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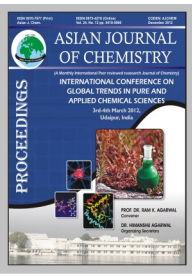

Ethnobotanical, Phytochemical and Pharmacological Profile of *Boerhaavia diffusa* Linn. - A Review†

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Boerhaavia diffusa, commonly known as Punarnava in Sanskrit, is a herbaceous plant and a member of Nyctaginaceae family. It is widely distributed in tropics and sub tropics. It has a long history of uses by indigenous and tribal people and in Ayurvedic medicines. In the traditional system of medicines, *Boerhaavia diffusa* roots have been widely used for the treatment of dyspepsia, jaundice, enlargement of spleen and abdominal pain. It is also used as antistress agent. Root extract had antihepatotoxic properties. Plant is also used as blood purifier, laxative, expectorant, diuretic. *Boerhaavia diffusa* contains a large number of bioactive chemical compounds such as flavonoids, alkaloids, steroids, triterpenoids, lipids, lignins, carbohydrates, proteins and glyco-proteins. Many rotanoids have been isolated from root of this plant. These include a series of boeravinones. Punernavoside, a phenolic glycoside is reportedly present in root. Pharmacological activities of the plant include antibacterial, antidiabetic, hepatoprotective, antiastrogenic, antoinflametory, anticonvulsant, antistress and adaptogenic activity, immunomodulatory, diuretic, antifertility, antioxidant, antiviral, antifibrinolytic. Multiple benefits of *Boerhaavia diffusa* made it a true miracle of nature. Plants contain thousands of constituents and are valuable sources of new and biologically active molecules. In spite of tremendous potential, this plant has not yet developed as a drug by pharmaceutical industries. The objective of this review is to show the recent advances in the exploration of plant *Boerhaavia diffusa* as phytotherapy and to illustrate its potential as a therapeutic agent.

Key Words: *Boerhaavia diffusa*, Punarnava, Ayurvedic medicines, Punernavoside, Boeravinones, Therapeutic agent.

INTRODUCTION

Boerhaavia diffusa is a herbaceous member of the family Nyctaginaceae. It is widely distributed in the tropics and subtropics. It has a long history of uses by indigenous and tribal people and in Ayurvedic or natural herbal medicines[1]. *Boerhaavia diffusa* L. is a wild perennial herb which may be encountered in different terrestrial habitats, ranging from managed grasslands, wastelands, agro-ecosystems to large forest gaps. The species of *Boerhaavia* have been in use for medicinal purpose in different parts of India. The plant was named in honor of Hermann Boerhaave, a famous Dutch physician of the 18th century[2]. The plant is mentioned in the Atharvaveda with the name '*Punarnava*', because the top of the plant dries up during the summer season and regenerates again during the rainy season[3].

The genus *Boerhaavia* has several species and is distributed in the tropical, subtropical and temperate regions of the world[4]. It is found in Australia, China, Egypt, Pakistan, Sudan, Sri Lanka, South Africa, USA and in several countries of the Middle East. Out of the 40 species of this genus, 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[5]. The plant is also cultivated to some extent in West Bengal[6].

The whole plant and preferably the roots are effectively used to cure several diseases including jaundice[7]. The root and aerial parts of *Boerhaavia diffusa* were used in Ayurveda for the treatment of diabetes. It has many ethnobotanical uses (the leaves are used as vegetable; the root juice is used to cure asthma, urinary disorders, leukorrhea, rheumatism and encephalitis) and is medicinally used in the traditional, Ayurvedic system. Besides, the *B. diffusa* plant is reported to posses many pharmacological, clinical and antimicrobial properties. *Punarnava* is an herb, which is useful for curing kidney diseases. It has English name also called spread hogweed. It is very useful in curing all type of health problems[8].

