Review Article

Therapeutic Potential of *Bauhinia Racemosa* - A Mini Review

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ABSTRACT

This review is aimed at the integration of traditional ethno-medicinal knowledge and modern scientific findings about *Bauhinia racemosa* in order to have understanding of its important therapeutic potential. It may attract the attention of natural product researchers throughout the world to focus on the unexplored potential of *Bauhinia racemosa*. More than 200 species of flowering plants are available under the genus *Bauhinia*, of which *racemosa* is one, which is known as 'Sonpatta Tree' as it is being considered to be as valuable as gold for its medicinal values. It is a small, crooked, bushy, deciduous tree with drooping branches and can grow in poor and very harsh climatic conditions. The tree is staggeringly beautiful when in bloom and it blooms for several months with flowers found in shades of magenta, lavender, purplish blue or even white. Almost each and every part of the plant possesses medicinal values. The bark and leaves of *B. racemosa* are sweetish and acrid, refrigerant, astringent and is used in the treatment of headache, fever, skin diseases, blood diseases, dysentery and diarrhoea. A decoction of the bark is recommended as a useful wash for ulcers. The tree is demonstrated to have anti-oxidant and hepato-protective effects. An extract of the leaves has been proved to show analgesic, anti-pyretic, anti-inflammatory, anti-spasmodic, anthelmintic and anti-microbial activity as well. The tree has anti-tumor qualities and is widely used in Ayurveda to treat first stage cancer. Chemical constituents such as ß-sitosterol and ß-amyrin, probably responsible for the popular use of the plant, were isolated from the stem bark of this plant. Also five flavonols (kaempferol and quercetin) and two coumarins (scopoletin and scopolin) were isolated from the leaves of the plant. Stilbene (resveratrol) was isolated from the heartwood of *B. racemosa*.

Keywords: ß-sitosterol, anti-inflammatory, *Bauhinia. racemosa,* anti-oxidant

INTRODUCTION

In spite of convincing progress in synthetic chemistry and Biotechnology, plants are the most important sources for preventive and curative medicinal formulations. Large scale use of medicinal plants and herbs in preparation of such formulations is increasing both in the developed as well as developing countries due to growing concern about the adverse effects of chemical and synthetic substances. The plant based drugs have the added advantage of being simple, effective, and offering a broad spectrum activity with an emphasis on the preventive action of drugs. Because of these factors, the demand for phyto pharmaceuticals is increasing worldwide. The plant under review is a valuable Indian medicinal plant, which enjoys ethnobotanical and ethnopharmacological importance.[1]

Bauhinia racemosa Lam (The Sonpatta Tree) is a small, crooked, bushy, deciduous tree with drooping branches, which can grow in poor and very harsh climatic conditions. The deciduous tree is propagated easily from seed.

Bauhinia is a genus of more than 200 species of flowering plants of subfamily, Caesalpiniaceae. Many species are widely planted in the tropics as orchid trees, particularly in northern India, Vietnam and southeastern China. This particular species *racemosa* is widely distributed throughout India, ascending to an altitude of 1,650 m from sea level in the western Himalayas, and in Ceylon, China and Timor. It is a useful species for filling blanks in forest plantings and helps in preventing soil erosion. In the United States of America, the trees grow in Hawaii, coastal California, Texas, Louisiana, and Florida.[2]

The plant is popularly known as *Sittacha* (Tamil), Banraj (Bengali), *Ashta, Jhinjeri, Katmauli*, *Kachnal* (Hindi), *Aapta, Aralukadumandara, Vana samtige* (Kannada), *Apto* (Konkani), *Omboroda* (Odia), *Kosundra* (Punjabi), *Arampaali, Kutabuli, Malayaththi* (Malayalam), *Asundro* (Gujrati), *Apta, Sona* (Marathi), *Yamalapatrakah, Yugmapatra, Ashmantaka, Kanchini* (Sanskrit), *Atti, Tataki, Kokku mandarai*, (Tamil), *Arechettu* (Telugu), *Kachnaar* (Unani). Other common names include *Mountain Ebony* and *Kachnar* (India and Pakistan).

The bark and leaves of *B. racemosa* are sweetish and acrid, refrigerant, astringent and is used in the treatment of headache, fever, skin diseases, blood diseases, dysentery and diarrhea.

A decoction of the bark is recommended as a useful wash for ulcers. The tree is demonstrated to have anti-oxidant and hepato-protective effects. An extract of the leaves has been proved to show analgesic, anti-pyretic, anti-inflammatory, anti-spasmodic, anthelmintic and anti-microbial activity. The tree has anti-tumor qualities and is widely used in Ayurveda to treat first stage cancer[3,4]. The root of *B. racemosa* contains a new tetra cyclic lupeol, betulin, β-sitosterol, and tetracyclic 2, 2-dimethyl chroman[5,6]. The seed contains flavonoids, crude protein, and lipid[7,8]. The bark of the plant contains ß-sitosterol and ß-amyrin and the leaves contain flavonols (kaempferol,

quercetin) and coumarins (scopoletin and scopolin). Stilbene (resveratrol) was isolated from the heartwood of *B. racemosa*[9].

