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REVIEW ARTICLE

Review on pharmacological properties of *Caesalpinia bonduc* L.

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Abstract: *Caesalpinia bonduc* L. is a medicinal plant belonging to the family *Caesalpiniaceae*. It is a prickly shrub widely distributed all over the world especially in India, Sri Lanka and Andaman and Nicobar Islands, in India specially found in tropical regions. In Indian traditional plant medicine, it has been considered as an important remedy for the treatment of several diseases. It is popular in indigenous system of medicine like Ayurveda, Siddha, Unani and Homoeopathy. All parts of the plant have medicinal properties so it is a very valuable medicinal plant which is utilized in traditional system of medicine. The plant has been reported to possess anxiolytic, antinociceptive, antidiarrhoeal, antidiabetic, adaptogenic, anthelmintic, antiestrogenic, anti- inflammatory, antimalarial, antimicrobial, antifungal, antispasmodic, antioxidant, antiproliferative, antipsoriatic, antitumor, larvacidal, muscle contractile, hepatoprotective, anticonvulsant and antifilarial activities. Phytochemical analysis of *Caesalpinia bonduc* (L.) has revealed the presence of alkaloids, flavonoids, glycosides, saponins, tannins and triterpenoids. This review attempts to encompass the available literature on *Caesalpinia bonduc* (L.) with respect to its pharmacognostic characters, chemical constituents, summary of its various pharmacological activities and traditional uses.

Keywords: *Caesalpinia bonduc*; remedy; triterpenoids; indigenous; review; pharmacognostic.

Introduction

Medicinal plants as potential source of therapeutic aids has attained a significant role in health system all over the world for both humans and animals not only in diseased condition but also as potential material for maintaining proper health. However there is need to know which constituents in the medicinal herb are responsible for therapeutic uses. In recent times, focus on plant research has increased all over the world and a large body of evidence has collected to show immense potential of medicinal plants used in various traditional systems**.** Today, there is a renewed interest in traditional medicine and an increasing demand for more drugs from plant sources. This revival of interest in plant derived drugs is mainly due to the current widespread belief that "green medicine" is safe and more dependable than the costly synthetic drugs, many of which have adverse side effects. Herbal drugs or medicinal plants, their extracts and their isolated compounds have demonstrated spectrum of biological activities. Such have been used and continued to be used as medicine in folklore or food supplement for various disorders.

Caesalpinia bonduc (L.) Roxb (Syn. *Caesalpinia bonducella* (L.) Fleming, Syn. *Caesalpinia crista* (Linn.), belonging to the family Febaceae / **c**aesalpiniaceae, is a prickly shrub widely distributed all over the world specially, In India, SriLanka and Andaman and Nicobar Islands, in India specially found in tropical regions (Asolkar et al. 1992; White R. et al.2005). All parts of the plant have medicinal properties so it is a very valuable medicinal plant, which is utilized in traditional system of medicine (Kirtikar et al. 1988). The plant has been reported to possess several activities and also revealed the presence of alkaloids, flavonoids, glycosides, saponins, tannins and triterpenoids (Gaur et al.2008; Gupta et al. 2005).

Taxonomy

Caesalpinia bonduc falls under the scientific classification as follows:

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Scientific Classification
Kingdom: Plantae
Phylum: Magnoliophyta
Division: Magnoliopsida
Class: Angiospermae
Order: Fabales
Family: Fabaceae
Genus: *Caesalpinia*
Species: *bonduc*

Synonyms

Hindi Name: Kantkarej, Kantikaranja, Sagar Gota.
English Name: Fever nut, bonduc nut, nicker nut, nicker seed
Sanskrit Name: Kakachika, Kantakikaranja, Kantakini, Karanja, Krakachika, Kuberaksah, Kuberakshi, Kuberaksi, Latakaranja, Prakirnah, Putikah, Putikaranja, Putikaranjah, Putikaranji, Tingachhika, Tirini, Valli, Varini, Vitapakaranja.
Urdu Name: Akitmakit
Persian Name: Khayahe-i-iblas
Bengali Name: Nata
Marathi Name: Gajaga
Tamil Name: Kalarci ver, Kalarcik Koluntu, Kalarcip paruppu, Kazharchikkaai, Kalachikai, Kalichikai, Kazarci, Avil
Kannada Name: Gajjiga, Kiri gejjuga, Gajikekayi
Malayalam Name: Ban-karetti, Kaka-moullou, Kazhanji, Kalanci, Kajanchikkur
French Name: Bois
Telgu Name: Mulluthige, Gaccakayai

Table 1: General characters.

Plant Type	Shrub
Foliage	Evergreen
Roots	Deep roots, Tap roots
Type of stem	Hard Wooded
Leaf Type	Bipinnately Compound, Elliptical Ovate
Leaf Arrangement	Alternate
Leaf Colour	Green
Leaf Surface	Glossy
Seed Type	Dicot
Odour	Characteristic
Taste	Bitter
Plant Height	Medium (10-20 m)
Actual Height	Maximum: 15 m
Plant Feature	Forest, hill side, ornamental, sea side plant, Spiny
Plant Utilities	Flower and Garden, Industrial, Commercial and Medicinal
Season	Perennial
Growth Habit	Shrub Vine

Habit and habitat

The plant grows all over in India, grows in shade as well as in open. Generally found up to an altitude of 1,000 m in Himalaya and wild throughout the plains on waste lands or coastal areas of India. It is also found in deltaic region of western, eastern and southern India (WOI, 1992). Found particularly the seacoast throughout the hotter parts of India, Burma and Sri Lanka [Table no.1] (Kapoor 2010).

Useful part of the plant

Root, stem, leaves, bark, seeds and nuts are used for medicinal purpose.

Ayurvedic description

Properties

Guna (properties): Laghu (light), ruksha (dry), tikshna (sharp)

Rasa (taste): Tikta (bitter), kashaya (astringent)

Veerya (potency): Ushna (hot)

Dosha: Pacifies tridosha

Vipak: Katu

Action and uses

Kapha, vat samak, sotha har, badana sthapan, dipan, anuloman, krimighan, rakt sodhak, swashar, mutral, jwaraghan.

Morphology characters

An extensive climber; very thorny shrub, branches finely grey-downy, armed with hooked and straight hard yellow prickles.