Vernacular names of *Boerhaavia diffusa:* *Boerhaavia* repens L. (Latin); *Punarnava* (Sanskrit); Lal *Punarnava*, Beshakapore, a Santh (Hindi); Spreading Hogweed, Shothagni,

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Red Hogweed, Rakta punarnava (English); Thazhuthama (Malayalam); Punarnnava (Bangali); Kommegida (Kanarese); Vakhakhaparo, Dholia-saturdo (Gujarati); Tambadivasu, Ghetuli (Marathi); Chattarani (Tamil); Galijeru (Telugu); Lalapuiruni, Nalipuruni (Oriya); ltcit (Ial), Khattan (Punjabi); Sanadika, Kommeberu, Komma (Kannada); Vanjula *Punarnava* (Kashmiri); Ranga Punarnabha (Assamese).

Ethno-medical uses: In India, *B. diffusa* has a long history of medicinal use in the Ayurveda and Unani forms of medicine. Different plant parts used as an appetizer, alexiteric, eye tonic, flushing out the renal system, to treat seminal weakness and blood pressure, *etc*. Seeds are used as tonic, expectorant, carminative, lumbago, scabies, scorpion sting, blood purifier and useful in muscular pain. Its roots are used in treating jaundice, ascites, anasarca, sentry urine, internal inflammations, asthma, piles, the plain juice used as an antidote for rat-poisoning[9-14].

In Brazil the plant as a whole or its extracts is used for albuminuria, beri-beri, bile insufficiency, cystitis, edema, gallstones, gonorrhea, guinea worms, hepatitis, hypertension, jaundice, kidney disorders, kidney stones, liver disorders, liver support, nephritis, renal disorders, sclerosis (liver), snakebite, spleen (enlarged), urinary disorders, urinary retention and gallbladder problems[15]. In Guatemala it is used for erysipelas, guinea worms[16] while in Iran it is used for abdominal pain, anemia, ascites, asthma, blood purification, cancer, cataracts, childbirth, cholera, constipation, cough, debility, digestive sluggishness, dropsy, dyspepsia, edema, eye problems, fever, gonorrhea, guinea worms, heart ailments, heart disease, hemorrhages (childbirth), hemorrhages (thoracic), hemorrhoids, inflammation (internal), internal parasites, jaundice, kidney disorders, kidney stones, lactation aid, liver disorders, liver support, menstrual disorders, renal insufficiency, rheumatism, snakebite, spleen (enlarged), urinary disorders, weakness and as a diuretic and expectorant.

In Iraq it is used for oedema, gonorrhea, hives, intestinal gas, jaundice, joint pain, lumbago, nephritis and as an appetite stimulant, diuretic and expectorant. In Nigeria, it is used for abscesses, asthma, boils, convulsions, epilepsy, fever, guinea worms and as an expectorant and laxative. In west Africa it is used for abortion, guinea worms, menstrual irregularities and as an aphrodisiac. In tropical Africa the boiled roots are applied to ulcers, abscesses and to assist in the extraction of Guinea worm. The boiled roots and leaves are considered expectorant and febrifuge and in large doses emetic. A decoction of the aerial parts is also taken to treat gastro-intestinal pains, convulsions, intestinal worms and to regulate menstruation[17].

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[18].

It cures corneal ulcers and night blindness[19] and helps restore virility in men. People in tribal areas use it to hasten childbirth[20]. 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[21].

Phytochemistry: The *Boerhaavia diffusa* plant contains a large number of such compounds as flavonoids, alkaloids, steroids, triterpenoids, lipids, lignins, carbohydrates, proteins and glycoproteins. Punarnavine $C_{177}H_{22}N_2O$, boeravinone A to F, hypoxanthine, 9-L arabinofuranoside, ursolic acid, punarnavoside, liirodendrin and a glycoprotein having a molecular weight of 16 to 20 kDa have been isolated and studied in detail for their biological activity.