Botanical Description

B. racemosa is a small crooked tree with dark scabrous bark, containing numerous drooping branches. The trees typically reach a height of 6–12 m and their branches spread 3–6 m outwards. The other important associated species under this genus *Bauhinia* include *B. tomentosa* Linn, *B. retusa* Roxb. *B. vahlii* Wight, *B. purpurea* Linn, *B. variegate* Linn, *B. malabarica* Roxb, B. *macrostachya* Wall. The bark of *B. racemosa* is bluish black, rough, pinkish red inside, which turns brown on exposure. The leaves are broader than long, having size 2-5 cm by 2.5-6.3 cm, divided a little less than half way down into two rounded lobes. The upper surface of leaf being green and glabrous, rigidly coriaceous, slightly cordate, clothed more or less densely beneath with grey pubescence and base is usually cordate. The five-petaled flowers are 7.5–12.5 cm diameter, generally in shades of red, pink, purple, orange, or yellow, and are often fragrant. The tree begins flowering in late winter and often continues to flower into early summer. The flowers are in short-peduncle, lax, terminal and leaf-opposed racemes. The calyx being pubescent, contain very short tube, limbs are of 6-8 mm long and the petals are narrowly oblanceolate, acute, 10-15 mm long. The flowers contain 10 fertile stamens with densely hairy filaments at the base and ovary is pubescent with sessile stigma. The pods are stalked, 15-25 in number having size of 1.3-2.2 cm, blunt at the apex and tapering to the base, somewhat falcate, glabrous, turgid, scarcely veined. Each pod contains 12-20 dark reddish brown, oblong, compressed, rounded at the apex, seeds. The bark of *B. racemosa* is bluish black, rough, pinkish red inside, which turns brown on exposure.[10,11,12]

Economic Importance

The leaves of *B. racemosa* are used for making *bidis,* thus the plant is commonly known as bidi leaf tree. Also the plant makes good fodder for sheep, goats and cattle. The flowers are of much importance in apiculture and also as a pot herb in curries and made into pickle (*chutni*). The tree yields a useful gum and fibers. The bark is used for tanning and dyeing. Almost each and every part of this tree possesses some medicinal values. It is planted for its value as well as for its extreme beauty. It is one of the loveliest of Indian trees. The tree is staggeringly beautiful when in bloom and it blooms for several months. Its flowers can be found in shades of magenta, lavender, purplish blue or even white. The wood is hard and heavy, thus used for making plough and yokes and also used as fuel.

Nutritional Importance

The Indian tribal pulse of *B. racemosa* was analyzed for pod morphology, proximate composition, seed protein fractions, amino acid composition, minerals and antinutritional factors. The seeds of *B. racemosa* were rich in Ca and Fe. Albumins and globulins constituted less predominant fractions of the seed protein whereas glutelins predominated in *B racemosa*. The contents of the essential amino acids lysine, tyrosine and phenylalanine were fairly high where as the contents of sulphur amino acids were limiting.

Further, two germplasms of *B. racemosa.* viz., Ayyanarkoil Forest and Mundanthurai Wildlife Sanctuary were analyzed for their nutritional values. Crude proteins, crude lipids, ash and nitrogen free extractives constituted 19.84%, 9.52%, 3.31% and 60.65%, respectively in Ayyanarkoil Forest germplasm. In Mundanthurai Wildlife Sanctuary germplasm they constituted 19.31%, 8.94%, 3.81% and 61.30%, respectively. The caloric values were found to be 407.64 KCal (Ayyanarkoil Forest) and 402.90 KCal (Mundanthurai Wildlife Sanctuary) germplasms. Essential amino acids like isoleucine, tyrosine, phenylalanine and lysine were found to be high in the seed proteins of both the germplasms. The fatty acids, palmitic, oleic and linoleic acids were found to be relatively higher in the seed lipids of both the germplasms. Both the germplasms seemed to be a rich source of calcium, potassium, magnesium, zinc, manganese and iron. Antinutritional substances like total free phenols, tannins, L-DOPA and phyto-haemagglutinating activity also were investigated.[13,14]

Pharmacological Investigation

Antitumor Activity

Some studies have revealed the antitumor activity of *B. racemosa.* For this study Male Swiss albino mice were divided into 6 groups (n=12). All the groups were injected with EAC cells (0.2 mL of 2×10^6 cells/mouse) intraperitoneally except the normal group. From the first day normal saline 5 $mL\cdot kg^{-1}\cdot mouse^{-1}\cdot d^{-1}$ and propylene glycol 5 $mL\cdot kg^{-1}\cdot mouse^{-1}\cdot d^{-1}$ were administered intraperitoneally to normal and EAC control groups respectively for 14 days. Similarly the plant extract at different doses (50, 100, and 200 $mg\cdot kg^{-1}\cdot mouse^{-1}\cdot d^{-1}$) and standard drug 5-flurouracil (20 mg/kg) were administered in groups 3, 4, 5, and 6, respectively. After the administration of last dose followed by 18 h fasting 6 mice from each group were sacrificed for the study of antitumor activity, hematological and liver biochemical parameters. The remaining animals in each of the groups were kept to check the mean survival time (MST) of the tumor bearing hosts.

Antitumor effect of methanolic extract was assessed by observation of changes with respect to body weight, tumor volume, packed cell volume, viable & non-viable tumor cell count, MST and percentage increase in life span (% ILS). MST of each group containing six mice was monitored by recording the mortality daily for 6 weeks and % ILS was calculated.

