Phytochemical And Biological Importance of *Boerhavia diffusa*: A Plant of Ethnopharmacological knowledge

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Abstract: *Boerhavia diffusa* (BD) and its other species have been assembled in this paper due to their enormous medicinal properties which hold tremendous influence on disease burden and affordability of health care. This paper enlightens mostly on the root part of this plant along with a number of bioactive rotenoid compounds and isolation of rotenoids from the roots of *Boerhavia diffusa* including traditional and recent advanced methods. The plant in whole has a numerous medicinal properties like anti-stress, hepatoprotective, anti-oxidant, anticonsulvant, antimicrobial, anti-inflammatory, hypoglycaemic etc. This paper explains the evidence based information on the plant morphology, phytochemical constituents (rotenoids) and its biological activities.

Keywords: *Boerhavia diffusa*, Rotenoids, HSCCC, Biological activity.

Introduction

Medicinal chemistry is the well-known branch of bio-organic research, where scientists are always interested to invent new drug molecules to prevent number of complicated diseases. It was observed that herbal medicinal concept had been utilized to establish new drug molecules for the mankind over hundreds of year. Moreover, it was reported that about eighty percent of the world population depends on herbal based alternative system of medicine such as Ayurveda, Unani medicine, Chinese traditional medicine etc. It can be well-justified to say that "Medicinal Plants" are the traditions of yesterday and drugs of tomorrow. According to the WHO, 75% of the world's population—predominantly those of developing countries—confide in plant-derived medicines for their healthcare[1].

Tribal communities use plants as a source of medicines from ancestral period, which shows that from the beginning of the civilization medicinal plants are being used as the lifesaving drugs, still today tribal communities are solely dependent on plants for their medication[2].

The modern medicine have been benefited with plant derived therapeutic agent in which most of the plants contain a variety of phytochemicals which showed very significant application in the fields of veterinary, plants and human medicine[3,4].

Boerhavia which habitually known as '**Punarnava**" that has been classified as "rasayana" herb which possess properties like re-establishing youth, antiaging, brain power, strengthening life and disease prevention; in other words, providing immunomodulation and hepatoprotection. It is a genus of about 40 species of annuls or perennial herbaceous plants in the four O' clock flower family[5].

The five (05) most important species of Boerhavia along with their characteristics, chemical constituents and reported biological activities are mentioned below:

Characteristic feature of different species of Boerhavia:

Table no-1 Characteristic feature of different species of genus Boerhaavia

Name of species	**Characteristic**	**Class of compound present**	**Activity reported**
Boerhavia coccinea[6] **Synnoym**-Scarlet, spiderling or Red spiderling **Family**- Nyctaginaceae  **A**	**Herbs**- Perennial, often ropelike woody at base **Stems**-Prostnatetodocumbent,usually profusely branched throughout 3-15 dm. **Leaves**-Larger leaves with petiole 5-25mm **Inflorescences**- axillary on terminal **Flowers**-0.5-1mm magenta. **Fruits**-gray brown, narrowly obovate	Phenols, flavonoids, terpenoids, reducing sugar.	Anti-microbial, Anti-bacterial, Anti-fungal.
Boerhavia elegans[7] **Synonym**-Rubi chandasterophylla. **Family**- Nyctaginaceae  **B**	**Herbs**- Perennial, erect herb up to 1 m. **Stems**- Fleshy, poberlulous. **Leaves**- Oblong. **Inflorescences**-Diffuse terminal panicle. **Flowers**- Solitary. **Fruits**- Oblong clavi form, grooved.	Phenols, Ligans, Flavonoids.	Anti-oxidant, Diuretic, Alexileria, Carminative, useful in muscular pain.
Boerhavia erecta[8,9] **Synonym**-Boerhavia adscendens. **Family**- Nyctaginaceae  **C**	**Herb**- Perennial, erect spiderlings.**Stems**-Perennating buds near the ground surface, glabious, woody. **Leaves**- fleshy opposite arrangement, base of the leaf can be cuneate or truncate. **Flower**- Peduncle **Fruits**- Sticky.	Phenols, Flavonoids, Enzymatic, antioxidant.	Anti-oxidant, Diuretic, Anti-inflamatory.

