

Boerhaavia diffusa roots (Punarnava mool) – Review as Rasayan (Rejuvenator / Antiaging)

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ABSTRACT

Boerhaavia diffusa roots (Punarnava mool) are in use since beginning of Ayurved era for various therapeutic benefits. This Research Paper basily enquires into work done in the field of its Rejuvenation (Rasayan) benefits. The name Punarnava itself means 'Rejuvenation'. In the modern allopathic terms, it has been translated as adaptogenic, immunomodulatory, anti-oxidant aphrodisiac and nootropic activities. The review indicates that this herb justifies its name but more detailed research needs to be done particularly in last two activities viz nootropic and aphrodisiac activities.

Key words: Boerhaavia diffusa, Rasayan, Anti aging, Anti oxidant, Immunomodulator, Adaptogen

INTRODUCTION

The plant Boerhaavia diffusa was named in honor of Hermann Boerhaave, a famous Dutch physician of the 18th century.¹

The Rasayan branch of Ayurveda deals specifically with and Rasayan herbs and formulations that bestows upon the user, the longevity with age stabilization and retaining youth for longer.²

From the rasayan treatment, one attains longevity, memory, intelligence, freedom from disorders, youthful age, excellence of luster, complexion and voice, oratory, optimum strength of physique and sense organs, respectability and brilliance. It means the attaining the excellent Rasa etc.

These antiaging attributes will also incorporate being Adaptogen, Antioxidant and Immunomodulator.

1.2 Scientific classification:

Kingdom: Plantae

Order: Caryophyllales

Family: Nyctaginaceae

Genus: Boerhavia

Species: *B. diffusa*

Synonyms: *Boerhavia adscendens*, *B. caribaea*, *B. coccinea*, *B. erecta*, *B. paniculata*, *B. repens*, *B. viscosa*.

6 species are found in India – *B. diffusa*, *B. chinensis*, *B. erecta*, *B. repens*, *B. rependa*, and

B. rubicunda. *Boerhaavia diffusa* is also indigenous to India; it is found throughout the warmer parts of the country up to an altitude of 2000 m in the Himalayan region. It grows well on wastelands and in fields after the rainy season.³

1.3 Names in different languages:⁴

Sanskrit : Kahtilla, Sophaghni, Sothaghni, Varshabhu

Assamese : Ranga Punarnabha

Bengali: Rakta punarnava

English: Horse Purslane, Hog Weed

Gujrati: Dholisaturdi, Motosatodo

Hindi: Gadapurna, Lalpunarnava

Kannada: Sanadika, Kommeberu, Komma

Kashmiri: Vanjula Punarnava

Malayalam: Chuvanna Tazhutawa

Marathi: Ghetuli, Vasuchimuli, Satodimula, Punarnava, Khaparkhuti

Oriya: Lalapuiruni, Nalipuruni

Punjabi: Khattan

Tamil: Mukurattai (Shihappu)

Telugu: Atikamamidi, Erra galijeru

1.4 Boerhavia diffusa in classical Ayurvedic texts:

The word punarnava literally means, one which renews the body, that is, which brings back the youth. Punarnava enjoys an important place among medicinal herbs in India since ancient times.

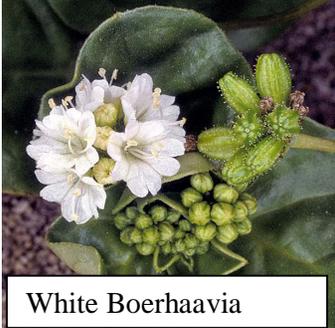
Various parts of *Boerhaavia diffusa* are used for the treatment of numerous

disorders. In Purulia (West Bengal), the tribes eat this plant as a vegetable. *Boerhaavia* leaves are cooked and eaten in Assam,

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There are two kinds of plants, one with white flowers and other with red flower



White Boerhaavia



Red Boerhaavia



Boerhaavia diffusa



Boerhaavia diffusa

The classical texts like Sushrut Samhita, Raj Nighantu, Bhavprakash Nighantu, Dhanvantari Nighantu and other texts also describe Punarnava similarly and are quoted below.⁴

पुनर्नवा भवेदुष्णा तिक्ता रुक्षा कफापहा ।
सशोफ पाण्डुहृद्रोगकोसोरः क्षतशूलनुत् ॥275 ॥
(धन्व.नि.गुडुच्यादिवर्ग, 275.)