Stem: Vine stem diameters to 5 cm recorded. Usually grows as a vine but also flowers and fruits as a shrub. Occasional spines or numerous spines present on the stems. Blaze odour resembles that of fresh green beans (Phaseolus vulgaris). Pith white, quite large in diameter.

Leaves: Leaves are with large, leafy, branched, baal appendanges; 30-60 cm. long; petioles; stipules a pair of reduced pinnaebipinnate, large,

stipules a pair of reduced pinnae at the base of the leaf each furnished with a long mucronate point; pinnae 6-8 pairs; 5-7.5 cm. long, with a pair of hook stipulary spines at the base, main leaf axis armed with stout, sharp, recurved spines, divided into 4-8 pairs of secondary branches.

Leaflet: leaflets 6-9 pairs, 2-3.8 by 1.3-2.2 cm. membranous, elliptic-oblong, obtuse, emarginated or retuse, strongly mucronate, glabrous above, more or less puberulous beneath; petioloules very short; stipels of short hooked spines. Leaflet blades about 18-75 x 12-40 mm. leaflet stalks about 1-2 mm long. Upper and lower leaflet blade surfaces clothed in pale golden hairs. Stipules foliaceous, about 8-10 x 8-30 mm. consisting of three to five divisions analogous to leaflets. Twigs armed with straight and recurved spines. Underside of the compound leaf primary axes and secondary axes armed with recurved spines.

Flowers: Flowers in dense (usually) long-peduncled, terminal and supraaxillary racemes dense at the top, looser downward, 15-25 cm. long; pedicels very short in buds, elongating to 5 mm. in flower and 8 mm. in fruits, brown-downy; bracts squarrose, linear, acute, reaching 1 cm. long, fulvous hair, Calyx 6-8 mm. long, fulvous and hairy; lobes obovate-oblong, obtuse. Petals about 10-12 mm long, oblanceolate, yellow, filaments declinate, flattened at the base, clothed with long white silky hairs. Ovary on a stalk (stipe) about 1 mm. long, 2 ovules.

Fruit: Fruit inflated pods, armed with rigid spines. Pods shortly stalked, oblong, 5.0-7.5 by about 4.5 cm. densely armed with wiry prickles. Seeds1-2 per pod.

Seeds: Seed coat is hard, glossy and greenish to ash grey in colour. And is traversed by circular and vertical faint markings of the cracks, forming uniform rectangular to squarish rectulations all over the surface seeds 1-2, oblong, lead-colored, 1.3 cm. long. In dry seed, kernel get detached from the testa. Testa is about 1-11.25 mm in thickness ans is composed of three distinct layers, the outermost – thin and brittle, the middle one – broad, fibrous and dark – brown and the innermost – white and papery. The seed is exalbuminous. The kernel surface is furrowed and ridged, hard, pale yellowish – white, circular to oval, flattened and about 1.23-1.75 cm. in diameter. A scar of the micropyle lies at one end of the kernel, from where arises a prominent ridge demarking the two cotyledons of the embryo. Plumule – radical axis is thick, cylindrical and straight. Taste is very bitter and odour is nauseating and unpleasant (Handa SS. et al.1996; Gopal 1992; Kirtikar et al. 1993; Sharma BM. et al. 1972).

Phytoconstituents present: Whole plant of Caesalpinia bonduc contain all major chemical constituents such as Steroidal Saponin, Fatty Acids, Hydrocarbons, Phytosterols, Isoflavones, Aminoacids and Phenolics.

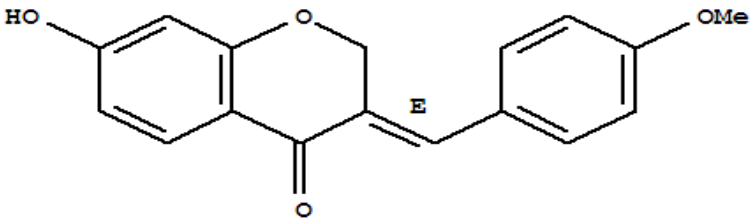
Pharmalogical activities

Antioxidant activity

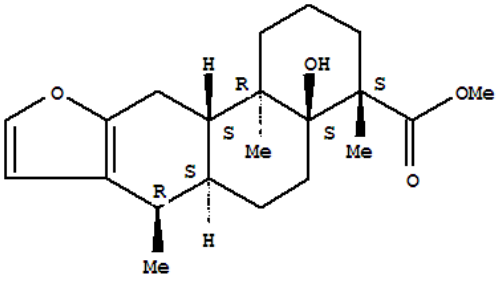
Kumar et al., has reported antioxidant actiity in chloroform extract of Caesalpinia bonducella seed. Chloroform extract of caesalpinia bonducella seeds were screened for antioxidant activity using, DPPH free radical scavenging activity, total phenolic content (tpc) estimation and β- carotene bleeching assay. The results showed Ic 50 of chloroform extract 170±4.08µg/ml and that of ascorbic acid is 2.03±0.16µg/ml. Total phenolic content was found to be 21.96±2.12 (for 1000µg/ml) and total antioxidant activity (taa) 24.96±0.31 while 'taa' of standard BHA was found to be 46.70±0.43. The study revealed the presence of antioxidant activity in chloroform extract of *Caesalpinia bonducella* seeds (Sachan et al. 2010).

Mandal et al., has reported the antioxidant and reactive oxygen species scavenging activity of methanolic extract of *Caesalpinia crista Leaf*. Antioxidants with ROS scavenging ability may have great relevance in the prevention of oxidative stress. The present study was undertaken, using a 70% methanolic extract of Caesalpinia crista leaves, to examine different in vitro tests in diversified fields including total antioxidant activity, scavenging activities for various ROS, iron chelating activity and phenolic and flavonoid contents. Total antioxidant activity was evaluated as trolox equivalent antioxidant ca-

pacity value of 0.546 ± 0.014. The extract was investigated for different ROS scavenging activities and IC50 values were found to be 0.44 ± 0.1 mg/ml, 24.9 ± 0.98 µg/ml, 33.72 ± 0.85 µg/ml, 61.13 ± 3.24 µg/mL and 170.51 ± 4.68 µg/mL for hydroxyl, superoxide, nitric oxide, singlet oxygen and hypochlorous acid, respectively; however, no significant results were obtained in scavenging of hydrogen peroxide and peroxynitrite anion. The extract was found to be a potent iron chelator with IC50 = 279.85 ± 4.72 µg/mL.. The plant extract (100 mg) yielded 50.23 ± 0.003 mg/mL gallic acid equivalent phenolic content and 106.83 ± 0.0003 mg/mL quercetin equivalent flavonoid content. In the in vivo experiments, the extract treatment showed significant increase in the level of superoxide dismutase, catalase, glutathione-S-transferase and reduced glutathione. In a word, it may be concluded that 70% methanol extract of C. crista leaves acts as an antioxidant and ROS scavenger; which may be due to the presence of phenolic and flavonoid compounds (Mandal et al. 2009).