Anemia and myelo-suppression create problems in cancer chemotherapy. When tumor bearing mice were treated

with the methanol extract of *B. racemosa,* the hemoglobin content, RBC and WBC cell count brought back near to normal values. Also the studies showed a decrease in tumor volume and viable tumor cell count and finally cause reduction in the tumor burden and made enhancement in the life span of EAC bearing mice.[15,16,17]

Anti-inflammatory, Antipyretic and Analgesic Activity

The anti-inflammatory, analgesic and antipyretic effects of methanol extract obtained from *B. racemosa* stem bark were investigated at the dose level of 50, 100 and 200 mg/kg body weight. The effects of the extract on the acute and chronic phases of inflammation were studied in carrageenan, dextran, histamine and serotonin induced paw edema and cotton pellet-induced granuloma, respectively. The plant extract (200 mg/kg b.w.) and indomethacin (10 mg/kg b.w.) decreased the formation of granuloma tissue induced by cotton pellet method at a rate of 50.4 and 56.2%, respectively. The extract also inhibited peritoneal leukocyte migration in mice. The anti-edema effect of the extract was compared with 10 mg/kg of indomethacin orally. In acute phase of inflammation, a maximum inhibition of 44.9, 43.2, 44.8 and 45.9% ($P < 0.001$) was noted at the dose of 200 mg/kg b.w. after 3 h of treatment with the extract in carrageenan, dextran, histamine and serotonin-induced paw edema, respectively.[18]

Analgesic effect of the extract was evaluated in acetic acid-induced writhing, hot plate test and tail immersion method. Aqueous and alcoholic extracts of dried stem bark of *B. racemosa* at the dose of 100 and 200mg/kg body weight were used in the study. Aqueous extract of stem bark at 200mg/kg body weight produced significant analgesic activity, whereas 100mg/kg dose did not produce significant results when compared with control. The analgesic activity of alcoholic extract produced significant results at both the doses. Further, the methanolic extract of *B. racemosa* potentiated the morphine-and aspirin-induced analgesia in mice.[19]

Antipyretic activity was evaluated by yeast-induced hyperpyrexia in rats using alcoholic extract of the stem bark of *B. racemosa*. The pyrexia was induced by injecting a suspension of 15% of brewer's yeast and 2% gum acacia in normal saline sub-cutaneously below the neck at the dose of 1ml/100gm of animal weight. The difference in temperature between 0 hour and respective time interval was found out by statistical method. The potency of extract to bring down the temperature was compared with that of the control group. Treatment with the extract showed a significant dose-dependent reduction in pyrexia in rats.[20]

Antihyperglycemic Activity

Both alcohol and aqueous extracts of *B. racemosa* were employed to assess the anti-hyperglycemic activity against alloxan induced hyperglycemic rats, which showed a significant decrease ($p<0.05$) in body weight on days 10, 15, 20 of the experiment. Daily oral treatment with both extracts showed significant increase ($p<0.05$) in body weight at the end of the experiment as compared to diabetic control group. This study showed that the treatment of alloxan induced rats with both methanol and aqueous extracts of *B. racemosa* for 20 days could restore the normal biotransformation by shifting the balance of carbohydrate metabolism. Improved pancreatic exocrine activities may be mediated due to insulin secretion from existing residual Beta-cells of islets.[21]

Hepatoprotective Activity

The methanol extract of *B. racemosa* Lam. (Caesalpiniaceae) stem bark was investigated for the hepatoprotective effects in Wistar albino rats. Different groups of animals were administered with paracetamol (500 mg/kg, (p.o.) once in a day for 7 days) and carbon tetrachloride (CCl4) (30 % CCl4, 1 ml/kg b.w. in liquid paraffin 3 doses (i.p.) at 72 h interval). The methanol extract of *B. racemosa* at the doses of 50, 100 and 200 mg/kg and silymarin 25 mg/kg were administered to the paracetamol and CCl4 treated rats. The effect of the extract and silymarin on serum transaminase (SGOT, SGPT), alkaline phosphates (ALP), bilirubin and total protein were measured in the rats induced hepatotoxicity by paracetamol and CCl4. Further, the effects of the extract on lipid peroxidation (LPO), glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT) were estimated. The plant extract and silymarin produced significant ($P < 0.05$) hepatoprotective effect by decreasing the activity of serum enzymes; bilirubin and lipid peroxidation and significantly ($P < 0.05$) increased the levels of GSH, SOD, CAT and protein in a dose dependant manner. The alcoholic extract also showed antioxidant effects on $FeCl_2$-ascorbate induced lipid peroxidation in rat liver homogenate and on superoxide scavenging activity. From these results, it was suggested that the extract could protect the liver cells from paracetamol and CCl4-induced liver damages perhaps, by its antioxidative effect on hepatocytes, hence eliminating the deleterious effects of toxic metabolites from paracetamol.[22,23,24,25]

Antioxidant Activity

To evaluate the antioxidant activity of the methanol extract of *B. racemosa* (Caesalpiniaceae) stem bark in various systems, 1, 1-Diphenyl-2-picryl-hydrazyl (DPPH) radical, superoxide anion radical, nitric oxide radical, and hydroxyl radical scavenging assays were carried out. The antioxidant activity of the methanol extract increased in a concentration-dependent manner. About 50, 100, 250, and 500 µg of the extract inhibited the peroxidation of a linoleic acid emulsion by 62.43, 67.21, 71.04, and 76.83%, respectively. On the similar way, the effect of alcoholic extract on reducing power increased in a concentration-dependent manner. In DPPH radical scavenging assays the IC_{50} value of the extract was 152.29 µg/ml. The alcoholic extract inhibited the nitric oxide radicals

generated from sodium nitroprusside with an IC_{50} of 78.34 µg/ml. The stem bark extract was investigated for the antioxidant effects on lipid peroxidation (LPO), glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT) estimation.