वर्षाभूमधुरा तिक्ता कषाया कटुका सरा ॥753 ॥
(कै.नि. ओषधि वर्ग, 753.)

रक्तपुनर्नवा (मूल)

तेषु पौनर्नवं शाकं विशेषाच्छोफनाशनम् ॥255 ॥
(सु., सूत्र स्थान 46,255)

पुनर्नवा (रक्त)

उष्णानि स्वादुतिक्तानि वातप्रशमनानि च ।
तेषु पौनर्नवं शाकं विशेषाच्छोफनाशनम् ॥
(सुश्रुत सू०; 46/255)

पुनर्नवाऽन्या रक्ताख्या क्रूरा मण्डलपत्रिका ।
रक्तकाण्डा वर्षकेतुर्लोहिता रक्तपत्रिका ॥
वैशाखी रक्तवर्षाभूः शोफघ्नी रक्तपुष्पिका ।
विकस्वरा विषघ्नी च प्रावृषेण्या च सारिणी ॥
वर्षाभवः शोणपत्रः शोणः सम्मीलितद्रुमः ।
पुनर्नवो नवो नव्यः स्याद्वाविंशतिसंज्ञया ॥
रक्ता पुनर्नवा तिक्ता सारिणी शोफनाशिनी ।
रक्तप्रदरदोषघ्नी पाण्डुपित्तप्रमर्दिनी ॥
(रा० नि०, पर्पटादि वर्ग; 117-120)

रक्तपुनर्नवा तिक्ता सारिणी शोफनाशिनी ।
रक्तप्रदर दोषघ्नी पाण्डुपित्तप्रमर्दिनी ॥
(रा.नि., पर्पटादि वर्ग, 120)

पुनर्नवाऽरुणा तिक्ता कटुपाका हिमा लघुः ॥
वातला ग्राहिणी श्लेष्म पित्त रक्त विनाशिनी ॥233 ॥
(भा.प्र., गुडुच्यादि वर्ग, 233)

In above Ayurvedic texts, it is cited to possess the following therapeutic properties.

Asmarighna – Litholytic,
Indralupta nasaka – Mitigates Alopecia aeriata,
Sothaghna – Relieves Edema
Mutrakrcichraghna alleviates Dysuria.

Traditional properties:

Rasa : Madhura, Tikta, Kasaya

Guna : Rooksha

Virya : Oorsna

Vipaka : Madhura

Karma : Anulomana, Sothahar, Mootral,
Vatasleshmahara

Acharya Charaka has categorized it as:

Kasahara – alleviates cough,

Vayasthapana – promotes longevity and maintains youth,

Svedopaga – adjunct to suctation (sweating therapy) and
 Anuvasanopaga – adjunct to oleating enemas.
 It is the best Rejuvenative to urinary system.

1.5 Traditional products:

Punarnavasava
 Punarnavadi Mandura
 Punarnavasataka
 Punarnavambu
 Punarnava Guggula
 Punarnavasak Kwath / Churna
 Sukumar Ghrit
 Sothaghna Lepa

1.6 Botany:

Boerhaavia diffusa, belonging to the family of the Nyctaginaceae, is mainly a diffused perennial herbaceous creeping weed of India (known also under its traditional name as *Punarnava*) and of Brazil (known as *Erva tostão*). *Boerhaavia diffusa* is up to 1 m long or more, having spreading branches. The stem is prostrate, woody or succulent, cylindrical, often purplish, hairy, and thickened at its nodes. The leaves are simple, thick, fleshy, and hairy, arranged in unequal pairs, green and glabrous above and usually white underneath. The shape of the leaves varies considerably ovate-oblong, round, or subcordate at the base and smooth above.