Boerhavia repens[10] **Synonym-**Red spiderlink. **Family-**Nyctaginaceae 	**Herb-**Perennial, creeping. **Stems-**Prostate, puberulous . **Leaves-** opposite, mostly less than 2.5 cm long. **Flower-** usually in clusters of 2-6, white, pink.	Flavonoids, Glycoside.	Anti-oxidant, Anti-microbial, activity.
Boerhavia diffusa[11] **Synonym-**Hog weed **Family-**Nyctaginaceae 	**Stem-** Greenish purple, stiff, selender, cylindrical. **Root-** Fairly long, cylindrical, 0.2-1.5 cm in diameter, yellowish brown. **Leaves-** Opposite in unequal pairs, ovate-oblong or suborbicular. **Flowers-** pink colured and very small (10-25 cm). **Fruit-**seeded nut, 6 mm long clavate.	Rotenoids, Phenolic glycoside, Methyl flavone.	Anti-inflamatory, Immunomudulatory, Antiproliferative, Antiestrogenic.

Among all these Boerhavia species "***Boerhavia diffusa***" is endemic to India and having a significant number of medicinal properties.

Pharmacognosy[11]:

Kingdom- Plantae; **Order**- Caryophyllales;

Genus-*Boerhavia*; **Species-***diffusa*

Family name- Nyctaginaceae

Fig no-2: Roots of *B. diffusa*

Common Indian name[12]:

Sanskrit: kahtilla, Sophaghni, Sothaghni; **Bengali:** Rakta Punarnabha;

Asamese: Ranga Punarnabha; **English:** Hog weed; **Gujrati:** Motosatodo;

Hindi: Gadapurna; **Kannada:** Sanadika; **Kashmiri:** Vanjula Punarnava;

Malayalam: Xhuvana Tazhtawa; **Marathi:** Ghetuli; **Oriya:** Lalapuiruni;

Punjabi: khattan; **Tamil:** Mukurattai; **Telegu:** Erra galijeru

Fig no-3: Punarnava

Fig no-1: A-*Boerhavia coccinea*, B-*Boerhavia elegans*, C-*Boerhavia erecta*, D- *Boerhavia repens*, E- *Boerhavia diffusa*.

Distribution and Habitant:

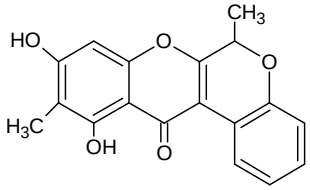
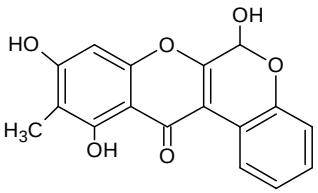
Boerhavia diffusa is originated throughout the warmer parts of the country upto an altitude of 2000 metre in the Himalayan region. It is a perennial, spreading hogweed, commonly grown abundantly in waste places, ditches and marshy places throughout rains[13].

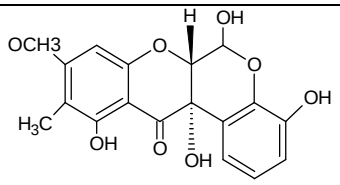
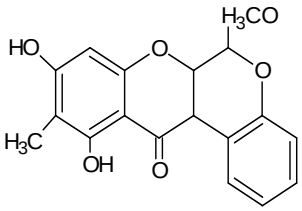
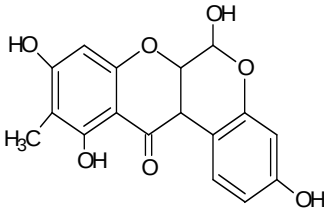
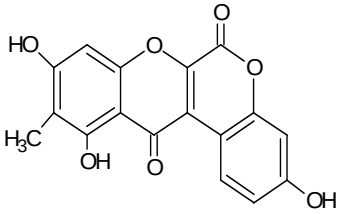
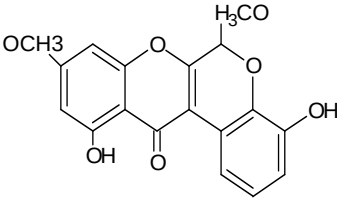
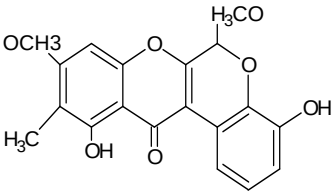
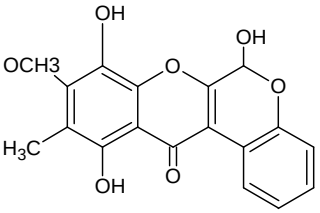
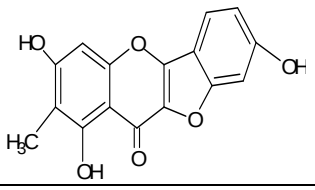
Importance of the root part of the plant:

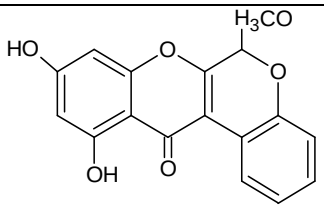
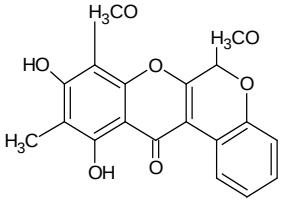
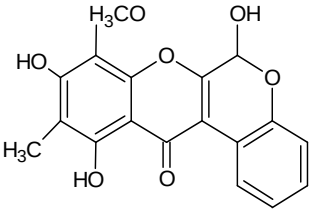
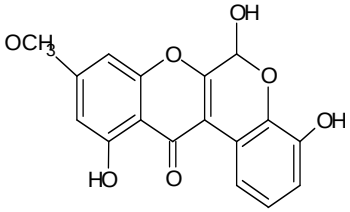
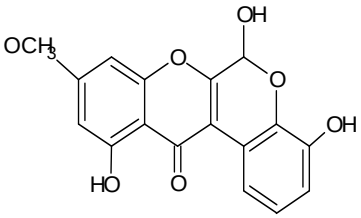
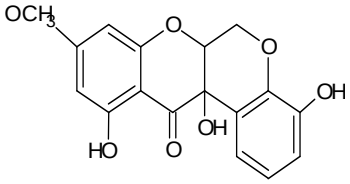
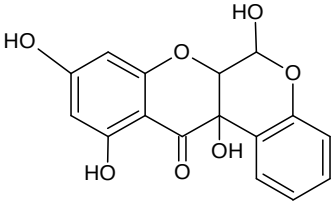
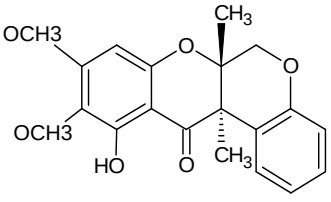
Among all the parts of the plant, the root part of *Boerhavia diffusa* was widely used in the traditional system of medicine for the treatment of jaundice, dyspepsia, enlargement of spleen, abdominal pain and also as an anti-stress agent as per literature[14]. The worldwide use of *Boerhavia diffusa* roots was validated when researchers demonstrated in the year 1980 and 1991 anti-hepatotoxic properties in the root extract[15, 16]. The aqueous extracts of *Boerhavia diffusa* roots are a rich source of basic protein known as systemic resistance inducing protein (BD-SRIP), it's application during virus infection/inoculation, induces strong systemic resistance in several susceptible plants against most commonly occurring viral infection. Because of the presence of all these properties, the root of this plant plays an important role to treat human and plant diseases[17].

Phytcochemical investigation on *Boerhavia diffusa* roots revealed that the presence of diverse class of chemical compounds including phenolic glycoside , terpenoids, organic acids, boeravinones A-J (a group of rotenoids), flavone, isoflavone, flavonol, flavonoid glycoside, xanthone, Lignin, purine nucleoside, sterol, sterol ester, ecdysteroid, fatty acid, hydrocarbons[18,19].

Rotenoids Isolated from the roots of *Boerhavia diffusa*:

Compound Isolated	Structure of the compound	References
Boeravinone-A		**19**
Boeravinone-B		**20**

Boeravinone-C		**21**
Boeravinone-D		**22**
Boeravinone-E		**18**
Boeravinone-F		**23**
Boeravinone-G		**24**
Boeravinone-H		**24**
Boeravinone-I		**25**
Boeravinone-J		**25**

Boeravinone-K		**26**
Boeravinone-L		**26**
Boeravinone-M		**26**
Boeravinone-N		**27**
Boeravinone-O		**27**
10-*O*-Demethylboeravinone C		**27**
Coccineone-B		**23**
Coccineone-E		**25**

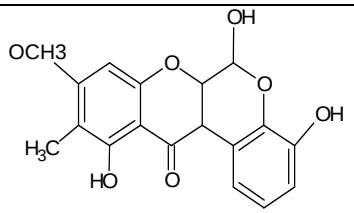
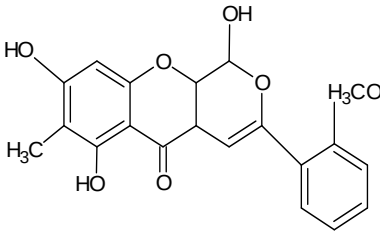
6-*O*-Demethyl boeravinone H		**26**
2'-*O*-methylabronisoflavone		**21**