The extract also showed antioxidant effects on $FeCl_2$-ascorbate induced lipid peroxidation in rat liver homogenate and on superoxide scavenging activity.[26,27]

Antimicrobial Activity

The antimicrobial activity of the leaves of the *B. racemosa* was evaluated by using the aqueous and methanol extract against standard bacterial and fungal cultures. *In vitro* antimicrobial test was performed by agar well diffusion method on Mueller hinton agar and Sabouraud dextrose agar for bacterial and fungal cultures respectively. Minimum inhibitory concentration test was performed by modified agar well diffusion method. Methanol extract showed significantly higher inhibitory effect compared to aqueous extract on tested organisms. The methanol extract showed a broad spectrum of antimicrobial activity as it inhibited Gram negative bacteria (*Escherichia coli, Micrococcus luteus, and Pseudomonas aeruginosa*), Gram positive bacteria (*Bacillus subtilis*) and fungi (*Candida albicans* and *Aspergillus niger*). Both extracts showed maximum relative percentage inhibition against *A. niger.* MIC values for methanol extract varied from 1.5-25 mg/ml.[28]

The petroleum ether extract, chloroform extract, ethyl acetate extract and methanol extracts of leaves of *B. racemosa* Linn. were prepared and antibacterial activity were studied by disc diffusion method against certain enteric bacterial pathogens such as *Escherichia coli, Staphylococcus aureus, Klebsiella pneumonia, Enterobacter aerogenes, Pseudomonas aeruginosa, Salmonella typhimurium, Salmonella typhi, Staphylococcus epidermidis* and *Proteus vulgaris*. The Methanol extracts had wide range of antibacterial activity against enteric bacterial pathogens than the petroleum ether extract, where as ethyl acetate extract were slightly higher antibacterial activity than chloroform extract.[29,30,31,32]

Antiulcer Activity

The dried fruit powder of the plant *B. racemosa was used* to study the antiulcer effect in Wistar albino rats. Thirty Wistar rats of either sex weighing between 150 - 200gm were selected and divided into five groups, each comprising of six rats. The rats were divided into 5 groups T1, T2, T3, T4, and T5 and were given 0.5 ml normal saline, aqueous extract at the dose rates of100mg/kg, 200mg/kg and alcoholic extract of 100mg/kg and 200mg/kg respectively. After one hour all the groups were administered Paracetamol at a dose rate of 200mg/kg body weight orally. After 24hrs, the number of ulcers, ulcer score, percent incidence, ulcer index and healing index were recorded. From the results obtained it was concluded that aqueous extract in the dose of 200mg/kg body weight and alcoholic extract (100mg/kg & 200mg/kg body weight) could produce antiulcer activity[33].

Antihistaminic Effect

The leaves of *B. racemosa* have been used in the treatment of asthma traditionally. Thus, to scientifically validate its benefit in asthma the study was undertaken using suitable animal models. The antihistaminic activity of the ethanol extract of *B. racemosa* (at a dose of 50 mg/kg, i.p.) was assessed using clonidine-induced catalepsy and haloperidol-induced catalepsy in Swiss albino mice. The results showed that the ethanol extract inhibits clonidine-induced catalepsy but there is no effect on haloperidol-induced catalepsy. This suggests that the inhibition is through an antihistaminic action and that there is no role of dopamine. Hence, it is concluded that the ethanol extract has significant antihistaminic activity.[34]

Anxiolytic Activity

This study was performed to investigate the anxiolytic-like effects of methanolic extract of *B. racemosa* (MEBR) in mice using the elevated plus-maze model (EPM), light dark model, hole board test, foot shock induced freezing behavior. Furthermore, the anxiolytic-like effects of MEBR were compared to a known active anxiolytic drug (Diazepam).

The extract administered orally in two different doses of 150mg/kg and 300mg/kg, was able to increase the time spent and the number of arm entries in the open arms of the elevated plus-maze. The increase in time spent by mice in the illuminated side of the light–dark test, showed significant increase in nose poking and decrease locomotion in hole board test, as well as caused significant reduction in freezing time in comparison with control animals. This effect was comparable to that of the benzodiazepine diazepam (2.0mg/kg p.o.). These results indicate that methanolic extract of *B. racemosa* is an effective anxiolytic agent.[35]

Anti-HIV Activity

The effect of *B. racemosa* extracts on acute HIV-1 infectivity was measured by the syncytia formation assay. In the presence or absence of various concentrations of samples, 4×104 C8166 cells were infected with HIV-1 at a multiplicity of infection (MOI) of 0.015, and cultured in 96-well plates at 37°C in 5% CO_2 for 3 days. AZT was used as a positive control. After 3 days post-infection, the cytopathic effect (CPE) was measured by counting the number of syncytia (multinucleated giant cell) in each well of 96-well plates under an inverted microscope (100×).