The margins of the leaves are smooth, wavy or undulate. The upper surface of the leaves is green, smooth and glabrous, whereas it is pinkish white and hairy beneath. The flowers are minute, subcapitate, present 4-10 together in small bracteolate umbrellas, mainly red or rose, but the white varieties are also known. The achene fruit is detachable, ovate, oblong, pubescent, five-ribbed and glandular, anthocarpous and viscid on the ribs.⁵

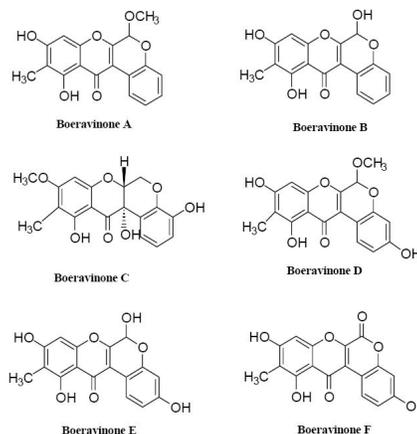
The seeds germinate before the onset of the monsoon. The plant grows profusely in the rainy season and mature seeds are formed in October-November. Due to its sticky nature, the plant gets stuck on the clothes of humans and on the legs of animals, which helps in its dispersal from one place to another. It has a large root system bearing rootlets. The tap root is tuberous, cylindrical to narrowly fusiform, conical or tapering, light yellow, brown or brownish grey. It is thick, fleshy and very bitter in taste.

1.7 Chemical constituents:

The root of *B. diffusa* contains alkaloids (punarnavine), rotenoids (boeravinones A-F), flavonoids, amino acids, lignans (liriodendrons), β -sitosterols and tetracosanoic, esacosanoic, stearic and ursolic acids.

The most interesting metabolites from the therapeutic point of view are the rotenoids (known as boeravinones (A - F)^{6,7,8,9, 10}

Main rotenoids (known as boeravinones A-F) present in the root of *Boerhaavia diffusa*



Punarnavoside, a phenolic glycoside, is reportedly present in roots.^{11,12} C-methyl flavone also has been isolated from *Boerhaavia diffusa* roots.¹³ Two known lignans viz., liriodendrin and syringaresinol mono- β -D-glycoside have been isolated.¹⁴ Presence of a purine nucleoside hypoxanthine 9-L-arabino-¹⁵ dihydroisofuroxanthone-borhavin¹⁶, phytosterols^{17,18} have been isolated from the plant. It contains about 0.04 % of alkaloids known as punarnavine and punernavoside, an antifibrinolytic agent. It also contains about 6 % of potassium nitrate, an oily substance, and ursolic acid.¹⁹ The seeds of this plant contain fatty acids and allantoin and the roots contain alkaloids.²⁰ The green stalk of the plant has also been reported to contain boerhavin and boerhavic acid.

1.8 Traditional medicinal uses:

The root, leaves, aerial parts or the whole plant of *Boerhaavia diffusa* have been employed for the treatment of various disorders in the Ayurvedic herbal medicine (daily used by millions of people in India, Nepal, Sri Lanka and indirectly through it being the major influence on Unani, Chinese and Tibetan medicines).

The root is mainly used to treat gonorrhea, internal inflammation of all kinds, dyspepsia, oedema, jaundice, menstrual disorders, anaemia, liver, gallbladder and kidney disorders, enlargement of spleen, abdominal pain, abdominal tumours, and cancers.²¹

It cures corneal ulcers and night blindness²², and helps restore virility in men. People in tribal areas use it to hasten childbirth.²³

The juice of *Boerhaavia diffusa* leaves serves as a lotion in ophthalmia. It is also administered orally as a blood purifier and to relieve muscular pain.²⁴

2 PHARMACOLOGICAL AND CLINICAL PROPERTIES

2.1 Rasayan properties:

Ethanol extract of roots of *Boerhaavia diffusa* was evaluated for antistress, adoptogenic activity in albino mice, by swim endurance test and cold restraint stress. The extract improved the stress tolerance by significantly increasing the swim duration and reducing the elevated WBC, blood glucose and plasma cortisol. Immunomodulatory activity was evaluated by carbon clearance assay and delayed hypersensitivity test. The extract significantly increased carbon clearance, indicating the stimulation of reticuloendothelial system. The extract produced an increase in DTH response to SRBC in mice, which was comparable with that of Levamisol, indicating stimulatory effects on lymphocytes and accessory cell types required for the expression of reaction.²⁵

