colitis (Kannan and Guruvayoorappan, 2013), motor coordination (Sathya et al., 2011), nephroprotective (Kannan et al., 2016), and nootropic (Sathya et al., 2011) activities in both *in vitro* and *in vivo* levels.

Further, ethanol extract was used in the majority of the reviewed studies. Anyway, no bioactive compound has been isolated from this plant species. As stated earlier, *B. tomentosa* has a range of uses in ethnomedicines. On the other hand, only ethnomedicinal treatments for inflammation, infections, diabetes, helminthiasis, hyperlipidemia, and would healing activities have scientific evidence currently. Only higher scientific level (*in vivo*) studies according to the lower dose and duration of treatment are deliberated below.

3. Reported *in vivo* studies

3.1. Analgesic activity

In a study carried out by Tiwari and Singh (2013), aqueous and methanol extracts of the root (200 mg/kg) were orally administered to mice. After 300 minutes, in eddy's hot plate method significant analgesic activity was observed.

3.2. Anti-anxiety activity

The anti-anxiety property was noticed in the elevated plus-maze model, hole board test, and light-dark models after administering 200 mg/kg of leaf ethanol extract (Sathya et al., 2011).

3.3. Anticatatonic activity

Leaf ethanol extract of dose 200 mg/kg administered to haloperidol-induced catalepsy animal models showed anticatatonic activity (Sathya et al., 2011).

3.4. Antidepressant activity

In an investigation conducted by Sathya et al. (2011), an extract prepared using leaves and ethanol (200 mg/kg) was administered revealed antidepressant activity and improved the depressant conditions in forced swim tests and diazepam-induced sleeping time models.

3.5. Antidiabetic activity

A dose of 100 mg/kg of flower ethanol extract was orally administered to Streptozotocin-induced diabetic animals reduced elevated blood glucose concentrations (Mannangatti et al., 2010a).

3.6. Antihyperlipidemic activity

Mannangatti et al. (2010a) observed significant antihyper-

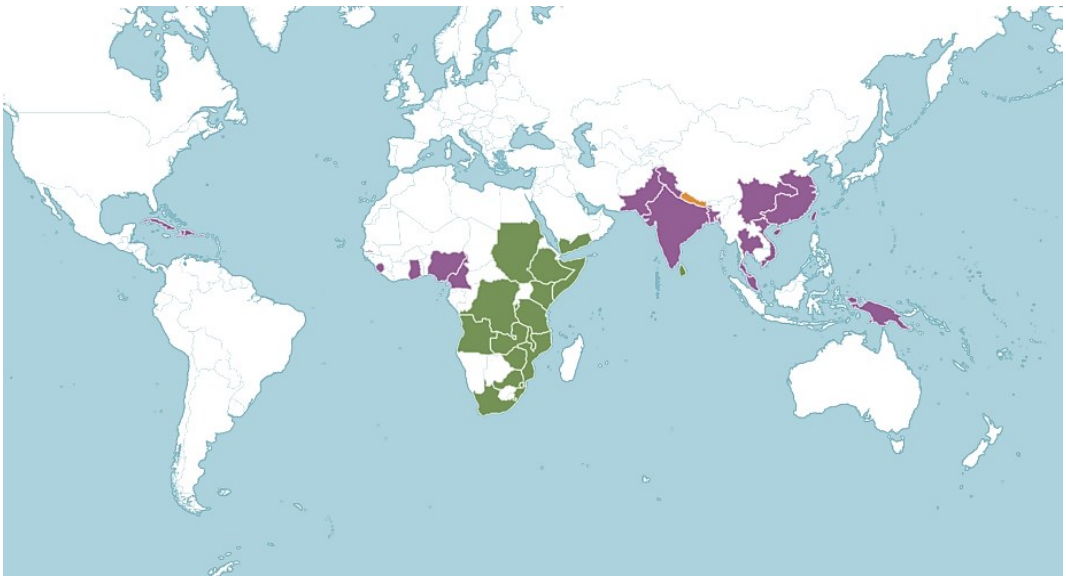

Fig. 2. Distribution map of *B. tomentosa* (**Source:** Plants of the World Online: Royal Botanic Gardens, Kew. Available at http://plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:30193-2). **Keys:** Orange: Doubtful; Green: Native and Purple: Introduced

lipidemic properties in Streptozotocin-induced diabetic animals after orally administrating 100 mg/kg of flower ethanol extract for 7 days.

3.7. Antinociceptive activity

An extract prepared using roots and ethanol (200mg/kg) was orally administered to mice unveiled antinociceptive potentials (Tiwari and Singh, 2013).

3.8. Antioxidant activity

Streptozotocin-induced diabetic animal models were orally administered 100 mg/kg of flower ethanol extract for 15 days showed antioxidant activity (Mannangatti et al., 2010b).

3.9. Antipyretic activity

In research performed by Tiwari and Singh (2015), root and stem 70% methanol extracts (200 mg/kg) were separately orally directed to yeast-induced hyperthermia models. After 300 min.s it was noticed that the hypothermia condition was reduced.