Punarnava also contains β-sitosterol, palmitic acid, esters of β-sisterol, tetracosanoic, hexacosonoic, stearic, arachidic acid, urosilic acid, hentriacontane, β-ecdysone, triacontanol.

The herbs and roots are rich in proteins and fats. The herb contains 6 essential amino acids while the root contains 14 amino acids, including 7 essential amino acids. Plant contains large amount of potassium nitrate besides punarnavine[22].

Previous studies reported the presence of flavonoids, alkaloids, steroids, triterpenoids, lipids, lignins, carbohydrates, proteins and glycoproteins in *B. diffusa*[23-25]. The present study also correlated with the aforesaid studies. These pytochemicals present in leaves extracts might be responsible for the antibacterial activity. It is not surprising that there are differences in the antimicrobial effects of different solvent extracts due to the phytochemical properties and differences among species.

Pharmacological activities: The plant has drawn lot of attention due to following biological activities.

Immunomodulatory effects: The alkaloidal fraction of *Boerhaavia diffusa* was studied for its effect on cellular and humoral functions in mice. Orally administration is significantly inhibited SRBC-induced delayed hypersensitivity reactions in mice. However, the inhibition was observed only during post-immunization drug treatment, while no effect during pre-immunization drug treatment was observed[26,27].

Antidiabetic activity: 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[28].

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[29].

Antioxidant activity: 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[30].

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[31].

Hepatoprotective activity: The *B. diffusa* extract is found to be antihepatotoxic[32] The *B. diffusa* extract is found to be Hepatoprotective[33]. 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 glutanic-oxaloacetic transaminase, serum glutanicpyruvic transaminase and bilirubin in serum against hepatic injury in rats[34]. Further experimental studies also evidenced a beneficial activity of the *Punarnava* root for the treatment of the jaundice[35,36].

Antiinflammatory activity: Ethanol extract of leaves at dose of 400 mg/kg exhibited maximum antiinflammatory 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 IC_{50} value of 100 ng/mL proving the drug use in the treatment of inflammatory condition. Antiinflammatory activity was assessed using extract of latex of plant by using a carragenan induced inflammatory model[37].

Diuretic activity: Maximum diuretic and antiinflammatory 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 arly onset of the liver cirrhosis and chronic peritonitis. The root is used to treat other renal ilments (calculations and cystitis), seminal weakness and blood pressure[10]. The extract of *Boerhaavia diffusa* is found to be diuretic with special effect to nephritic syndrome[34].

Antiviral activity: 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[38].

Anticonvulsant activity: Study showed the crude methanolic extract of *B. diffusa* and its liriodendrin-rich fraction showed a dose-dependent protection against PTZ-induced convulsions[39].

Antiproliferative and antiestrogenic activity: 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 [3*H*]-estradiol for binding to ER with IC_{50} value of 320 ± 25 µg/mL. RT-PCR analysis revealed that BME reduced the mRNA expression of pS2 indicating the antiestrogenic action of 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[40].

Antistress and adoptogenic activity: The extract improved the stress tolerance by significantly increasing the swim duration and reducing the elevated WBC, blood glucose and plasma cartisol. Immunomodulatory activity was evaluated by carbon clearance and 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[41].

Anti fibrinolytic activity: A study that evaluates the effect of antifibrinolytic agents; α-aminocaproic acid (α-ACA), tranexamic acid (AMCA); antiinflammatory drugs (indomethacin, ibuprofen, naproxen); and plant extract (root extract of *Boerhaavia diffusa*) on endometrial histology of IUD-fitted menstruating monkeys. It is effective in reducing stromal edema, inflammation and tortuosity of glands and in increasing the degree of deposition of fibrin and platelets in the vessel lumen[42].