2.2 Immunomodulation:

2.2.1 The alkaloidal fraction of *Boerhaavia diffusa* was studied for its effect on cellular and humoral functions in mice. Oral administration of the fraction (25–100 mg/kg) significantly inhibited SRBC-induced delayed hypersensitivity reactions in mice. However, the inhibition was observed only during post-immunisation drug treatment, while no effect during pre-immunisation drug treatment was observed. A significant dose-related increase in antibody titre was observed during pre- and post-immunisation treatment. The alkaloidal fraction failed to show any blastogenic responsiveness of murine splenocytes to Concanvalin A (Con A) and lipopolysaccharide (LPS). Similarly, it did not display any mitogenic activity. Thus, the present study has shown the in vivo immunostimulatory activity of *B. diffusa* alkaloidal fraction without an in vitro effect.²⁶

2.2.2 Immunosuppressive activity: Plant extracts have been widely evaluated for possible immunomodulatory properties. We have earlier reported that ethanolic extract of *Boerhaavia diffusa* root, a plant used in Indian traditional medicine, has significant immunomodulatory potential. *B. diffusa* hexane, chloroform and ethanol extracts, and two pure compounds Bd-I (eupalitin-3-O-β-D-galactopyranoside) and Bd-II (eupalitin) were evaluated in vitro for their effect on T cell mitogen (phytohemagglutinin; PHA) stimulated proliferation of human peripheral blood mononuclear cell (PBMC), mixed lymphocyte culture, lipopolysaccharide (LPS) stimulated nitric oxide production by RAW 264.7, PHA and LPS induced IL-2 and TNF-α production, in human PBMCs, superoxide production in neutrophils, human natural killer (NK) cell cytotoxicity and

nuclear translocation of nuclear factor-κB and AP-1 in PHA stimulated PBMCs.

The chloroform and ethanol extracts inhibited PHA stimulated proliferation of peripheral blood mononuclear cells, two-way MLR, NK cell cytotoxicity as well as LPS induced NO production by RAW 264.7; the hexane extract showed no activity. Bd-I purified from the ethanolic extract at equivalent dose, inhibited PHA-stimulated proliferation of peripheral blood mononuclear cells, two-way MLR and NK cell cytotoxicity as well as LPS induced NO production by RAW 264.7 equally or more effectively than the parent ethanolic extract. Bd-I inhibited production of PHA stimulated IL-2 at the protein and mRNA transcript levels and LPS stimulated TNF-α production in human PBMCs; it also blocked the activation of DNA binding of nuclear factor-κB and AP-1, two major transcription factors centrally involved in expression of the IL-2 and IL-2R gene, which are necessary for T cell activation and proliferation. Our results report selective immunosuppressive activity of *B. diffusa* leaf extracts and that this activity lies in eupalitin-3-O-β-D-galactopyranoside (Bd-I) isolated and purified from the ethanolic extract. Thus, Bd-I could be a candidate for development as an immunosuppressive agent.²⁷

2.2.3 We have earlier reported that ethanolic extract of *Boerhaavia diffusa*, a plant used in Indian traditional system of medicine, significantly inhibits the cell proliferation. This led us to evaluate the immunomodulatory properties of this plant extract on various in vitro tests such as human natural killer (NK) cell cytotoxicity, production of nitric oxide (NO) in mouse macrophage cells, RAW 264.7, interleukin-2 (IL-2), tumor necrosis factor-α (TNF-α), intracytoplasmic interferon-γ (IFN-γ) and expression of various cell surface markers on human peripheral blood mononuclear cells (PBMCs). Ethanolic extracts of *B. diffusa* roots inhibited human NK cell cytotoxicity in vitro, production of NO in mouse macrophage cells, IL-2 and TNF-α in human PBMCs. Intracytoplasmic IFN-γ and cell surface markers such as CD16, CD25, and HLA-DR did not get affected on treatment with *B. diffusa* extract. Our study demonstrates immunosuppressive potential of ethanolic extract of *B. diffusa*.²⁸

2.3 Adaptogenic activity:

2.3.1 Hydroethanolic extract (80%) of *Boerhaavia diffusa* (HEBD) and a polyherbal formulation (Punarnava mandur) PHF-09 containing *Boerhaavia diffusa* were compared for their antistress activity using Cold restraint stress model. Punarnava mandur contains *Boerhaavia diffusa*, mandur bhasm, varun, bharangi.

