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Phytochemistry and Therapeutic potential of *Bauhinia racemosa* Lam. - A Concise Review

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Abstract

Nature has consistently been a healing source of ailments for living organisms from the millennium era. Even though nature comprises of diverse animals and plants of immense therapeutic potential, plants due to its easy accessibility play a predominant lead in this perspective. In this scenario, herbal medicine dawned on the treatment of various diseases and the suffering of mankind. Each plant has to be scientifically explored to validate its therapeutic potential. *Bauhinia racemosa* Lam. Is a tree broadly distributed in the tropical climate regions of the earth. Bauhinia species are generally flowering trees found in the Caesalpiniaceae family. The plant, from its root to stem bark fibers, possesses curative properties. Ethnopharmacologically, various parts of the plant ranging from the bark of the plant to the gum obtained has been used in a wide spectrum of diseases such as Epilepsy, Diarrhoea, Leucoderma, etc. This plant, due to its wide distribution in the population, is still in use for many ailments among the tribal people. All the therapeutic properties of a plant are the perquisite of the phytoconstituents present in them. *B. racemosa* is abundant in flavonoids, glycosides, phenols, saponins, and tannins. Many pharmacological actions of the plant have already been proved, which include anti-microbial, anthelmintic, antitumor, antidiabetic activity, etc. This review aims at emphasizing the pharmacological actions and phytochemistry of *B. racemosa*.

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INTRODUCTION

Plants have been used in the treatment and prevention of diseases from times immemorial. A plant can be distinguished as a medicinal plant based on the scientific studies and researches done on the plant. A medicinal plant can be any plant in which one or more organs possess compounds with therapeutic properties that can be utilized for the treatment or prevention of diseases. Plants are less explored for their preventive potential and more exploited for the treatment of diseases. Preventive proficiency of a plant can be accounted for by phytochemicals, the secondary metabolites, or compounds present in the plant. A single plant may contain an infinite number of active metabolites, among which very few are explored and utilized due to lack of information and technology to extract, isolate and characterize these compounds (Sofowora *et al.*, 2013). The utilization of the plant for therapeutic purposes is termed as Phytomedicine. According to the World Health Organization (WHO), 4 billion people consume herbal medicine as a primary health care sup-

plement. Thus, herbal medicine has been recognized as an essential component of the health care system by WHO. Even though herbal medicine is promoted effectively, the challenges in the development of herbal medicine are intact. Although standardization and quality control remain relevant among the challenges in herbal medicine, identification of the plant and accurate scientific validation of its medicinal properties persist in being the key barrier in the herbal medicine (Shakya, 2016).

Bauhinia racemosa Lam., (Caesalpiniaceae) is a small, bushy tree, crooked in nature found widely distributed in India, mostly from Maharashtra to southern parts of India. Globally, the plant is found in the tropical climate regions of the world, namely in countries such as Bangladesh, Cambodia, China, Thailand, Myanmar, Sri Lanka, Vietnam, etc. About 200 or more species of flowering plants come under the Bauhinia genus, which in taxonomical classification belongs to Fabaceae, the largest flowering plant family. Other Bauhinia species commonly found include *Bauhinia purpurea, B. accumulate, B. tomentose, B. ovata, B. vestigia*l.

Each of these species has a distinct flower color enabling easy distinguishing of the species from one another even though their other morphological characters are highly in differentiable. *B. racemosa* is an abundant source of various phytoconstituents such as phenols, glycosides, tannins, saponins, and flavonoids. Racemosolone, a novel compound, has been yielded from the root of the plant, whereas Resveratrol, phytoalexin, has been isolated from the heartwood of the plant. These phytoconstituents are found to be allocated in different parts of the plant body ranging from its seed to heartwood. Each part of the plant being a possession of these phytoconstituents, they even account for the therapeutic potential of the plant parts. From the ancient period onwards, the plant has been used in the treatment of various ailments.

The use of bark in the treatment of malaria has been divulged even in the scripts of Ayurveda. The plant bark is used for Diarrhoea and Dysentery among the Bhil tribe of Rajasthan. Lodhas utilize the combination of long pepper decoction and gum of *B. racemosa* as a remedy for a brain tumor (Sahu and Sahu, 2015). This review aims at inspecting a medicinal plant, *Bauhinia racemosa* Lam. for its taxonomical, morphological, phytochemical properties and scientifically validated pharmacological actions. The taxonomical classification of the plant contributes to the specific identification of the plant given in Table 1, and the picture of the plant in its natural habitat is provided in Figure 1.