Table no-2 : Rotenoids isolated from the roots

Different technique of Isolation:

- **Traditional Method :**Column chromatography, Analytical and preparative HPLC, HPTLC[23].
- **Recent advances method :**

HSCCC: High Speed Counter Current Chromatography is a liquid-liquid partition chromatographic technique. It offers various advances such as low solvent consumption, rapid separation and high recovery. So it is an advantageous chromatographic technique compared with the other traditional chromatographic technique like column chromatography, HPLC etc. This technique was applied to isolate and purify rotenoid class of compounds from *Millettia pachycarpa* Benth[23].

Biological Activities of *Boerhavia diffusa*:-

The roots, leaves, seeds, flowers or we can say the whole plant of *B. diffusa* is being utilized for the treatment of various disorders. The roots and leaves part of *B. diffusa* were reported for a huge number of biological activities by a number of researchers[5].

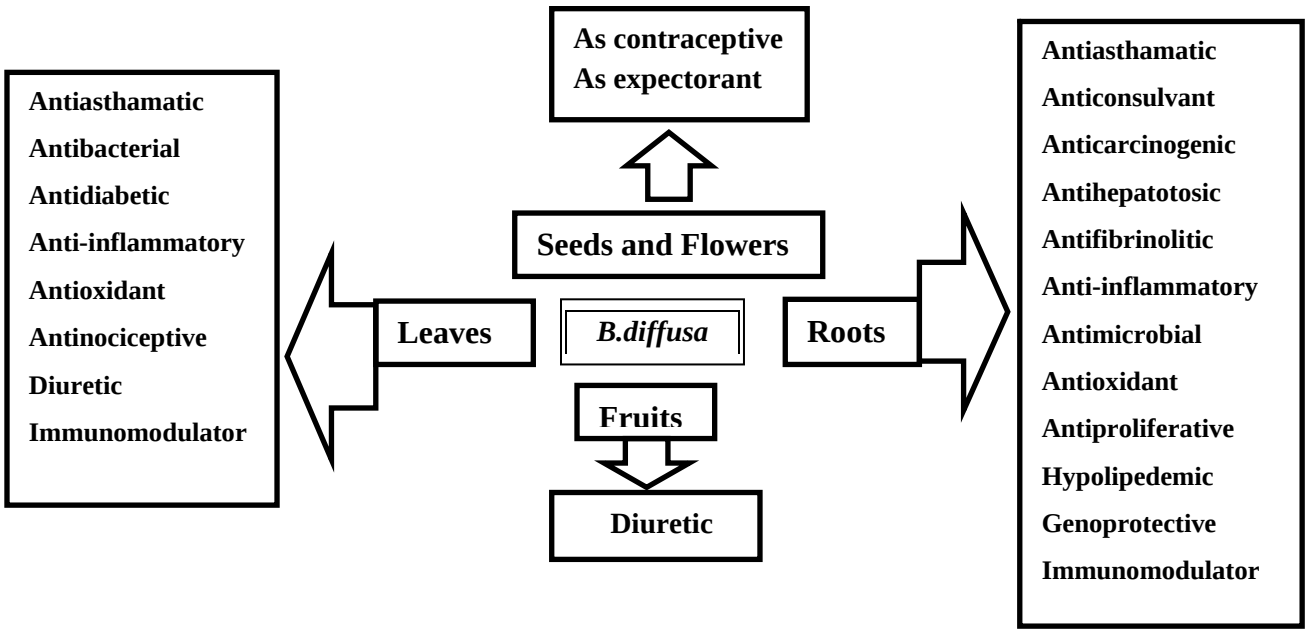


Fig no-4: Biological activities of *B. diffusa*

Analgesic and anti-inflammatory activity:

The analgesic property of *B. diffusa* was mainly showed by its leaf part. The mechanism of its analgesic effect was not known. The study proved that the active anti-nociceptive principle of *B. diffusa* was present mainly in the aqueous extract of fresh leaf juice. Whereas aqueous and acetone extracts of the *B.diffusa* root was mentioned for anti-inflammatory activity against carrageenan-induced oedema and formaldehyde- induced arthritis in albino rats. The aqueous extract of root was also reported for its inhibiting activity on increased serum amino transferase in arthritic animals similar to hydrocorticosone[29,30]. Whereas, COX inhibition was exhibited by the ethanol extract of stem bark of this plant[31].