The HEBD and PHF-09 showed antistress activity in dose dependent manner. Cold restraint stress resulted in significant decrease in glucose & triglyceride levels. Triglyceride level was near normalized following the administration of HEBD and PHF-09, the effect being more profound following treatment with PHF-09 at 600 mg/kg p.o. as compared to HEBD treatment. A significant increase was observed in the levels of cholesterol, SGOT, SGPT in stress control group as compared to normal control group.²⁹

2.3.2 Phytochemical constituents like flavonoids, alkaloids, glycosides and sterols have been reported to be present in the alcoholic root extracts of *Boerhaavia diffusa*. The antistress activity of *Boerhaavia diffusa* is mainly attributed to these constituents with established antioxidant activity.³⁰

2.3.3 The extract improved the stress tolerance by significantly increasing the swim duration & reducing the elevated WBC, blood glucose & plasma cortisol. Immunomodulatory activity was evaluated by carbon clearance & delayed hypersensitivity test. The extract significantly increased carbon clearance, indicating the stimulation of reticuloendothelial system. The extract also produced an increase in DTH response to SRBC in mice.²⁵

2.3.4 Adaptogens seem to be useful during both adrenal hyperstress as well as adrenal hypofatigue. By definition, an adaptogen implies the capability for bi directional or normalizing effects. The most important adaptogens for the adrenals include *Panax Ginseng*, Siberian Ginseng, Ashwagandha, Rhodiola, *Boerhaavia diffusa*, and Holybasil Leaf Extract. *Boerhaavia diffusa* (PUNARNAVA) has the ability to support both adrenal over and under activation. In stressful conditions it has demonstrated the ability to buffer the elevations of serum cortisol and prevent the suppression of the immune system that takes place with elevated cortisol. On the other hand, *Boerhaavia diffusa* has also demonstrated the ability to improve cortisol levels with end stage adrenal exhaustion.³¹

2.3.5 The treatment with the watery extract from the root of *B. diffusa* induced leucocytosis with predominant neutrophils, associated to the phagocytosis ability and it was bactericidal to the neutrophils and the macrophages.³²

2.4 Antioxidant activity:

2.4.1 Leaves revealed stronger antioxidant activity than roots, the first analysis of volatile compounds of a widely used medicinal plant, *B. diffusa*, using a HS-SPME-GC-MS technique directly into the headspace of the aqueous extract of the leaves and roots. In addition to phenolics (determined by HPLC-DAD), the organic acids (HPLC-UV)

profile and in vitro antioxidant and anti acetylcholinesterase activities are described for the first time, providing further knowledge on this species' chemistry and biological potential.³³

2.4.2 Ethanol and methanol extracts were prepared and screened for in-vitro antioxidant activities using Ferric reducing power and Hydrogen peroxide scavenging activity. The activity was compared to standard antioxidant like ascorbic acid. Both the extract showed strong antioxidant activity in both the methods. Between these two extracts, ethanolic extract has shown better antioxidant activity as compared to methanolic extract in both the activities.³⁴

2.4.3 *Boerhaavia diffusa* is a plant which is extensively used in folk medicine. However, when it comes to its phytochemical characterization, little attention has been given to secondary metabolites other than rotenoids and alkaloids. A metabolite profiling and biological study was undertaken in this species' leaves and roots and substantial differences were found between the two parts of the plant. The volatile composition was analysed for the first time using HS-SPME-GC-MS and several compounds, including terpenes, phenylpropanoids, indol compounds, norisoprenoids, among others, were identified. Organic acid analysis was also performed, allowing their characterization in this species for the first time, and oxalic, ketoglutaric, pyruvic, quinic and fumaric acids were identified. Quantitative differences between the two vegetal materials were found. Additionally, several flavonoids and one phenolic acid were also confirmed. Concerning the biological potential, the aqueous extract of each plant part was tested against DPPH radical, one reactive oxygen species and one reactive nitrogen species (NO). Moreover, activity against acetylcholinesterase, an enzyme with a well-known role in several physio-pathological processes, was assayed. When possible, the relation between the chemistry and activity displayed was established. Leaves revealed stronger antioxidant activity than roots, and acetylcholinesterase inhibition was not found in neither plant part.³⁵