3.10. Anti-ulcerative colitis activity

An extract was made using leaves and 70% methanol and it was orally administered to colonic inflammation animals at a dose of 20 mg/kg. After 5 days, it was spotted significant anti-ulcerative colitis activity (Kannan and Guruvayoorappan, 2013).

3.11. Motor coordination activity

Ethanol extract of leaves (200 mg/kg) administered to animals showed motor coordination activity after 30 minutes in the Rotarod test (Sathya et al., 2011).

3.12. Nephroprotective activity

Kannan et al. (2016) administered 250 mg/kg leaf methanol extract to cisplatin-induced renal damaged models. After 5 days, it was observed that an elevation in antioxidant enzymes such as glutathione, catalase, and superoxide dismutase. Also, the bodyweight rose and reduced creatinine, serum urea, and lipid peroxidation. This study explains that this plant species has nephroprotective effects.

3.13. Nootropic activity

In a study carried out by Sathya et al. (2011), leaf methanol extract at a dose of 400 mg/kg was orally administered to the elevated plus-maze models exhibited nootropic properties.

3.14. Wound healing activity

The methanol extract was applied to both incision and excision wound models healed the wounds after 14 days (Panda et al., 2018).

4. Toxicity study

A study was carried out to observe the toxic and identify the safest dose (ED) of stem and root 70% methanol extracts separately. A dose of 3000 mg/kg orally administered to mice for 1 week showed no toxic effects and it is considered to be safe (Tiwari and Singh, 2015).

5. Conclusion

This review work revealed that *B. tomentosa* has a range of ethnomedicinal uses and scientific evidence is available for some of the ethnomedicinal utilizations. Hence, further bioactivities and phytochemical studies should be conducted to produce more scientific evidence to confirm the ethnomedicinal uses for standardization, safety, and efficacy purposes.

Also, the bioactive compounds should be discovered from this plant species, and they might be a candidate as a lead compound in future researches to combat diseases like cancer. Then these useful bioactive compounds could be synthesized in the laboratory to produce a large scale.

So far, an enormous number of bioactive phytochemicals have been isolated from several plant species. Anyway, not all the compounds or extracts have *in vivo* and clinical trial eviden-

ce and mechanisms of action for their bioactivities. Therefore, there is an urgent requirement to conduct these studies to find more effective drugs with few or no side effects than currently available drugs.

This work analyzed, documented, and summarized the reported bioactivities of *B. tomentosa*. Further, this work will be very useful for the researchers who are interested to study further bioactivity and phytochemical studies using this plant species.

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Table
Reported bioactivities of *B. tomentosa*.

Level of scientific evidence	Bioactivity	Part used	Extract/Compound	Assay/Model	Dose/Concentration	Duration	Reference
In vitro	Antibacterial	Leaf	Chloroform, Methanol, Ethanol, Petroleum ether, Ethyl acetate, Aqueous	*Bacillus cereus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus*	100 µg/ml (MIC)	NA	Mythreyi et al. (2005)
		Leaf	Chloroform, Methanol, Ethanol, Petroleum ether, Ethyl acetate, Aqueous	*Candida albicans, Aspergillus niger*	100 µg/ml (MIC)	NA	
In vitro	Antibacterial	Root	Ethyl acetate	*Proteus vulgaris* (ATCC 12454)	7 µg/ml (MIC)	NA	Dugasani et al. (2010)
		Root	Ethyl acetate	*Pseudomonas aeruginosa* (ATCC 27853), *Enterococcus faecalis* (ATCC 2912), *Bacillus subtilis* (ATCC 10774), *Bacillus pumilus* (ATCC 14884), *Escherichia coli* (ATCC 25922)	15 µg/ml (MIC)	NA	
		Root	Ethyl acetate	*Staphylococcus aureus* (ATCC 25923)	31 µg/ml (MIC)	NA	
		Root	Hexane	*Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), *Proteus vulgaris* (ATCC 12454), *Bacillus subtilis* (ATCC 10774), *Bacillus pumilus* (ATCC 14884), *Enterococcus faecalis* (ATCC 2912), *Staphylococcus aureus* (ATCC 25923)	250 µg/ml (MIC)	NA	
		Root	Methanol	*Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), *Proteus vulgaris* (ATCC 12454), *Bacillus subtilis* (ATCC 10774), *Bacillus pumilus* (ATCC 14884), *Enterococcus faecalis* (ATCC 2912)	31 µg/ml (MIC)	NA	
		Root	Methanol	*Staphylococcus aureus* (ATCC 25923)	62 µg/ml (MIC)	NA	
In vitro	Anticonvulsant	Leaf	Aqueous, Ethanol	GABA A-benzodiazepine receptor binding assay	1 mg/ml	NA	Risa et al. (2004)
In vitro	Antifungal	Root	Aqueous, Ethanol Ethyl acetate	*Candida krusei* (ATCC 6258), *Candida albicans* (ATCC 10231)	15 µg/ml (MIC)	NA	Dugasani et al. (2010)
		Root	Hexane	*Candida krusei* (ATCC 6258), *Candida albicans* (ATCC 10231)	250 µg/ml (MIC)	NA	
		Root	Methanol	*Candida krusei* (ATCC 6258), *Candida albicans* (ATCC 10231)	31 µg/ml (MIC)	NA	
In vitro	Antihelminthic	Root	Ethanol, aqueous	*Pheritema postuma, Ascaris lumbricoides*	10% solution	NA	Aditya et al. (2013)
In vitro	Antioxidant	NS	NS	Mouse liver microsomes	90 µg/ml (IC_{50})	NA	Kannan et al. (2010)
		NS	NS	NO radical scavenging	65 µg/ml (IC_{50})	NA	
In vitro	Antioxidant	Pod, seed	NS	DPPH radical scavenging, NO radical scavenging, OH radical scavenging, ABTS radical scavenging, metal iron chelating, β-carotene-linoleate model system	NS	NA	Krishnaswamy et al. (2013)