Antibacterial activity: *B. diffusa* leaves have potent antibacterial activity against various Gram-negative and Gram-positive bacteria, which might be due to the phytochemicals present in the leaves. Ethanol extract showed inhibitory an effect on grampositive bacteria like *S. aureus, B. subtilis, S. faecalis, M. luteus* and all gram-negative bacteria selected for the present study. Methanol extract showed inhibitory effect against all gram-positive bacteria selected for the present study except *M. luteus* and gram-negative bacteria like *K. pneumoniae, P. vulgaris, S. marcescens* and *S. flexneri*[43]. The antibacterial activity of the various extracts of the stem bark of *Prosopis cineraria* (Linn.) Druce, was evaluated by the agar well diffusion method[44].

Conclusion

The multiple benefits of *Boerhaavia diffusa* made it a true miracle of nature. Numerous studies have been conducted on different parts of *Boerhaavia diffusa*, but this plant has not yet developed as a drug by pharmaceutical industries. A detailed and systematic study is required for identification, cataloguing and documentation of plants, which may provide a meaningful way for the promotion of the traditional knowledge of the herbal medicinal plants. In view of the nature of the plant, more research work can be done on humans so that a drug with multifarious effects will be available such as aphrodisiac and nootropic activities in the future market.

REFERENCES

1. M.L. Dhar, M.M. Dhar, B.N. Dhawan, B.N. Mehrotra and C. Ray, *Indian J. Exp. Biol.*, **6**, 232 (1968).
2. G.L. Chopra, Angiosperms: Systematics and Life Cycle. S. Nagin and Co., Jalandhar, Punjab, India, pp. 361-365 (1969).
3. A. Singh, *Curr. Sci.*, **93**, 446 (2007).
4. V.H. Heywood, Flowering Plants of the World. Oxford University Press, London, UK, **22**, 69 (1978).
5. R.N. Chopra, S. Ghosh, P. Dey and B.N. Ghosh, *Indian Med. Gazette*, **68**, 203 (1923).
6. R.N. Chopra, S.L. Nayar and I.C. Chopra, Glossary of Indian Medicinal Plants. Council of Scientific and Industrial Research (CSIR), New Delhi, India, pp. 34:39 (1956).