2.4.4 Extracts of *Boerhaavia diffusa* leaves were evaluated for antioxidant and hepatoprotective properties in the acetaminophen-induced liver damage model. Antioxidative evaluation of ethanolic extract gave total phenolic content, total flavonoid content, vitamin C content and vitamin E content and the levels of selenium and zinc as 6.6 ± 0.2 mg/g tannic acid equivalent, 0.092 ± 0.003 mg/g quercetin equivalent, 0.21 ± 0.03 mg/g, 0.054 ± 0.002 mg/g, 0.52 ± 0.05 ppm and 9.28 ± 0.16 ppm, respectively. The DPPH scavenging capacity and

the reductive potential were $78.32 \pm 2.41\%$ and 0.65 ± 0.02 mg/g ascorbic acid, respectively. Pretreatment with aqueous and ethanolic extracts decreased the activities of alkaline phosphatase, lactate dehydrogenase, alanine aminotransferase, aspartate aminotransferase, and the level of bilirubin in the serum that were elevated by acetaminophen. The two extracts also ameliorated the elevation in the activities of the enzymes in the liver. Acetaminophen intoxication led to reduction in serum and liver albumin levels which were not significantly increased by pretreatment with the extracts. The extracts also protected against acetaminophen induced lipid peroxidation. These results indicated that leaf extracts from *B. diffusa* possess hepatoprotective property against acetaminophen-induced liver damage which may be mediated through augmentation of antioxidant defenses.³⁶

2.4.5 The present study was carried out to evaluate the antioxidant activity of extracts of *Boerhaavia diffusa* dried root powder (Nyctaginaceae). In evaluation, ethanol and methanol extracts were prepared and screened for in-vitro antioxidant activities using Ferric reducing power and Hydrogen peroxide scavenging activity. The activity was compared to standard antioxidant like ascorbic acid. Both the extract showed strong antioxidant activity in both the methods. Between these two extracts, ethanolic extract has shown better antioxidant activity as compared to methanolic extract in both the activities. In addition to antioxidant activity, the total alkaloid and total tannin content was also measured. The total alkaloid and total tannin content was found to be 0.15% and 0.52% respectively. Hence, the extract can be subjected to detailed study as an antioxidant.³⁷

2.4.6 The present study was undertaken to evaluate antioxidant activity of Chloroform, Ethanol, and Ethyl acetate fraction of *B. diffusa L* roots which might have improved hepatoprotective action. Preliminary phytochemical testing showed the presence of high amount of tannins and phenolics in the various extracts of *B. diffusa L*. Herbal drugs containing free radical scavengers like phenolics, tannins and flavonoids are known for their therapeutic activity hence the present study was undertaken to evaluate antioxidant activity of different extracts of *B. diffusa L* roots which might have improved its reported pharmacological action. *In vitro* nitric oxide scavenging activity, the percentage inhibition was 71.35%, 33.74%, 23.85% in ethanol, chloroform and ethyl acetate extracts at 250mcg/ml when compared with Curcumin at 62 mcg/ml showed only 84.7% inhibition respectively. The ethanol extract and ethyl acetate showed a biphasic response whereas the chloroform extract

showed a dose dependent increase. In DPPH radical scavenging activity, the ethanol extract showed 81.94% inhibition and the chloroform extract showed 42.58% inhibition at 1000mcg/ml compared with 88.02 % inhibition by Quercetin. The above results suggest that roots of *B. diffusa L* were found to reveal antioxidant potential which supports the use of this plant in traditional medicine.³⁸