Bonducellin (4H-1-Benzopyran-4-1,2,3-dihydro-7-hydroxy-3-[(4-methoxyphenyl)methylene]



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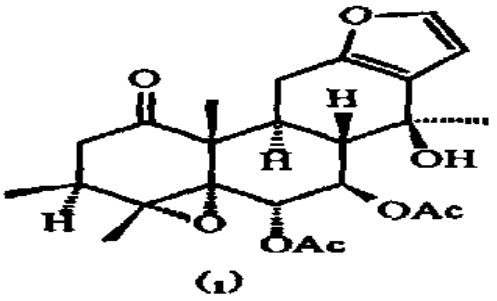
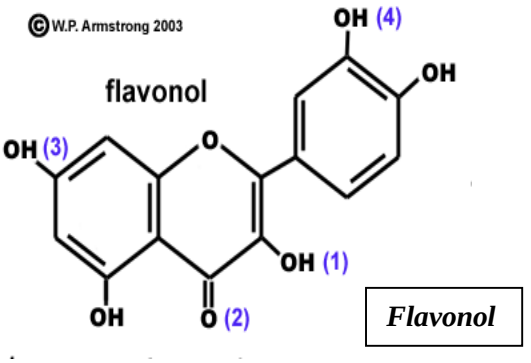
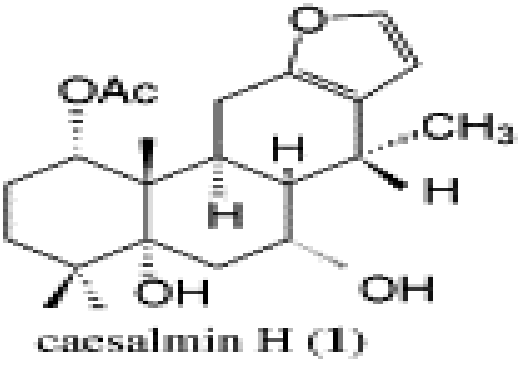


Caesalpinin





Shukla et al. (2009) has reported Antioxidant activity and total phenolic content of ethanolic extract of *Caesalpinia bonducella seeds***.** This study was to assess the *in vitro* potential of ethanolic extract of *Caesalpinia bonducella* seeds as a natural antioxidant. The DPPH activity of the extract (20, 40, 50, 100 and 200 µg/ml) was increased in a dose dependent manner, which was found in the range of 38.93–74.77% as compared to ascorbic acid (64.26–82.58%). The IC_{50} values of ethanolic extract and ascorbic acid in DPPH radical scav-

enging assay were obtained to be 74.73 and 26.68 µg/ml, respectively. The ethanolic extract was also found to scavenge the superoxide generated by EDTA/NBT system. Measurement of total phenolic content of the ethanolic extract of *C. bonducella* was achieved using Folin–Ciocalteau reagent containing 62.50 mg/g of phenolic content, which was found significantly higher when compared to reference standard gallic acid. The ethanolic extract also inhibited the hydroxyl radical, nitric oxide, superoxide anions with IC_{50} values of 109.85, 102.65 and 89.84 µg/ml, respectively. However, the IC_{50} values for the standard ascorbic acid were noted to be 70.79, 65.98 and 36.68 µg/ml respectively. The results obtained in this study clearly indicate that *C. bonducella* has a significant potential to use as a natural antioxidant agent (Shukla et al. 2009).

Adaptogenic activity

Caesalpinia bonduc Roxb. Seed extracts were screened for adaaptogenic activity using cold stress model and swim endurance model, the seed coat as well as kernel extracts showed significant antistress activity when administered orally at a dose of 300 mg/kg. The extracts significantly increased the swim endurance time. Stress induced animals exhibited hypoglycemia as well as depletion in serum cortisol level and increased total leukocyte count, the extracts showed a significant action in overcoming these imbalances. It was also found that extracts proved efficient in controlling the hyperlipidaemic condition due to stress (Kannur et al. 2006).

Antidiabetic activity

Parameshwer et al. has reported Oral Antidiabetic Activities of Different Extracts of *Caesalpinia bonducella* Seed Kernels. *Caesalpinia bonducella* F. (Leguminosae) seed kernels are used in the management of diabetes mellitus, in the folklore medicine of Andaman and Nicobar as well as the Caribbean Islands. The seed kernel powder was reported to have hypoglycaemic activity in experimental animals. In diabetic rats, both the polar extracts (ethyl acetate and aqueous) as well as glibenclamide, showed significant hypoglycaemic effect, besides, reversing the diabetes induced changes in lipid and liver glycogen levels. As far as the non-polar extracts were concerned, the ether extract showed a marginal antidiabetic activity, while the petroleum ether extract failed to show any. Since both the polar extracts were, chemically, found to contain triterpenoidal glycosides, we presume that they might be the active principles contributing to the antidiabetic actions. In in vitro antioxidant studies, the aqueous extract was found to be devoid of any free radical scavenging activity, while the ethyl acetate extract showed a maximum of 49% activity at the end of 1 h. Although the antioxidant potential of ethyl acetate extract may contribute to overcome the diabetes linked oxidative stress, it needs not necessarily contribute to its hypoglycaemic activity (Parameshwar et al. 2002).

Patil et al. has reported Antidiabetic activity of bark and root of *Caesalpinia bondue.* The different extracts of the roots of *Caesalpinia bondue* (Family- Fabaceae) were tested for antidiabetic activity, by glucose tolerance test in normal rats and alloxan induced diabetic rats. Aqueous ethanol and chloroform extracts had shown significant protection and lowered the blood glucose levels to normal in glucose tolerance test. In alloxan induced diabetic rats the maximum reduction in blood glucose was observed after 3h at a dose level of 250 mg/kg of body weight. The percentage protections by aqueous chloroform and ethanol extracts were 22.28 and 23% respectively. In long term treatment of alloxan induced diabetic rats, the degree of protection was determined by measuring blood glucose, triglycerides, cholesterol and urea levels on 0,3,5,7 and 10th day. Both the extracts showed a significant anti- diabetic activity comparable with that of glibenclamide, standard anti-diabetic drug (Patil et al. 2010).