In vitro	Antioxidant	Flower	Aqueous	DPPH radical scavenging	74 µg/ml (IC_{50})	NA	Banerjee and De (2014)
		Flower	Aqueous	Total antioxidant capacity	265 µg/ml (IC_{50})	NA	
In vitro	Antioxidant	NS	Aqueous	DPPH radical scavenging	85 µg/ml	NA	Tiwari and Singh (2013)
		NS	Aqueous	NO radical scavenging	310 µg/ml	NA	
		NS	Ethanol	DPPH radical scavenging	167 µg/ml (IC_{50})	NA	
		NS	Ethanol	NO radical scavenging	220 µg/ml	NA	
		NS	Methanol	DPPH radical scavenging	65 µg/ml (IC_{50})	NA	
		NS	Methanol	NO radical scavenging	150 µg/ml	NA	
In vivo	Analgesic	Root	Aqueous, methanol	Eddy's hot plate method in mouse	200 mg/kg	300 min	Tiwari and Singh (2013)
		Root	Ethanol	Eddy's hot plate method in mouse	400 mg/kg	300 min	
		Root	Ethanol, Aqueous, Methanol	Acetic acid-induced writhing test in mouse	400 mg/kg	300 min	
In vivo	Anti-anxiety	Leaf	Ethanol	Elevated plus maze model, hole board test, light dark model	200 mg/kg	NS	Sathya et al. (2011)
	Anticatatonic	Leaf	Ethanol	Haloperidol-induced catalepsy	200 mg/kg	NS	
	Antidepressant	Leaf	Ethanol	Forced swim test, diazepam-induced sleeping time	200 mg/kg	NS	
In vivo	Antidiabetic	Flower	Ethanol	Streptozotocin-induced diabetic	100 mg/kg	7 d	Mannangatti et al. (2010a)
In vivo	Antidiabetic	Leaf	Aqueous	Alloxan-induced diabetic	300 mg/kg	180 min	Devaki et al. (2011)
In vivo	Antidiabetic	Root	Petroleum ether	Alloxan-induced diabetic	250 mg/kg	14 d	Kaur et al. (2011)
In vivo	Antidiabetic	Stem	Aqueous, Ethanol	Streptozotocin-induced diabetic	250 mg/kg	21 d	Tiwari and Singh (2014)
In vivo	Antihyper-lipidemic	Flower	Ethanol	Streptozotocin-induced diabetic	100 mg/kg	7 d	Mannangatti et al. (2010a)
In vivo	Antinociceptive	Root	Ethanol	Mouse	200 mg/kg	NS	Tiwari and Singh (2013)
In vivo	Antinociceptive	Root, Stem	Methanol (70%)	Mouse (Acetic acid-induced writhing test)	250 mg/kg	30 min	Tiwari and Singh (2015)
		Root, Stem	Methanol (70%)	Mouse (Eddy's hot plate method)	250 mg/kg	120 min	
In vivo	Antioxidant	Flower	Ethanol	Streptozotocin-induced diabetic	100 mg/kg	15 d	Mannangatti et al. (2010b)
In vivo	Antipyretic	Root, Stem	Methanol (70%)	Yeast-induced hyperthermia	200 mg/kg	300 min	Tiwari and Singh (2015)
In vivo	Anti-ulcerative colitis	Leaf	Methanol (70%)	Colonic inflammation	20 mg/kg	5 d	Kannan and Guruvayoorappan (2013)
In vivo	Motor coordination	Leaf	Ethanol	Rota rod test	200 mg/kg	30 min	Sathya et al. (2011)
In vivo	Nephroprotective	Leaf	Methanol	Cisplatin-induced renal damage	250 mg/kg	5 d	Kannan et al. (2016)
In vivo	Nootropic	Leaf	Ethanol	Elevated plus maze model	400 mg/kg	NS	Sathya et al. (2011)
In vivo	Wound healing	NS	Methanol	Incision wound, excision wound	NS	14 d	Panda et al. (2018)

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