2.4.7 Type-II Diabetic Mellitus is characterized by reduced insulin sensitivity by insulin receptors in the cell membrane or insulin resistance combined with reduced insulin secretion due to defective responsiveness of body tissues to insulin. The purpose of this study was to estimate the effect of a methanolic extract of *Boerhaavia diffusa* on oxidative stress. Results through this research demonstrate that diabetic patients experience on exaggerated oxidative stress when compared with normal significant increase in plasma, TG, TC, VLDL-C, LDL-C, HDL-C, HDL2-C, HDL3-C and non HDL-C levels. This may be due to markedly increased production of oxidant and significantly diminished antioxidant defence including a decline in total plasma antioxidant power. Thus the study depicts that daily intake of *Boerhaavia diffusa* extract by Diabetic Mellitus patients may be useful in the prevention and treatment of the Diabetes-induced hyperlipidemia and atherosclerosis. In addition, daily use of *Boerhaavia diffusa* will be efficacious and cost effective and good source of natural antioxidant.³⁹

2.4.8 The present study was carried out to evaluate the antioxidant and cytotoxic activity of unexploited plant, *Boerhaavia diffusa* indigenous to India. Different concentrations of the ethanolic whole-plant extract were subjected to 1,1-diphenyl-2-picryl hydrazyl (DPPH) radical scavenging, reducing power activity and cytotoxic study against vero cell lines. The maximum DPPH radical scavenging potential was found to be 93% at 1000 µg/ml. The inhibition percentage with regard to cytotoxicity was found to be 89 % at 1000 µg/ml.⁴⁰

3. OTHER PHARMACOLOGICAL ACTIVITIES

3.1 Cancer:

3.1.1 *Boerhaavia diffusa*, Linn (Fam: Nyctagenaceae), is widely used for the treatment of Jaundice in various parts of India. In the present study, cancer chemopreventive property of *B. diffusa* was evaluated on 7,12-dimethyl benz(a)anthracene (DMBA) induced skin

papillomagenesis in male Swiss albino mice (6-7 weeks old). A single topical application of 7,12-dimethyl benz(a)anthracene (50 µg/50 µl of acetone), followed 2 weeks later by repeated application of croton oil (1% in acetone three times a week) and continued till the end of the experiment exhibited 100% tumor incidence. In contrast, mice treated topically on the shaven backs with the *Boerhaavia diffusa* extract at either the peri-initiation phase (i.e. 7 days before and 7 days after the application of DMBA; Group II), post initiation phase (i.e. from the day of start of croton oil treatment and continued till the end of the experiment; Group III) or continuously at the peri- and post-initiation stages (i.e. 7 days prior to DMBA application and continued till the end of the experiment; Group IV), a significant reduction in the values of tumor incidence (Group II – 65%; Group III – 30%; Group IV – 25%), average number of tumors per tumor bearing mouse (Group II – 2.8; Group III – 0.75; Group IV – 0.35) and papillomas per papilloma bearing mouse (Group II – 3.1; Group III – 2.5; Group IV – 1.2) were observed.⁴¹

3.1.2 The plant was reported to be efficient for the treatment of the abdominal tumours and cancers and was proved to be useful as a haematic and as a growth promoter with the children fed with milk fortified with the plant drug. In the form of a powder or an aqueous decoction, the plant drug was proved to be beneficial in the treatment of nephritic syndrome and compared well with corticosteroids. It was also demonstrated that the drug decreased the albumin urea, increased the serum protein and lowered serum cholesterol level.⁴²

3.1.3 Treatment with varying concentrations of BME (20-320 µg/mL) resulted in moderate to very strong growth inhibition in MCF-7 cell lines. BME competed with [3H]-estradiol for binding to ER with IC₅₀ value of 320±25 µg/mL. RT-PCR analysis revealed that BME reduced the mRNA expression of pS2 indicating the antiestrogenic action of BME. BME treatment for 48 h resulted in a remarkable increase in the number of MCF-7 cells in the G0-G1 fraction from 69.1% to 75.8 %, with a reciprocal decrease of cells in all other phases indicating cell cycle arrest at G0-G1 phase. Hence, it demonstrates that *Boerhaavia diffusa* possess antiproliferative and Antiestrogenic properties and suggest that it may have therapeutic potential in estrogen dependent breast cancers.⁴³

3.2 Hepatoprotective activity:

3.2.1 The *B. diffusa* extract is found to be Anti-hepatotoxic⁴⁴

3.2.2 The *B. diffusa* extract is found to be Hepatoprotective⁴⁵

3.2.3 An aqueous extract of thinner roots of *B. diffusa* at a dose of 2 mg/kg exhibited the remarkable protection of various enzymes such as serum glutamic-oxaloacetic transaminase, serum glutamicpyruvic transaminase, and bilirubin in serum against hepatic injury in rats.^{46, 53}