The seed extracts of *Caesalpinia bonducella* were subjected to screening of antidiabetic activity in alloxan induced hyperglycemia. The oral administration of the extracts (300 mg/kg) produced significant antihyperglycemic action as well as it lowered the BUN levels significantly. In the same study the action of the extracts on diabetes induced

hyperlipidemia was analyzed where the extracts significantly lowered the elevated cholesterol as well as LDL level. The antihyperglycemic action of the extracts may be due to the blocking of glucose absorption. The drug has the potential to act as antidiabetic as well as antihyperlipidemic (Kannur et al. 2006).

Anti-inflammatory activity

The anti-inflammatory activity was studied in rats using the formalin arthritis and granuloma pouch methods. At a dose of 250 mg/kg the extract was found to be effective in the granuloma pouch model and compared favourably with phenylbutazone. The seeds showed a 50% inhibitory activity against carrageenan-induced oedema in the rat hind paw, at an oral dose of 1000 mg/kg, when gives 24 hours and 1 hour prior to carrageenan injection (IP). The activity (66.67% inhibition) was comparable to that of phenylbutazone at a dose of 100 mg/kg (Shukla et al. 2010; Archana et al. 2005; Devi et al. 2008).

Anthelmintic activity

Jabbar et al. has first time reported anthelmintic activity in *Caesalpinia bonducella* by in-vitro and in-vivo, they justified their use in the traditional medicine system of Pakistan (Jabbar et al. 2007).

Anthelmintic activity of leaves of *Caesalpinia bonducella* was investigated for their anthelmintic activity against *Phertima posthuma* and *Ascardia galli*. Variuos concentrations were used in bioassay. Both extracts showed significant anthelmintic activity (Wadkar et al. 2010).

Antifilarial activity

Gaur et al., has reported Antifilarial activity of *Caesalpinia bonducella* against experimental filarial infections. Lymphatic filariasis is a disabling disease that continues to cripple population in tropical countries. We undertook this study to assess the antifilarial activity of *Caesalpinia bonducella*-seed kernel against rodent filarial parasite in experimental model. Microfilaraemic cotton rats and Mastomys coucha harbouring *Litomosoides sigmodontis* and *Brugia malayi* respectively, were treated with crude extract or fractions of the seed kernel *C. bonducella* through oral route for 5 consecutive days. Microfilaricidal, macrofilaricidal and female worm sterilizing efficacy was assessed. Crude extract showed gradual fall in microfilariae (mf) count in *L. sigmodontis*-cotton rat model from day 8 post-treatment attaining more than 95 per cent fall by the end of observation period. It also exhibited 96 per cent macrofilaricidal and 100 per cent female sterilizing efficacy. The butanol fraction F018 caused 73.7 per cent reduction in mf count and 82.5 per cent mortality in adult worms with 100 per cent female sterilization. The aqueous fraction F019 exerted more than 90 per cent microfilaricidal activity and 100 per cent worm sterilization. Two chromatographic fractions, F024 and F025 of hexane soluble fraction exhibited 64 and 95 per cent macrofilaricidal activity, respectively. Both the fractions caused gradual fall in microfilaraemia and 100 per cent worm sterilization. In *B. malayi-M. coucha* model F025 showed gradual reduction in microfilaraemia and caused 80 per cent sterilization of female parasites. Interpretation & conclusions: In conclusion, *C. bonducella*- seed kernel extract and fractions showed microffiaricidal, macrofilaricidal and female-sterilizing efficacy against *L. sigmodontis* and microfilaricidal and female-sterilizing efficacy against *B. malayi* in animal models, indicating the potential of this plant in providing a lead for new antifilarial drug development (Gaur et al. 2008).

Antimicrobial activity

Simin et al., has reported Antimicrobial activity of seed extracts and bondenolide from *Caesalpinia bonduc* (L.) Roxb. The antibacterial and antifungal activities, along with a phytotoxicity test of the newly isolated diterpene bondenolide (1), of a methanol extract, ethylacetate fraction and water soluble part of the methanol extract of *Caesalpinia bonduc* (L.) Roxb. were assayed (Simin et al. 2001).

Arif et al. has reported in vitro and in vivo antimicrobial activities of seeds of *Caesalpinia bonduc* (Linn.) Roxb (Arif et al. 2009).

Sagar et al. has reported Antimicrobial activity of α-(2-hydroxy-2-methylpropyl)-ω-(2-hydroxy-3-methylbut-2-en-1-yl) polymethylene from *Caesalpinia bonducella* (L.) Flem. The compound, α-(2-hydroxy-2-methylpropyl)-ω-(2-hydroxy-3-methylbut-2-en-1-yl) polymethylene, isolated from ethyl acetate leaf extract of *Caesalpinia bonducella* (L.) Flem. was evaluated for antimicrobial activity against clinical isolates, *Proteus vulgaris, Pseudomonas aeruginosa, Klebsiella sp., Staphylococcus citrus, Staphylococcus aureus, Escherichia coli, Candida albicans* and *Rhodotorula* sp. using agar diffusion method. The compound exerted inhibitory zone at all concentrations and revealed the concentration-dependent activity against all tested bacterial and yeast strains comparable to standards streptomycin sulphate and gentamycin for bacteria and fluconazole and griseofulvin for *Candida albicans* and Rhodotorula sp. The inhibition zones were wider and clear for *C. albicans* and *Rhodotorula* sp. (IZ >20 mm) and for Pseudomonas aeruginosa, *P. vulgaris* and *E. coli* zones were greater than standards tested, whereas, zones for *Klebsiella* sp. and *S. aureus* were similar to standards (Sagar et al. 2010).

The in vivo and in vitro antimicrobial activity was also reported in the seed of *Caesalpinia crista* herb containing various active chemical constituent (Tusharkanti et al. 2011).

Antiestrogenic activity

Kanchan et al. results suggested that alcohol seed extract of *Caesalpinia bonducella* has antiestrogenic property, possibly acting via inhibition of estrogen secretion (Salunke et al. 2011).