Table 1: Taxonomical classification

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Fabales
Family	Caesalpiniaceae
Genus	Bauhinia
Species	Racemosa

* The contents of this table was obtained from (Soni *et al.*, 2015)

Figure 1: Bauhinia racemosa Lam

Phytochemistry

The phytochemical analysis involves the estimation of the chemical constituents present in the plant, both quantitatively and qualitatively. The chemical constituent differs in each part of the plant accounting for the specific medicinal property of each plant part. Based on the preliminary phytochemical screening done on the ethanolic extract of leaves and seeds o*f B. racemo*se, it is found that the plant possesses chemical constituents such as flavonoids, glycosides, phenolic compounds, saponins, and tannins. Preliminary phytochemical screening aids in the quantification of the phytochemicals present in the plant.

The phenolic content of the plant was estimated by using Folin's Ciocalteau method, which reported the following phenolic compounds in the leaves: Hydroquinone, Catechol, and 4-Nitrophenol. On comparison of the phenolic content of the leaves and seeds o*f B. racemo*sa, leaves of the plant are found to be more abundant than the seeds of the plant. These phenolic compounds shield the plant against the deleterious effects of UV rays and disease-causing microorganisms. Lowry's method of quantitative protein estimation was applied, and it was detected that

the seed of the plant contains standard amino acids, namely Lysine, Methionine, Leucine, and Phenylalanine. The seed oil on Thin Layer Chromatographic (TLC) study showed the presence of Phosphatidylinositol, Lysophosphotidylethanolamine, and Phosphatidylcholine (Sharanabasappa *et al.*, 2007).

The heartwood of the plant has been extracted to isolate two crystalline compounds: Resveratrol, which is chemically 3,5,4'-trihydroxy trans-stilbene and Dibenzoxepine derivative, namely Pacharin. Structurally Pacharin is 1,7–dihydroxy-3-methoxy-2–methyl-dibenzo (2,3-6,7) oxepine. Compounds belonging to dibenzo (2,3-6,7) oxepine are reported to display anti-inflammatory activity. The significance of Resveratrol enhances as ring closure of Stilbene derivative can lead to the formation of corresponding Benzoxepine derivative (Anjaneyulu *et al.*, 1984). Even the stembark of the plant is found to possess steroidal compounds such as β-amyrin and β-sitosterol. The studies on roots indicate the presence of Lupeol, Betulin, and β-sitosterol (Jain *et al.*, 2002). Altogether the aerial parts of the plant on extraction and isolation produced Kaempferol, Quercetin, and Rutin, which implies the flavonoid content of the plant (Rashed and Butnariu, 2014).

Pharmacological Actions

Antioxidant activity

Aerial parts of *B. racemosa* were extracted using Millipore water by hot maceration, and the filtered extract was subjected to antioxidant activity by employing the techniques TEAC (Trolox Equivalent Antioxidant Capacity) method and ORAC (Oxygen Radical Absorbance Capacity) method.

1. TEAC Method: The antioxidant potential of the plant is estimated based on the decolorization of cation ABTS+ [2,2'–azino– bis (3–ethylbenzothiazoline–6–sulphonic acid)] to ABTS in the presence of the antioxidant biomolecules. B. racemosa exhibited a high TEAC value of 201.36 $\pm$ 3.6 mM TE/g (Trolox equivalents), implying a good antioxidant activity.

2. ORAC Method: In the ORAC assay method, the inhibiting capacity of the antioxidant biomolecules on Peroxyl radical is estimated. The antioxidant molecules are anticipated to prevent the oxidative degeneration of the fluorescent molecules, thus inhibiting the fluorescence loss induced by Peroxyl radical. B. racemosa extract showed a low ORAC value of 1033 mM TE/g in comparison with the TEAC method. But overall antioxidant activity is prominent for B. racemosa due to the high polyphenol content (Rashed and Butnariu, 2014).

Anti-microbial activity

The anti-microbial activity was estimated both qualitatively and quantitatively employing the Kirby-Bauer method (adapted disk diffusion method) and binary microdilution method, respectively, on the methanolic extract of aerial parts of *B. racemos*e. The anti-microbial screening was done on Gram-positive bacteria, namely Staphylococcus aureus, Bacillus subtilis, Gram-negative bacteria such as Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia; Candida albicans, fungal strain. Mueller-Hinton medium and Yeast Peptone Glucose medium was employed for the bacterial strain and fungal strain, respectively. Kirby-Bauer method involves the method of analyzing the susceptibility of various microbes to the plant extract. The qualitative screening was done in 3 modified systems. 10μL of the extract in DMSO was utilized in all the 3 systems. 3 modified system includes filter paper disk, agar well, and Petri dish seeded with bacterial/fungal inoculum. The plates were incubated for 24hrs at 37ºC. In binary microdilution method, from a 200μL culture medium, binary serial dilutions were performed, ranging a concentration of 1000μg/mL to 0.97μg/mL. 0.5 MacFarland density 50 μL microbial suspension was used to seed the 96 well-plate. For the quantitative antimicrobial analysis, a sterility control and a microbial culture control was set up in each test. The incubation condition for the analysis was set up at 37ºC for 24hrs. Minimum Inhibitory Concentration (MIC) assay was employed for the quantitative analysis of anti-microbial activity. Qualitative and quantitative assay results were found to be quite relatable. The growth of inhibition zone was measured around the filter paper disk impregnated with the test extract for the qualitative analysis, and the Minimum Inhibitory Concentration (MIC) of the extract was calculated to assure the anti-microbial activity. The results were confirmed by performing Gram-stained smears. From Gram-stained smears, it was illustrated that the test extract was highly active against Bacillus subtilis and moderately active against Klebsiella Pneumonia. The test extract also exhibited a commendable activity against Candida albicans implying the anti-fungal activity of the plant (Rashed and Butnariu, 2014).