The inhibitory percentage of syncytia formation was calculated by the percentage of syncytia number in sample-treated culture compared to that in infected control culture 50% effective concentration (EC50) was calculated, 50% cytotoxic concentration (CC50) and 50% effective concentration (EC50) was also determined.[36]

Anthelmintic Activity

Anthelmintic activity of stem bark, leaves, seeds and root of *B. Racemosa* were separately studied using Indian adult earthworms, *Pherentima posthuma*. Results showed that the leaves of *B. Racemosa* took less time to cause paralysis and death of the earthworms. The petroleum ether, chloroform, ethyl acetate and methanol extracts of leaves were also studied for their anthelmintic activity, which involved determination of the time of paralysis and time of death of the worms. Results showed that the petroleum ether extract of leaves of *B. Racemosa* at 60 mg/ml was most potent as compared to other extracts and standard drug Albendazole. The order of potency was observed as petroleum ether > ethyl acetate > methanol > chloroform extract. It can be concluded that anthelmintic activity of the leaves of *B. Racemosa* is due to the active principles present in the petroleum ether and ethyl acetate extracts.[37]

Phytochemistry

Various parts of *B. racemosa* plant have yielded different phytoconstituents on their extraction and isolation. Bioassay guided fractionation of ethanolic extract of the leaves of *B. racemosa* led to the isolation of galactolipid and catechin class of the compounds from the most active n-butanol fraction. Among the active galactolipids, (2S)-1, 2-di-O-linolenoyl-3-O-a-galactopyranosyl-(1/6)-O-b-galactopyranosyl glycerol emerged as the lead molecule which was active on both forms of lymphatic filarial parasite, *Brugia malayi*. It was found to be better than the standard drug ivermectin and diethylcarbamazine (DEC) in terms of dose and efficacy. The other phytoconstituents found in the n-butanol fraction include (2S)-1-O-linolenoyl-2-O-palmitoyl-3-O-a-galactopyranosyl-(1/6)-O-b-galactopyranosyl glycerol and (2S)-1-O-oleoyl-2-O-palmitoyl-3-O-a-galactopyranosyl-(1/6)-O-b-galactopyranosyl glycerol, whereas catechins were characterized as (-) epiafzelechin, (-)-epicatechin and (-)-catechin together with protocatechuic acid.[38]

The root bark of *B. racemosa* yielded one new compound, which was characterized as racemosolone, a pentacyclic phenolic compound possessing an unusual skeleton with a cycloheptane ring and a rare furopyran moiety. The structure elucidation was carried out on the basis of UV, infrared (IR), HR-ESI-MS, 1D and 2D NMR spectra and finally confirmed by the single crystal X-ray analysis. The known compounds were characterized as n-tetracosane, b-sitosteryl stearate, eicosanoic acid, stigmasterol, b-sitosterol, racemosol, octacosyl ferulate, de-O-methyl racemosol, lupeol and 1,7,8,12b-tetrahydro-2,2,4-trimethyl-2H-benzo[6,7]cyclohepta [1,2,3-de][1] benzopyran-5,10,11 triol on the basis of spectroscopic data comparison with the literature value. Compounds with skeleton similar to racemosolone have never been reported from any natural or other source.[39]

Various root extracts of *B. racemosa* on isolation have produced different polyphenolics, viz. 1,7,8,12b-tetrahydro-2,2,4-trimethyl-10-methoxy-2H-benzo [6,7] cyclohepta[1,2,3-de][1]benzopyran-5,9-diol (racemosol), 1,7,8,12b-tetrahydro-2,2,4-trimethyl-2H-benzo[6,7]cyclohepta[1,2,3-de][1]benzopyran- 5,10,11-triol and 1,7,8,12b-tetrahydro-2,2,4-trimethyl-2H-benzo[6,7] cyclohepta [1,2,3-de][1]benzopyran-5,9,10-triol (de-O-methyl racemosol). These were screened for antibacterial, antifungal, and antiviral activities. The isolated compounds exhibited profound antibacterial and antifungal activities while methanol extract exhibited potential efficacy against *Herpes simplex* virus.[40]

The root bark of *B. racemosa* produced a new tetracyclic 2, 2-dimethylchroman derivative, de-Omethylracemosol, which was obtained from the column chromatographic separation of a benzene extract of the root bark on recrystallization from benzene as brown crystals.[9] The roots of *B. racemosa* afford lupeol, betulin and sitosterol along with a novel tetracyclic phenol. The latter is identified as 3-hydroxy-de-*O*-methyl racemosol by comparative spectral studies with racemosol and de-*O*-methyl racemosol isolated earlier from this plant.[36]

Phytochemical analysis of the methanol extract and other extracts of stem of *B. racemosa* has shown bioactive components such as flavonoids, tannins and terpenes. While on further chromatographic separation of the bioactive components resulted in the isolation and identification of two triterpenic acids; oleanoic and ursolic, two hydrolysable tannins, gallic and ellagic acids, and three flavonoids; luteolin, quercetin 3-O-β-glucoside and myricetin 3–O–β–glucoside.[5]

The heartwood of *B. racemosa* was extracted and isolated to produce a new dibenzoxepin derivative, pacharin. Its structure has been established as I, 7-dlhydroxy-3-methoxy-2-methyl-dibenzo (2, 3-6, 7) oxepin by the study of its chemical and spectroscopic properties, including X-ray analysis.[8,41]