7. A. Bajpay, Ecological Studies of Boerhaavia verticillata Poir with Special Reference to Phytochemical and Therapeutic Importance. Ph.D. Thesis, Banaras Hindu University, Varanasi, India (1993).
8. Krishna Murti, Mayank A. Panchal and Vijay Lambole, *Int. J. Pharmaceut. Sci. Rev. Res.*, **5**, Article-020, November-December (2010).
9. R.B.L. Gupta, S. Singh and Y. Dayal, *Indian J. Med. Res.*, **50**, 428 (1962).
10. B.B. Gaitonde, H.J. Kulkarni and S.D. Nabar, *Bull. Haffkine Inst. (Bombay, India)*, **2**, 24 (1974).
11. A.K. Nadkarni, Indian Materia Medica. A.K. Nadkarni, Popular Prakashan Pvt. Ltd., Bombay, Maharashtra, India, **1**, 203 (1976).
12. R.K. Anand, *Flora Fauna*, **6**, 167 (1995).
13. R. Mitra and R.C. Gupta, *Appl. Bot. Abstr.*, **17**, 209 (1997).
14. V. Mudgal, *Planta Med.*, **28**, 62 (1997).
15. G.L. Cruz, Dicionario Das Plantas Uteis Do Brasil. 5th Edition. Bertrand, Rio de Janeiro, Brazil (1995).
16. L. Taylor, The Healing Power of Rainforest Herbs. Square One Publishers, 253 (2005).
17. Gulshan Chaudhary and P.K. Dantu, *J. Med. Plants Res.*, **5**, 2125 (2011).
18. K.R. Kirtikar and B.D. Basu, Indian Medicinal Plants. Lalit Mohan Basu, Allhabad, India (1956).
19. R.B.L. Gupta, S. Singh and Y. Dayal, *Indian J. Med. Res.*, **50**, 428 (1962).
20. G.L. Shah, S.S. Yadav and V. Badinath, *J. Eco. Taxo. Bot.*, **4**, 141 (1983).
21. CSIR. The Wealth of India: Raw Materials, CSIR, New Delhi, India, **7B**, 174 (1988).
22. R.N. Chopra, S. Ghosh, P. Dey and B.N. Ghosh, *Indian Med. Gazette*, **68**, 203 (1923).
23. R.R. Agarwal and S.S. Dutt, *Chem. Abstr.*, **30**, 3585 (1936).
24. N.K. Basu, S.B. Lal and S.N. Sharma, *Q.J. Pharm. Pharmacol.*, **20**, 38 (1947).
25. S.R. Surange and G.S. Pendse, *J. Res. Indian Med.*, **7**, 1 (1972).
26. A.A. Mungantiwar, A.M. Nair, U.A. Shinde, V.J. Dikshit, M.N. Saraf, V.S. Thakur and K.B. Sainis, *J. Ethnopharmacol.*, **65**, 125 (1999).
27. B.M. Goyal, P. Bansal, V. Gupta, S. Kumar, R. Singh and M. Maithani, *Int. J. Pharmaceut. Sci. Drug Res.*, **2**, 17 (2010).
28. L. Pari and M.A. Satheesh, *J. Ethnopharmacol.*, **91**, 109 (2004).
29. R.K. Nalamolu, K.M. Boini and S. Nammi, *Tropical J. Pharmaceut. Res.*, **3**, 305 (2004).
30. D.M. Pereira, J. Faria, L. Gaspar, P. Valentão and P.B. Andrade, *Food Chem. Toxicol.*, **47**, 2142 (2009).
31. P.R. Rachh, M.R. Rachh, D.C. Modi, B.N. Shah, A.S. Bhargava, N.M. Patel and M.T. Rupareliya, *Int. J. Pharmaceut. Res.*, **1**, 36 (2009).
32. J.P. Mishra, *Indian J. Pharm.*, 12 (1980).
33. A.K.S. Rawat, S. Mehrotra, S.K. Tripathi and U. Shama, *J. Ethnopharmacol.*, **56**, 61 (1997).
34. K.K. Chakraborti and S.S. Handa, *Indian Drugs,* **27**, 161 (1989).
35. V. Singh and R.P. Pandey, *J. Eco. Taxo. Bot.*, pp. 137-147 (1980).
36. G.V. Gopal and G.L. Shah, *J. Res. Edu. Indian Med.*, **4**, 44 (1985).
37. T.N. Bhalla, M.B. Gupta, P.K. Sheth and K.P. Bhargava, *Indian J. Phys. Pharmacol.*, **12**, 37 (1968).
38. B.B. Gaitonde, H.J. Kulkarni and S.D. Nabar, *Bull. Haffkine Inst. (Bombay, India)*, **2**, 24 (1974).
39. K.K. Chakraborti and S.S. Handa, *Indian Drugs,* **27**, 161 (1989).
40. S. Lohani, A. Jan and H.N. Verma, *Biotechnology*, **3**, 389 (2007).
41. S.K. Adesina, *Quart. J. Crude Drug Res.*, **17**, 84 (1979).
42. Teepica Priya Darsini D, J.M. Sasikumar and M. Kulandhaivel, *Ethnobotanical Leaflets*, **13**, 263 (2009).
43. M. Sumantha, S.S. Mustafa, *Int. J. Pharmacol.*, **3**, 416 (2007).
44. M. Barthwal, K. Srivastava, *Adv. Contraception*, **6**, 113 (1990).
45. M. Sharma, S. Vohra, J.T. Arnason and J.B. Hudson, *Pharm. Biol.*, **46**, 111 (2008).
46. V. Velmurugan, G. Arunachalam and V. Ravichandran, *Arch. Appl. Sci. Res.*, **2**, 147 (2010).