Antimalarial activity

Three new cassane furanoditerpenoids (1-3) together with known cassane diterpenes were isolated from the seed kernels of *Caesalpinia bonduc*. Compound 1-3 exhibited good antimalarial activity against multidrug resistant K1 strain of plasmodium falciparum (Pudhom et al. 2007).

Kalauni et al. has reported antimalarial activity of cassane and norcassane type diterpenes from *Caesalpinia crista* and their structure-activity relationship (Kalauni et al. 2006).

Linn et al., has reported cassane and norcassane type diterpene from *Caesalpinia crista* of Indonesia and their antimalarial activity against the growth of plasmodium falciparum (Linn et al. 2005).

Antibacterial, antifungal, antispasmodic activity

Khan et al., has reported antibacterial, antifungal, antispasmodic and Ca++ antagonist effects of *Caesalpinia bonducella* (Khan et al. 2011).

Saeed and Sabir have reported antibacterial activity in *Caesalpinia bonducella* seeds (Saeed and Sabir 2001).

Antiproliferative activity

Yadav et al., isolated Cassane diterpenes from *Caesalpinia bonduc*. The isolated compounds were tested for their antiproliferative activity against MCF-7 (breast adenocarcinoma), DU145 (prostate carcinoma), C33A (Cervical carcinoma) and Vero (African green monkey kidney fibroblast) cells (Yadav et al. 2009).

Antipsoriatic activity

Murugananthamet et al. screening of *Caesalpinia bonduc* (L.) Roxb. Have been used for antipsoriatic activity. Leaves of *Caesalpinia bonduc* (L.) Roxb. Have been used by traditional Siddha system healer of Malabar reagion for psoriasis treatment (Murugananthamet et al. 2011).

Antitumor activity

Gupta et al., has reported antitumor activity and Antioxidant Status of *Caesalpinia bonducella* Against Ehrlich Ascites Carcinoma in Swiss Albino Mice. The methanol extract of *Caesalpinia bonducella* FLEMING

(Caesalpiniaceae) leaves (MECB) were evaluated for antitumor activity against Ehrlich ascites carcinoma (EAC)-bearing Swiss albino mice. The extract was administered at the doses of 50, 100, and 200 mg/kg body weight per day for 14 days after 24 h of tumor inoculation. After the last dose and 18 h fasting, the mice were sacrificed. The present study deals with the effect of MECB on the growth of transplantable murine tumor, life span of EAC-bearing hosts, hematological profile, and biochemical parameters such as lipid peroxidation (LPO), glutathione content (GSH), superoxide dismutase (SOD), and catalase (CAT) activities. MECB caused significant (P<0.01) decrease in tumor volume, packed cell volume, and viable cell count; and it prolonged the life span of EAC-tumor bearing mice. Hematological profile converted to more or less normal levels in extract-treated mice. MECB significantly (P<0.05) decreased the levels of lipid peroxidation and significantly (P<0.05) increased the levels of GSH, SOD, and CAT. The MECB was found to be devoid of conspicuous short-term toxicity in the mice when administered daily (i.p.) for 14 days at the doses of 50, 100, 200, and 300 mg/kg. The treated mice showed conspicuous toxic symptoms only at 300 mg/kg. The results indicate that MECB exhibited significant antitumor and antioxidant activity in EAC-bearing mice (Gupta et al. 2004).

Anxiolytic activity

Ali et al. has reported Anxiolytic Activity of Seed Extract of *Caesalpinia bonducella* (Roxb) *in* Laboratory Animals. In Stair-case model, all the three doses i-e low, medium and high 400, 600 and 800mg/kg of PECB had showed a significant and dose dependent anxiolytic activity by increasing the number of steps climbed, without any significant effect on rearings by all these three doses. Similarly in EPM model medium and high doses, but not the low dose of PECB had significantly enhanced both number of entries and time spent in open arms and decreased in number of entries and time spent in closed arms. In Hole- board model, medium and high doses 600 and 800mg/kg but not the low dose 400mg/kg of PECB had significantly enhanced the number, latency and the duration of head dipping but not the rearings. However in LDT model high doses 800mg/kg of PECB had significantly exhibited anxiolytic activity by increasing time spent, number of crossings in light compartment and decreased the time spent in dark compartment and decreased the number of rearings in both light and dark compartments. In OFT models, medium and high doses 600 and 800mg/kg but not the low dose 400mg/kg of PECB had significantly enhanced total locomotion, central locomotion, number of grooming but the immobility time has drastically reduced. All doses of PECB have not exerted any significant effect with rearing, defecation and urination. Moreover in Mirror-chamber model of anxiety, both medium and high doses 600 and 800mg/kg but not the low dose 400mg/kg of PECB had significantly reduced the time latency to enter in to the mirror chamber and increased the number of entries and time spent in the chamber. Thus the result recorded with above experimental models confirms the anxiolytic activity of PECB (Ali et al. 2008).

Larvicidal activity

Saravanan et al. has reported Mosquito larvicidal properties of various extract of leaves and fixed oil from the seeds of *Caesalpinia bonduc* (L) Roxb. A preliminary laboratory trial was undertaken to determine the efficacies of petroleum ether, ethanolic, aqueous extracts of dried leaves and fixed oil from the seeds of *Caesalpinia bonduc* (L).Roxb at various concentrations against the fourth instar larvae of *Culex quinquefasciatus* by WHO guidelines. Hundred per cent mortality was observed in 1% concentration of petroleum ether and ethanolic extract of leaf, whereas it was 55% in 2.5% concentration of aqueous extract and 92.6% in 2.5% concentration of fixed oil. The active constituent responsible for the mortality is to be isolated to come up with a promising larvicidal agent, which will be economic, non pollutant and ecofriendly (Saravanan et al. 2007).

Immunomodulatory activity

The present study involved the investigation of immunomodulatory activities of ethanolic

extract of *Caesalpinia bonducella* seeds. The evalution of immunomodulatory potential by oral administration of ethanolic seed extract of *Caesalpinia bonducella* (200-500 mg/kg) evoked a significant increase in percent neutrophil adhesion to nylon fibers. It also showed the dose-dependent increase in antibody titre values and potentiated the delayed type hypersensitivity reaction induced by sheep red blood cells. Neutrophil adhesion test, haemagglutinating antibody (HA) titre, delayed type hypersensitivity (DTH) response, phagocytic activity and cyclophosphamide induced myelosupperession were determined by in vivo experiments (Tummin et al 1930; Parameshwar et al. 2002).