CONCLUSION

B. racemosa, the versatile medicinal plant is the unique source of various types of compounds having diverse chemical structure. Some studies have been done on the biological activity and plausible medicinal applications of these compounds and hence a thorough investigation is needed to exploit their therapeutic utilities for combating diseases. A formulation development programme may be undertaken to develop, novel drugs with the compounds isolated from *B. racemosa*. Although crude extracts from various parts of this plant have medicinal applications from time immemorial, modern formulations can be developed after extensive investigation of its bioactivity, mechanism of action, pharmacotherapeutic and toxicity studies with help of standardization protocols and clinical trials. Global scenario is now changing toward the use of nontoxic plant products having traditional medicinal uses. Therefore, development of novel drugs from the centuries old knowledge on this tree should be undertaken for the control of various diseases. In fact,

time has arrived to make good use through modern approaches of drug development and a significant amount of research has already been carried out during the past few decades in exploring the chemistry of different parts of the plant, which generate enough encouragement amongst the researchers in exploring more information about this medicinal plant. *B. racemosa* and its products enjoy the importance for their economics and therapeutic utilization. Hence, this review article might be helpful for researchers to find further new chemical entities responsible for its claimed traditional activities.

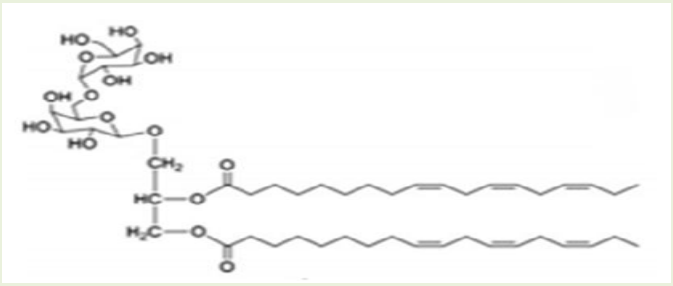
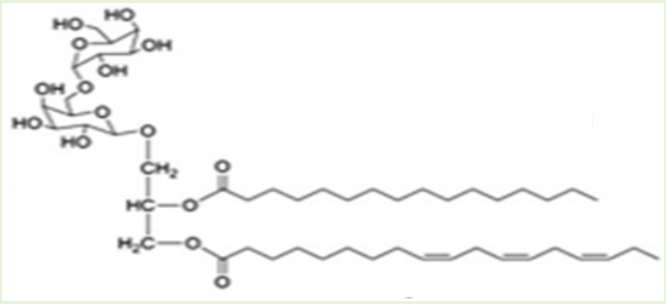
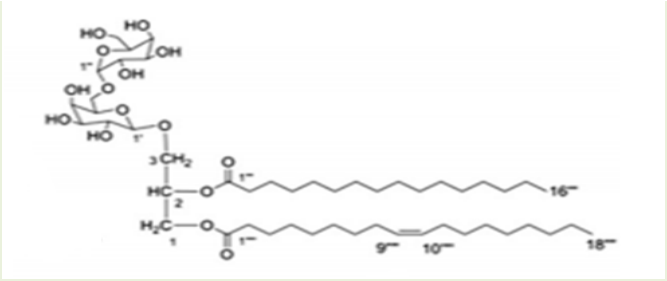
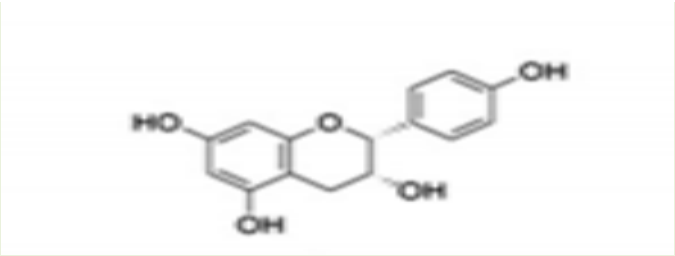
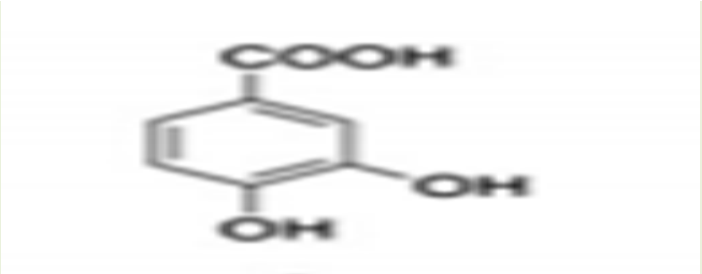
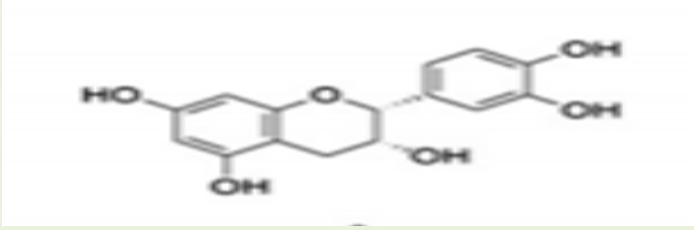
Table1: Ethnomedicinal uses and pharmacological activities of *Bauhinia racemosa*