Anticonvulsant activity:

The methanolic extract of root part of *B.diffusa* was reported for anticonvulsant activity in PTZ induced convulsion in mice[32].

Anti-microbial activity:

The methanolic extract of *B. diffusa* leaves was pointed out for its antimicrobial activity and further study revealed that among several pathogenic bacteria methanolic extract of *B.diffusa* showed potent activity against *Staphylococcus aureus*. More study revealed that the aqueous extract of the plant was active against *Escherichia coli* and inactive against *Staphylococcus aureus*[33,34,35].The seed part of *B.diffusa* exhibited antibacterial activity against *Bacillus subtilis, Pseudomonas cichorii* and *Salmonella typhimurium*, but it was inactive against *Escheichia coli*[36].Moreover it was also reported that ethanol extract of leaves of *B.diffusa* had potent antibacterial activity due to the presence of huge number of phytochemicals in the leaves[37].

Antifibrinolitic:

The research on roots extract of *B.diffusa* was noted down for their antifibrinolitic activity[38].

Anticarcinogenic activity:

B.diffusa was reported for its significant reduction property in the tumor incidence[30].This plant was also reported for the treatment of abdominal tumours and cancers. Whereas treatment with varying concentrations of BME (20-320 μg/ml) showed satisfactory growth inhibition in MCF-7 (breast cancer) cell lines[39,32].

Antioxidant activity:

The roots of *B.diffusa* were mentioned by researchers for their potential antioxidant property[40]. Whereas ethanolic root extract of this plant was reported for its potent antioxidant activity on enzymatic and non-enzymatic experiments[41].

Bronchial asthma:

The dried leaves of *B. diffusa* were used in dhoomapana (smoking) to treat bronchial asthma. Even the leaf part was also reported for the excellent expectorant property along with ginger and black pepper[42].

Antiproliferative and Antiestrogenic activity:

Anti-proliferative and anti-estrogenic properties of methanol extract of *Boerhaavia diffusa* was found in MCF-7 breast cancer cell lines. It was assumed that antiproliferative and antiestrogenic activity could be present due to the presence of alkaloids, flavonoids, phenols and saponins[32].

Adaptogenic activity/Antistress activity:

A polyherbal formulation and hydroethanolic extract of *B. diffusa* were reported for their antistress activity by resulting in significant decrease in triglyceride levels[43].It is believed that the presence of certain phytochemicals like flavonoids, alkaloids, glycosides and sterol in the ethanolic roots extract of *B.diffusa* could be responsible for its antistress activity by researchers[44,45].

Immunomodulatory activity:

Immunoregulation is a complex balance between regulatory and effector cells and any imbalance in the immunological mechanism may lead to pathogenesis of several diseases. Immunomodulators are any substance which can modify the body's mechanism by enhancing or controlling immune response. They can regulate the cytokine production such as tumor necrosis factor, interleukins and interferons and these cytokines may in turn activate different cells of immune system such as T-cells or natural killer cells. The hexane, chloroform and ethanol extracts of *B.diffusa* were reported for their potent immunomodulatory activity[46].

Anti-diabetic activity:

The Ethanolic extract of *Boerhavia diffusa* was reported for its significant anti-hyperglycemic activities in alloxan induced as well as streptozotocin induced hyperglycemic rats[47,48,49].

Anti-fertility:

The aqueous ethanolic extract of root of *B.diffusa* was reported for its anti-fertility activity[50].

Cytological activity:

The plant B.diffusa was reported by researchers for its cytological activity. The root extracts of *B. diffusa* was mentioned for inhibiting mitosis and also reported for cytological studies over expensive colchicines[51].

Conclusion:

Punannava means "once again becoming new", due to its multiple beneficial medicinal properties the plant proved itself a magical natural remedy for mankind. In this new era it is observed that an impressive number of pharmaceutical industries have shown their interest towards design and development of new indigenous plant based drugs through investigation of leads from traditional system of medicine. A huge number of investigations on *B. diffusa* established that it is an important medicinal plant having a plethora of chemical constituents specially rotenoids class of compounds effective against a large number of ailments. In near future a novel procedure of isolation of rotenoids by HSCCC from the plant extract could help in better understanding of antiglycating properties for prevention of bio-macromolecule damage in hyperglycemic condition. This could also help in prevention of onset of several diseases linked to the glycation reaction like diabetes, blood pressure, arthritis and ageing.

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