Shukla et al. studies in vivo immunomodulatory activities of the aqueous extract of bonduc nut *Caesalpinia bonducella* seeds. This study evaluated the in vivo immunomodulatory activities of the aqueous extract of *Caesalpinia bonducella* Fleming seeds. *C. bonducella* is a plant widely used in the traditional medicinal systems of India. In the present investigation, the aqueous extract of *C. bonducella* seeds was tested for its effect on cell mediated and humoral components of the immune system in rats. Administration of *C. bonducella* seed extract produced an increase of 93.03 +/- 4 mean hemagglutinating antibody (HA) titer and a change of 0.56 +/- 0.058 mm in delayed type hypersensitivity (DTH) as compared to control at a dose of 400 mg/kg body weight. Thus, the results of this study indicate that *C. bonducella* extract could be a promising immunostimulatory agent (Shukla et al 2010).

Shukla et al. investigated Immunomodulatory activities of the ethanolic extract of *Caesalpinia bonducella* seeds. The results obtained in this study indicate that *Caesalpinia bonducella* possesses potential immunomodulatory activity and has therapeutic potential for the prevention of autoimmune diseases (Shukla et al. 2009).

Hypoglycemic activity

Jana et al. has reported Antihyperglycemic and antioxidative effects of the hydromethanolic extract of the seeds of *Caesalpinia bonduc* on streptozotocin-induced diabetes in male albino rats. There are no satisfactory effective treatment is available yet to cure diabetes mellitus. Though, synthetic drugs are used but there are several drawbacks. The attributed antihyperglycemic effects of many traditional plants are due to their ability for the management of diabetes mellitus. A hydromethanolic extract was administered orally at a dose of 250 mg/kg of body weight per day for 21 days. Its effects on the fasting blood glucose (FBG) level, activities of key carbohydrate metabolic enzymes like hexokinase, glucose-6-phosphatase, and glucose-6-phosphate dehydrogenase, and antioxidant enzymes like catalase and superoxide dismutase along with the effect on the lipid peroxidation level in hepatic tissues were measured. Glycogen levels were also assessed in hepatic and skeletal muscles and some toxicity parameters, such as serum glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, and alkaline phosphates activities were measured. Treatment of the hydromethanolic extract of the seeds of Caesalpinia bonduc resulted in a significant ($P < 0.05$) recovery in the activities of carbohydrate metabolic enzymes along with correction in FBG and glycogen levels as compared with the untreated diabetic group. The extract also resulted in a significant ($P < 0.05$) recovery in the activities of toxicity assessment enzyme parameters. Activities of antioxidant enzymes like catalase and superoxide dismutase along with the lipid peroxidation levels were also recovered significantly ($P < 0.05$) after the treatment of the extract. The corrective effects produced by the extract were compared with the standard antidiabetic drug, glibenclamide. Our findings provide that the extract shows possible antihyperglycemic and antioxidative action (Jana et al. 2010).

Chakrabarti et al. has reported advanced studies on the hypoglycemic effect of *Caesalpinia bonducella* F. in type 1 and 2 diabetes in Long Evans rats. *Caesalpinia bonducella*, widely distributed throughout the coastal region of India and used ethnically by the tribal people of India for controlling blood sugar was earlier reported by us to possess hypoglycemic activity in animal model. This prompted us to undertake a detail study with the aqueous and ethanolic extracts of the seeds of this plant in both type 1 and 2 diabetes mellitus

in Long Evans rats. Significant blood sugar lowering effect ($P < 0.05$) of *C. bonducella* was observed in type 2 diabetic model. Special emphasis was given on the mechanistic study by gut absorption of glucose and liver glycogen (Chakrabarti et al. 2003).

Moshi and Nagpa have reported effect of *caesalpinia bonducella* seeds on blood glucose in rabbits. The seeds of *Ceasalpinia bonducella* are sold in shops in Dar es Salaam, Tanzania, for the treatment of diabetes mellitus. A suspension of the powdered seed kernel in 0.5% carboxymethylcellulose (CMC) was tested for ability to lower blood glucose in fasted and glucose-fed normal albino rabbits. Following administration of 0.2, 0.4 and 0.8 g/kg body weight of the powder there was no difference in areas under the fasting blood glucose and oral glucose tolerance test (OGTT0 curves as compared to controls given CMC (P & gt ; 0.05). similarly, 0.2 g/kg body weight of the powder administered for 7 consecutive days had no effect on either fasting blood glucose or the clearance of a glucose load from the blood. However, 0.1 g/kg body weight chlorpropamide significantly decreased the area under the fasting blood glucose and OGTT curves as compared to controls given CMC (P+0.05) (Moshi and Nagpa 2000).

Biswas et al. have reported oral hypoglycemic effect of *Caesalpinia bonducella*. The blood sugar lowering efficacy of the aqueous extract of *Caesalpinia bonducella* F. (seed shell) was evaluated in fasted, fed, glucose loaded, streptozotocin diabetic, and alloxan diabetic rat models. The extract was administered orally at a dose of 250 mg/kg of rat body weight. It produced very significant blood sugar lowering (at least $P < 0.005$) in glucose loaded, streptozotocin diabetic, and alloxan diabetic models. However, effects were not so pronounced in fasted and fed models. As a whole, *Caesalpinia bonducella* can be regarded as a good oral hypoglycemic agent in rat (Biswas et al. 1997).

Muscle contractile activity

Datte et al. have reported the effects of leaf extract of *Caesalpinia bonduc* (Caesalpiniaceae) on the contractile activity of uterine smooth muscle of pregnant rats. The extract (Cebo) increased the contractile force in the isolated strips in a concentration-dependent manner. The effects were comparable to those obtained with acetylcholine. Contractions induced by Cebo or acetylcholine were inhibited in the presence of atropine. The stimulating action of Cebo on the contractile responses of isolated myometrium preparations inhibited by atropine may be mediated by cholinergic receptors. In calcium-free solution Cebo induced a tonic contraction (contracture) of the muscle. Moreover, in high-potassium calcium-free solution Cebo caused contracture of the uterine smooth muscle. Cebo was still able to elicit contractions in calcium-free solution containing EDTA or EGTA. These findings suggest the existence of cholinergic receptors sensitive to Cebo which could influence the influx of calcium (phasic contraction) and mobilization of calcium from cellular stores (tonic contraction), both of which are responsible for the increase of contractile activity and development of the contracture of uterine smooth muscle (Datte et al. 2004).