Anthelmintic activity

The Petroleum ether, Ethanol, and aqueous extract of the whole plant of *Bauhinia racemosa* Lam. were subjected to anthelmintic activity using the

saline solution as control and Albenzadole as reference drug. For the performance of the anthelmintic assay, Indian adult earthworms, *Pheretima Posthuma*, which resemble roundworm parasites of human intestine anatomically and physiologically was employed. Time taken for complete paralysis and death were the parameters evaluated. It was found that on a dose-dependent basis, all the extracts showed a comparable activity with that of the reference drug. Thus, the plant is found to possess prominent anthelmintic activity (Kumar *et al.*, 2011).

Anti-filarial activity

The leaves of *B. racemosa* Lam. were extracted using Ethanol and then fractionated using n-Hexane, Chloroform, and n- Butanol for the anti-filarial studies. In-vitro studies on the fractions showed that n-Butanol fraction was the most active fraction, and further isolation of the n-Butanol fraction led to the isolation of Galactolipids and some catechins. Both in-vitro and in-vivo studies were deployed for the anti-filarial assay. *Brugia malayi*, a human lymphatic filarial parasite, was recovered from the peritoneal cavity of infected *Meriones unguiculatus*, jirds for in-vitro studies, and in-vivo studies were performed by intraperitoneally transplanting the *B. malayi* parasite. Ivermectin and Diethylcarbamazine (DEC) were the reference drugs employed in the assay. The adult worms and microfilaria forms of the parasite were subjected to the assay. In the in-vitro assay, Minimum Inhibitory Concentration (MIC), IC_{50} value, CC_{50} value of the isolated Galactolipids, and Catechins were tested. The in-vitro results revealed that the Galactolipids exhibited prominent anti-filarial activity when compared with the Catechins. The long-chain fatty acid present in the Galactolipids accounted for the anti-filarial activity of these compounds, which were found out from further evaluation. In-vivo studies were done on the male jirds by two methods by administrating subcutaneously and intraperitoneally at 100 mg/kg and 50 mg/kg for 5 days, respectively. Both the in-vitro and in-vivo anti-filarial results imply that the Galactolipids isolated from *the B. racemosa* plant possesses good anti-filarial activity in comparison to the control, Ivermectin (Sashidhara *et al.*, 2012).

Anti-histaminic activity

The ethanolic extract of the leaves of *B. racemosa* was subjected to the in-vivo assay of anti-histaminic activity using Clonidine-induced catalepsy model and Haloperidol-induced catalepsy model in Swiss albino mice. Pheniramine maleate was selected as the standard drug for the analysis of anti-histaminic activity. Both models were evaluated using the bar test. Ethanolic extract was administered in a dose of 50 mg/kg intraperitoneally as a pre-treatment in both the models. Clonidine-induced catalepsy was inhibited by the ethanolic extract of the leaves, whereas it was ineffective against Haloperidol-induced catalepsy. The anti-histaminic activity of the ethanolic extract of the plant makes it a promising candidate for Asthma treatment (Nirmal *et al.*, 2011).

Anti-inflammatory activity

The anti-inflammatory activity of the Methanolic extract of stem bark of *B. racemosa* was evaluated using the in-vivo technique. Models used for the assay include Carrageenan-induced, Dextran-induced, Histamine & Serotonin-induced, and Cotton pellets-induced paw edema. Indomethacin, a non-steroidal anti-inflammatory drug, was used as a reference drug. The extract was administered at a dose of 50, 100, 200 mg/kg to the mice. The results imply an effective anti-inflammatory activity of *B. racemosa* when compared to the standard drug Indomethacin (Gupta *et al.*, 2005).