3.2.4 Further experimental studies also evidenced a beneficial activity of the

Punarnava root for the treatment of the jaundice.^{57, 58}

3.3 Anti-inflammatory activity:

3.3.1 Ethanol extract of leaves at dose of 400mg/kg exhibited maximum anti-inflammatory effect with 30.4, 32.2, 33.9 and 32% with carrageenin, serotonin, histamine and dextran induced rat paw edema models, respectively. Ethanol extract of stem bark also exhibited COX-1 and IC50 value of 100ng/ml proving the drug use in the treatment of inflammatory condition. Anti-inflammatory activity was assessed using extract of latex of plant by using a carragenan induced inflammatory model.⁴⁷

3.3.2 Anti-inflammatory activity of *Boerhaavia diffusa*.⁴⁸

3.4 Diuretic activity:

3.4.1 Maximum diuretic and anti-inflammatory activities of *Punarnava* have been observed in samples collected during the rainy season. Due to the combination of these two activities, *Punarnava* is regarded therapeutically highly efficacious for the treatment of renal inflammatory diseases and common clinical problems such as nephritic syndrome, oedema, and ascites developing at the early onset of the liver cirrhosis and chronic peritonitis.

The root is used to treat other renal ailments (calculations and cystitis), seminal weakness and blood pressure.⁴⁹

3.4.2 The extract of *Boerhaavia diffusa* is found to be diuretic with special effect to nephrotic syndrome.⁵³

3.4.3 The extract of *Boerhaavia diffusa* is found to be diuretic.⁵¹

3.5 Kidney disorders:

3.5.1 Useful in kidney disorders.^{50, 52}

3.6 Antidiabetic activity:

3.6.1 A study was carried out to investigate the effects of daily oral administration of aqueous solution of *Boerhaavia diffusa* L. leaf extract (BLEt) (200 mg/kg) for 4 weeks on blood glucose concentration and hepatic enzymes in normal and alloxan induced diabetic rats. A significant decrease in blood glucose and significant increase in plasma insulin levels were observed in normal and diabetic rats treated with BLEt.⁵⁴

Chloroform extract of *B. diffusa* leaf produced dose-dependent reduction in blood glucose in streptozotocin-induced NIDDM rats comparable to that of glibenclamide. The results indicate that the reduction in blood glucose produced by the extract is probably through rejuvenation of pancreatic beta-cells or through extra pancreatic action.⁵⁵

3.6.2 This study depicts that daily intake of *Boerhaavia diffusa* extract by Diabetic Mellitus patients may be useful in the prevention and treatment of the Diabetes-induced hyperlipidemia and atherosclerosis.³⁹

3.7 Antiviral activity:

3.7.1 Root of *Boerhaavia diffusa* contains basal proteins which show high virus inhibitory activity against plant viruses. Root extract of this plant induce strong systemic resistance in susceptible host plant. In the study, we found that the BD-SRIP induces the resistance against the TMV infection.⁵⁶

3.8 Anticonvulsant activity:

3.8.1 Anticonvulsant activity: Study showed the crude methanolic extract of *B. diffusa* and its lirioidendrin-rich fraction showed a dose-dependent protection against PTZ-induced convulsions.⁵⁹

4 TOXICOLOGICAL STUDIES:

4.1 Toxicological studies conducted on *B. diffusa* demonstrated the absence of teratogenic and mutagenic effects.⁶⁰

5. CONCLUSION: The review of wide body of research papers and theses, represented as above, could be concluded as

a) Considerable research work already done proves that the herb Punarnava (*B. diffusa*) is really has Rejuvenation / Antiaging benefits (Rasayan) in terms of Adaptogenic, Immunomodulatory, Antioxidant, Hepatoprotective and anti-cancer activities.

b) Further research needs to be undertaken to establish the Aphrodisiac and Nootropic activities. Confirmation of these activities will establish it to be true Rasayan (Rejuvenator / Antiaging herb)

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