Datté et al. has reported Leaf extract of Caesalpinia bonduc Roxb. induces an increase of contractile force in rat skeletal muscle in situ. The mechanism through which *Caesalpinia bonduc* extract (Cebo) affects gallamine-induced relaxation in rat tibial muscle contractility were studied via measurement of isometric-tension-anesthetized, 10-12-week-old, male rats. Isometric twitch contractions of the indirectly-stimulated anterior tibia muscle of the right hindleg were recorded in situ. Cebo administered intravenously (i.v.) increased twitch contractions in a dose-dependent manner. The ED50 value is 2.75 x 10(-4) g/kg body wt. Similar results were obtained using the anticholinesterase neostigmine. In contrast, gallamine (a non-depolarizing muscle relaxant) or the venom of the puff adder Bitis arietans reduced the force of contraction. Treatment with Cebo or neostigmine, however, reversed the relaxation induced by either gallamine or puff adder venom. In conclusion, Cebo stimulates the muscle contractile activity, an effect which may be due to an activation of the cholinergic mechanism found to be 0.44 ± 0.1 mg/ml, 24.9 ± 0.98 µg/ml, 33.72 ± 0.85 µg/ml, 61.13 ±

3.24 µg/mL and 170.51 ± 4.68 µg/mL for hydroxyl, superoxide, nitric oxide, singlet oxygen and hypochlorous acid, respectively; however, no significant results were obtained in scavenging of hydrogen peroxide and peroxynitrite anion. The extract was found to be a potent iron chelator with IC50 = 279.85 ± 4.72 µg/mL.. The plant extract (100 mg) yielded 50.23 ± 0.003 mg/mL gallic acid equivalent phenolic content and 106.83 ± 0.0003 mg/mL quercetin equivalent flavonoid content. In the in vivo experiments, the extract treatment showed significant increase in the level of superoxide dismutase, catalase, glutathione-S-transferase and reduced glutathione. In a word, it may be concluded that 70% methanol extract of *C. crista* leaves acts as an antioxidant and ROS scavenger; which may be due to the presence of phenolic and flavonoid compounds (Datte et al. 1998).

Hepatoprotective activity

Kumar et al. study was carried out to evaluate the hepatoprotective and antioxidant effect of the methanol extract of *Caesalpinia bonducella* in wister albino rats. Hepatoprotective and antioxidant effects of *Caesalpinia bonducella* on carbon tetrachloride-induced liver injury in rats. The present study was carried out to evaluate the hepatoprotective and antioxidant effect of the methanol extract of *Caesalpinia bonducella* (MECB) in Wistar albino rats. The different groups of animals were administered with carbon tetrachloride (CCl4) (30 % CCl4, 1 ml/kg b. wt. in liquid paraffin 3 doses (i.p.) at 72 h interval). The MECA at the doses of 50, 100 and 200 mg/kg and silymarin 25 mg/kg were administered to the CCl4 treated rats. The effect of MECB and silymarin on serum glutamyl pyruvate transaminase (SGPT), Serum glutamyl oxalacetic acid transaminase (SGOT) Serum alkaline phosphatase (SALP), bilirubin, uric acid and total protein were measured in the CCl4 induced hepatotoxicity in rats. Further, the effects of the extract on lipid peroxidation (LPO), enzymatic antioxidant (superoxide dismutase (SOD) and catalase (CAT)), and non enzymatic antioxidant (glutathione (GSH), vitamin C and vitamin E) were estimated. The MECB and silymarin produced significant ($p < 0.05$) hepatoprotective effect by decreasing the activity of serum enzymes, bilirubin, uric acid, and lipid peroxidation and significantly ($p < 0.05$) increased the levels of SOD, CAT, GSH, vitamin C, vitamin E and protein in a dose dependent manner. From these results, it was suggested that MECB possess potent hepatoprotective and antioxidant properties (Sambath et al. 2010).

Anti-amyloidogenic activity

Ramesh et al. reported anti-amyloidogenic property of leaf aqueous extract of *Caesalpinia crista*. Amyloid beta (Abeta) is the major etiological factor implicated in Alzheimer's disease (AD). Abeta (42) self-assembles to form oligomers and fibrils via multiple aggregation process. The recent studies aimed to decrease Abeta levels or prevention of Abeta aggregation which are the major targets for therapeutic intervention. Natural products as alternatives for AD drug discovery are a current trend. We evidenced that *Caesalpinia crista*leaf aqueous extract has anti-amyloidogenic potential. The studies on pharmacological properties of C. crista are very limited. Our study focused on ability of C. crista leaf aqueous extract on the prevention of (i) the formation of oligomers and aggregates from monomers (Phase I: Abeta(42)+extract co-incubation); (ii) the formation of fibrils from oligomers (Phase II: extract added after oligomers formation); and (iii) dis-aggregation of pre-formed fibrils (Phase III: aqueous extract added to matured fibrils and incubated for 9 days). The aggregation kinetics was monitored using thioflavin-T assay and transmission electron microscopy (TEM). The results showed that C. crista aqueous extract could able to inhibit the Abeta (42) aggregation from monomers and oligomers and also able to dis-aggregate the pre-formed fibrils. The study provides an insight on finding new natural products for AD therapeutics (Ramesh et al. 2010).

Antipyretic and analgesic activity

Archana et al. has reported Antipyretic and analgesic activities of *Caesalpinia bonducella* seed kernel extract. Ethanolic extract (70%) of

Caesalpinia bonducella seed kernel has been subjected for its antipyretic and antinociceptive activities in adult albino rats or mice of either sex at 30, 100 and 300 mg/kg orally. The extract demonstrated marked antipyretic activity against Brewer's yeast- induced pyrexia in rats. The extract had significant central analgesic activity in hot plate and tail flick methods. It also exhibited marked peripheral analgesic effect in both acetic acid-induced writhing test in mice and Randall-Selitto assay in rats. It also significantly inhibited the formalin-induced hind paw licking in mice. In conclusion, the present study suggests that the ethanolic extract of *Caesalpinia bonducella* seed kernel possesses potent antipyretic and antinociceptive activities and thus, validates its use in the treatment of pain and pyretic disorders (Archana et al. 2005).