Analgesic activity

Analgesic activity of the stem bark was evaluated using Methanolic extract in two models of the in-vivo assay. Acetic acid-induced writhing in mice and hot plate reaction time was employed for the evaluation. Aspirin was treated as the standard drug. The in-vivo results illustrate that the Methanolic extract not only inhibits the Acetic-acid induced writhing but also act synergistically with Aspirin in producing analgesia. For the hot plate reaction time experiment, Morphine was used as the reference drug. Both the models produced comparable results in analgesic activity. But the results of hot plate reaction time demonstrate the potential of the plant to produce a centrally acting analgesic (Gupta *et al.*, 2005).

Anti-pyretic activity

Methanolic extract of the stem bark of *B. racemosa* was assayed for its antipyretic activity using Yeast-induced hyperpyrexia in mice. The rectal temperature was measured after 24 hours of oral administration of the extract and Paracetamol, the standard drug. Pre-drug control temperature was recorded 1 hour prior to the administration of the drug in the fevered animals. After 1-4 hours of drug treatment, the temperatures were recorded. The results illustrate that the extract shows valid antipyretic action when compared with the standard drug (Gupta *et al.*, 2005).

Anti-tumor activity

The stem bark of *B. racemosa* was extracted using

Methanol, and the extract was used for the in-vivo assay on Ehrlich Ascites Carcinoma (EAC) in mice model. 5-Fluorouracil was used as the standard drug of treatment at a dose of 50 mg/kg, whereas the extract was administered at 50, 100, 200 mg/kg doses. EAC cells were injected into the mice via the intraperitoneal route. After 18 hours of fasting after the drug administration, half of the animals were sacrificed to study the parameters of assay and the other half to assess the mean survival time. The parameters under assessment include liver biochemical parameters, which include lipid peroxidation and Glutathione estimation; hematological parameters comprise of Hemoglobin content, total Red Blood Corpuscles (RBC) count, and total White Blood Corpuscles (WBC) count. Some observational changes were also assessed, such as ascetics tumor volume, change in body weight, packed cell volume, the percentage increase in life span, mean survival time, viable and non-viable tumor cell count. The results expressed the inhibition of body weight, packed cell volume, tumor cell count, and volume. The deprived hematological parameters, hepatic lipid peroxidation, and Glutathione enzymes were retrieved to its normal count. Thus, *B. racemosa* assures the potential of anti-cancer activity (Gupta *et al.*, 2004).

Anti-ulcer activity

Anti-ulcer activity of the aqueous and alcoholic extract of the stem bark of *B. racemosa* was evaluated using a Paracetamol-induced Gastric ulcer model using Wistar albino rats. Ulcer reading, ulcer index, and healing index were the parameter of the study. A decrease in the ulcer number was recorded in the animals treated with alcoholic and aqueous extract and ulcer score decrease in the alcoholic extract-treated animals. The flavonoids present in the plant accounts for its anti-ulcer activity (Borikar *et al.*, 2009).

Anti-diabetic activity

Anti-diabetic activity of the Petroleum ether extract of leaves of *B. racemosa* was evaluated using the Streptozotocin (STZ) induced diabetes model and the eighteen-hours fasted rat model in doses 250 mg/kg and 500 mg/kg. Glibenclamide was used as the reference drug for the in-vivo assay. In Oral Glucose Tolerance Test (OGTT), blood glucose level was recorded at 0 min, 30 min, and 90 min, and another technique Glucose Oxidase/Peroxide method was also employed for the same analysis. Despite the in-vivo assay, the Insulin ELISA test was also performed to study the anti-diabetic potential. In an eighteen-hours fasted rat model, the extract decreased the blood glucose level at a dose of 250 mg/kg, and at 500 mg/kg dose showed a comparable effect with Glibenclamide. In the OGTT method, although an increase in blood glucose level was seen at 30^{th} min, at 90^{th} min, blood glucose level showed a prominent decrease in the dose of 500mg/kg comparable to that of the reference drug. In STZ-induced diabetes model, the fasting serum glucose level and Insulin level were recorded at 7^{th} day, 14^{th} day, 21^{st} day and 28^{th} day and the observations show a vital decrease in the fasting serum glucose level and increase in the Insulin level assuring the anti-diabetic potential of *B. racemosa* (Kumar *et al.*, 2017).

CONCLUSION

From the above concise review, knowledge has been imparted on the different aspects of *Bauhinia racemosa* Lam. such as taxonomical classification, phytoconstituents, and the pharmacological actions of the plant. The plant has been subjected to numerous isolation procedures and many compounds such as Resveratrol, Racemosolone, Pacharin, Lupeol, etc. These compounds do play an important role in the therapeutic properties exhibited by the plant. Some of the reported pharmacological actions of the plant include anti-microbial, anthelmintic, antifilarial, anti-tumor, anti-diabetic, anti-histaminic activities. The complete therapeutic potential of the plant must be explored further, and isolated compounds have to be formulated for the betterment of mankind

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