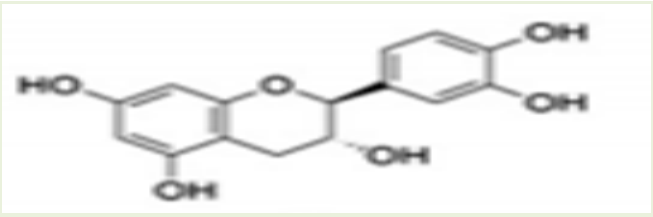
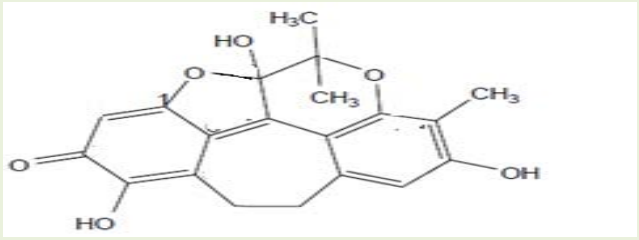
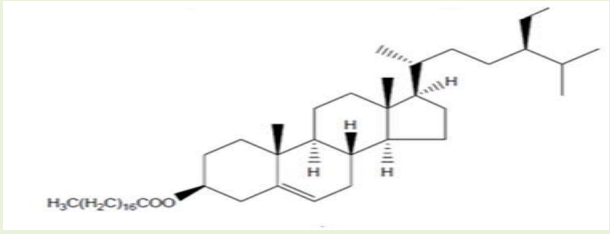
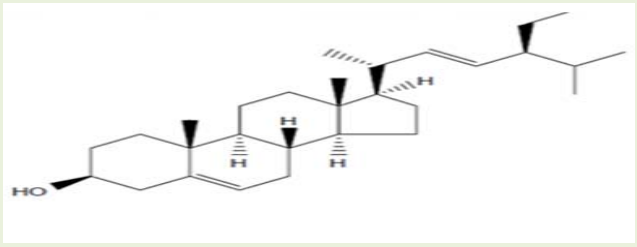
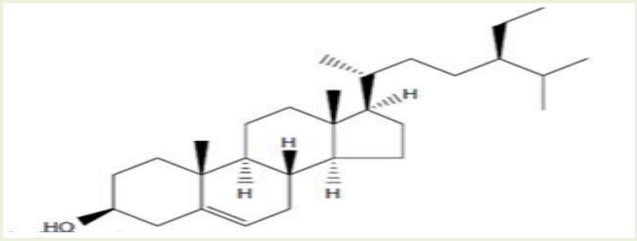
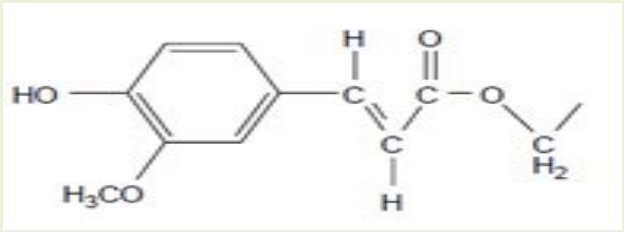
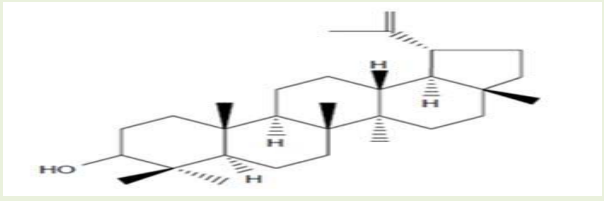
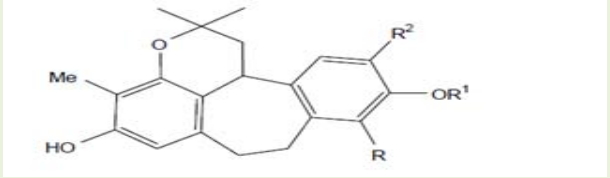
Plant part	Chemical Constituents	Method of Preparation	Uses/Properties	Reference
Leaf	Flavonols (Kaempferol, Quercetin) and Coumarins (Scopoletin and Scopolin).	Decoction with onion Unspecified extract	Malaria	25, 26
			Diarrhoea	
			Anthelmintic	19
			Analgesic	20
			Anti-pyretic	30
			Anti-inflammatory, Anti-spasmodic, Anthelmintic	
			Anti-microbial	12
			Antihyperglycaemic	21
			Antihistaminic	33
			Antifilarial	40
			Antibacterial	27,28,29,30,31
			Nutritive	13,14,15
Bark	Octacosane B-amyrin B-sitosterol	Extract Decoction Methanol extract	Dysentery	18
			Anti-inflammatory	
			Analgesic	
			Antipyretic	
			Cholagogue	
			Headache, Fever, Skin diseases, Diarrhoea	
			Glandular inflammations, Skin diseases	29
			Antimicrobial	
			Wash for ulcer	
			Antitumor	15, 16,17
			Antioxidant	25,26
			Hepatoprotective	22, 23
			Antianxiety	34
			Antiulcer	32
Entire plant		Extract	Hepatoprotective	
			Antitumor	
			Antioxidant	
			Antimicrobial	30
			Hypotensive	
			Hypothermic	28
Flower		Infusion	Laxative	
			Cough	
			Haemorrhages,	
Seed	Flavonoids, Crude protein, and lipid		Antibacterial	25, 26
Fruit		Alcoholic extract	Antiulcer	32
Root	Tetracyclic lupeol, Betulin, β-sitosterol, and tetracyclic 2, 2-Dimethyl chroman.			41
Heart Wood	Stilbene (resveratrol)			27