Toxicity studies

Preeja et al. have reported evaluation of acute and sub-acute toxicity of methanolic extract of *Caesalpinia bonducella* (L) Fleming was evaluated in Albino mice. The acute toxicity studies were conducted as per the OECD guidelines420 where the limit test dose of 2000mg/kg used. Observations were made and recorded after treatment at 2 hrs, 4 hrs, 8 hrs and then for seven days regularly for respiration rate, heart rate, and behavioural signs like apathy, reduced locomotor activity as well as licking. For the sub-acute toxicity, three groups of 6 mice were received distilled water (control), 200 and 400 mg/kg of extracts every 24 hr orally for 28 days. No significant variation in the body and organ weights between the control and the treated group was observed after 28 days of treatment. Hematological analysis and clinical blood chemistry revealed no toxic effects of the extract. Pathologically, neither gross abnormalities nor histo pathological changes were observed. No mortality was recorded in 28 days (Preeja et al. 2011).

Kumar et al. have reported investigation deals with the hematology and hepatorenal function of *Caesalpinia bonducella* Flem. and *Bauhinia racemosa* Lam. The tribal people of Kolli Hills, Tamil Nadu, India, use the leaves of *Caesalpinia bonducella* and the stem bark of *Bauhinia racemosa* in combination with some other herbs for the treatment of various tumors, liver disorders, inflammation and some other diseases. In ancient Ayurveda medicine these plants were mentioned to possess antitumor agents. Since there are no scientific reports regarding the toxicological aspects of these plants, the present investigation deals with the sub-chronic toxicity studies of a methanol extract of *Caesalpinia bonducella* (MECB) leaves and *Bauhinia racemosa* (MEBR) stem bark in Swiss albino mice. The MECB and MEBR were administered intraperitoneally to Swiss albino mice twice a week for thirteen weeks. No significant alterations in hematological, biochemical and histopathological parameters were observed in the MECB- and MEBR-treated groups at the doses of 100 and 200 mg/kg body weight. Administration of MECB and MEBR at the dose of 400 mg/kg body weight elevated the levels of serum enzymes and altered the hematological parameters. Our results suggested that MECB and MEBR at doses 100 and 200 mg/kg body weight did not induce any toxic effects in the mice. Adverse effect was noted at the dose of 400 mg/kg body weight (Kumar et al. 2005).

Traditional and modern uses

The seed is claimed to be styptic, purgative and anthelmintic and cures inflammations, useful in colic, malaria, hydrocele, skin diseases and leprosy. In Madras (Chennai) an ointment is made from the powdered seeds with castor oil and applied externally in hydrocele and orchitis (WOI, 1992; Kapoor CRC Press 88; Elizabeth M. 83-86; Handa et al. 1996).

The seeds are considered tonic, ferifuge, anthelmintic, antiblennorrhagic, and specific in the treatment of hydrocele. The oil from the seeds is used in convulsions and paralysis. In Guinea, the pounded seeds are considered vesicant. The powdered seeds were mixed with equal part of pepper powder to malaria patients and were found to posses feeble antiperiodic properties. In malignant malaria, they did not do any good. The seeds are ground in water and given internally in snake-bite. The seeds are not an antidote to snake-venom (Kirtikar et al. 1975; Kumar et al. 2005). Seed and long pepper powders

taken with honey gives good expectorant effect. Burnt seeds with alum and burnt arecanut are a good dentifrice useful in spongy gums, gum boils, etc. In West Indies, the roasted seeds are used as anti diabetic (WIO 1992; Komal et al. 2010).

The kernel of the seed is very useful and valuable in all ordinary cases of simple, continued and intermittent fevers. The kernel powder mixed with equal parts of black pepper is taken thrice a day in a dose of 15-30 grains by adults and 3-4 grains by children. It was made official in the Indian Pharmaceutical Codex 16 the dose of the powder being 15-18 grains. It is said to produce lots of perspiration, leading to the reduction of fever. Kernel powder with sugar and goat milk gives good result results in liver disorder (Tummin Katti 1930). Decoction of roasted kernels was used in asthama. Children unable to digest mother's milk were given the extract of the kernel or its powder along with ginger, salt and honey to get good stomachic effect. Paste prepared from kernel gives relief from boils and other such swellings.

A cake made of 30 grains of powdered kernels, fried in ghee taken twice a day is a valuable remedy in cases of acute orchitis, ovaritis and scrofula. Root (WIO 1992; Elizabeth 2008; Handa et al. 1996; Kirtikar and Basu 1993; Komal et al. 2010) in La Reunion and Madagascar, the roots are considered febrifuge and anthelmintic, they are much used as an astringent in leucorrhoea and blennorrhagia. In Guinea, a decoction of the root is prescribed in fever. The root-bark is good for tumours and for removing the placenta after child birth (Kirtikar et al. 1975). Bark of root possesses number of properties like febrifuge, intestinal worms, amenorrhoea, cough, and anthelmintic etc. In Jamaica, it is used as rubifacient and as a local application for sores. Flowers are used in treating ascites and fruits in treating urinary disorder, leucorrhoea, piles and wounds. Leaves and twigs are traditionally used for the treatment of tumors, inflammation and liver disorder. They have also been applied for treatment of toothache. Leaves and juices have been used traditionally for elephantiasis and smallpox.

Conclusion

The present study shows the Phytopharmacological properties of various bioactive compounds present in the plant. The leaves, seed kernels, seed oil, flowers and fruits are used in India for the treatment of various diseases. The different extracts of Caesalpinia crista shows anthelmintic activity**,** anti-amyloidogenic activity, immunomodulatory, analgesic, antipyretic, anti-inflammatory, anti-tumor, antioxidant activity, antidiabetic and hypoglycemic activity, and also used as nootropic or memory enhancer.

The pharmacognostic parameters, which are being reported, could be useful in the identification and standardization of a crude drug. The data produced in the present investigation is also helpful in the preparation of the crude drug's monograph and inclusion in various pharmacopoeias. However, more Clinical and Pathological studies should be conducted to investigate the active potentials of bioactive compounds present in this plant.

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