Table 2: Summary of pharmacological studies of B. *racemosa*

Pharmacological activity	Tested substance Study	model (type of study, duration of study, standard control)	Dose range (route of administration)	Reported dose	Reference
Antitumor Activity	Methanolic extract of stem bark	Injected with EAC cells (0.2 mL of 2×10^6 cells/mouse) intraperitoneally (in vivo, 14 days, 5-flurouracil (20 mg/kg))	50, 100, 200, 400 mg/kg	200 mg/kg	22, 15
Anti-inflammatory activity	Methanolic extract of stem bark	Carrageenan, Dextran, Histamine and Serotonin induced paw edema and cotton pellet-induced granuloma (*in vivo*, 3hr, Indomethacin (10mg/kg))	50, 100, 200 mg/kg	200 mg/kg	18
Analgesic effect	Aqueous and alcoholic extract of stem bark	Acetic acid-induced writhing, hot plate test and tail immersion method (*in vivo*, Aspirin (100 mg/kg))	100, 200 mg/kg	Alcoholic extract both 100 and 200 mg/kg, aqueous extract 200 mg/kg	20
Antipyretic	Methanolic extract of stem bark	Yeast-induced hyperpyrexia (15% aqueous suspension) (*in vivo*, 24hr, paracetamol(150 mg/kg))	50, 100, 200 mg/kg	200 mg/kg	20
Anti hyper glycemic Activity	Methanol and aqueous extract	Alloxan induced hyperglycemic rat (*in vivo*, 20 days)			21
Hepato protective activity	Methanolic extract of stem bark	Paracetamol (500 mg/kg, (p.o.) once in a day for 7 day, carbon tetrachloride (30 % CCl4, 1 ml/kg b.w. in liquid paraffin 3 doses (i.p.) at 72 h interval)	50,100,200 mg/kg		27, 30
Antioxidant Activity	Methanolic extract of stem bark	Radical scavenging activity using DPPH, superoxide anion radical, nitric oxide radical, and hydroxyl radical scavenging assay (in vitro, BHA, curcumin, Quercetin)	50, 100, 250, and 500 µg/ml	500 µg/ml	27, 30
Antimicrobial activities	Methanolic extract of stem bark	Disc diffusion method (*in vitro*, 24 hr, Ofloxacin (5µg/ml), Miconazole (40 µg/ml))	25, 50, 100, 200 µg/ml	200 µg/ml	28
Antiulcer Activity	Dried fruit powder of aqueous and methanolic extract	Paracetamol induced ulcer	100 and 200 mg/kg		33
Antihistaminic effect	Ethanolic extract of leaves	Clonidine (1 mg/kg, s.c.) and haloperidol (1 mg/kg, i.p.)-induced catalepsy (*in vivo*, 180 min., pheniramine maleate (10 mg/kg, i.p)	50 mg/kg	50 mg/kg	34
Anxiolytic Activity	Methanolic extract of stem	Elevated plus-maze model (EPM), light dark model, hole board test, foot shock induced freezing behavior (*in vivo*, diazepam (2mg/kg))	150mg/kg, 300mg/kg		35
Anti-HIV activity	Ethyl acetate, n-butanol, methanol and aqueous extract of stem	Syncytia formation assay (4×104 C8166 cells were infected with HIV-1) (*in vitro*, 3 days, AZT(4000µg/ml))	Ethyl acetate (1000, 200, 40, 8, 1.6 µg/ml) n-butanol (1000, 200 µg/ml), aqueous (1000, 200, 40 µg/ml), methanol (1000, 200, 40µg/ml)	Methanol extract (1000 µg/ml)	36

Table 3: Phytoconstituents of *Bauhinia racemosa*

S. No.	Chemical Structures	Chemical Names
1		**Figure 1:** (2S)-1, 2-di-O-linolenoyl-3-O-a-galactopyranosyl-(1/6)-O-b-galactopyranosyl glycerol
2		**Figure 2:** (2S)-1-O-linolenoyl-2-O-palmitoyl-3-O-a-galactopyranosyl-(1/6)-O-b-galactopyranosyl glycerol
3		**Figure 3:** (2S)-1-O-oleoyl-2-O-palmitoyl-3-O-a-galactopyranosyl-(1/6)-O-b-galactopyranosyl glycerol
4		**Figure 4:** Epiafzelechin
5		**Figure 5:** Protocatechuic acid
6		**Figure 6:** Epicatechin

7		**Figure 7:** Catechin
8		**Figure 8:** Racemosolone
9		**Figure 9:** β-sitosteryl stearate
10		**Figure 10:** Stigmasterol
11		**Figure 11:** β-sitosterol
12		**Figure 12:** Octacosyl ferulate
13		**Figure 13:** Lupeol
14		**Figure 14:** R=OH; R^1=Me; R^2=H (racemosol) R=OH; R^1=R^2=H (de-O-methyl racemosol) R=H; R^1=H; R^2=OH (1,7,8,12b-tetrahydro-2,2,4-trimethyl-2H benzo[6,7] cyclohepta [1,2,3-de] [1] benzopyran-5,10,11 triol)

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