REVIEW ARTICLE

# Pharmacognostical, Phytochemical and Pharmacological Study of *Boerhaavia diffusa* - An Ayurvedic Boon for Liver Care

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## Abstract

*Boerhaavia diffusa* Linn. is a plant that holds significant importance in the field of medicine due to its various therapeutic properties. It has been extensively studied and proven to have hepatoprotective, anti-diabetic, and anti-inflammatory effects. These beneficial attributes have been documented in numerous Ayurvedic texts, making it a key ingredient in many pharmaceutical preparations. The information for this review was acquired from a wide range of literature sources, like Google Scholar, Research Gate, Science Direct, and PubMed to comprehensively understand phytochemistry and the pharmacological activity of *B. diffusa*. A systematic and structured search strategy was employed to ensure diverse perspectives and findings that describe the plant's botanical description, traditional uses, chemical composition, pharmacological activities, specifically its hepatoprotective effects, and safety profiles. This comprehensive review examines the therapeutic potential of *B. diffusa*, with a focus on its hepatoprotective effects. The aim is to link traditional knowledge and scientific understanding, offering a valuable resource for researchers, healthcare practitioners, and enthusiasts interested in the multifaceted aspects of this plant. By combining information from Ayurvedic texts and modern scientific studies, the review seeks to contribute to evidence-based research, validate traditional remedies, and promote further exploration of *B. diffusa*'s therapeutic applications, especially in the treatment of liver-related disorders.

**Keywords:** *Boerhaavia diffusa*, Hepatoprotective, Anti-inflammatory, Ayurveda, Phytochemistry, Pharmacology.
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## Introduction

Ayurvedic and traditional remedies are not widely accepted globally because they lack scientific support.[1] The development of evidence-based research in the field of Ayurveda is essential for the acceptance of their formulations in the global market.[2] The use of modern methods is now imperative for the validation of raw pharmaceuticals as ingredients and various polyherbal compositions. The main threats to human health are infectious diseases. People turn to Ayurveda as an alternative therapy because they seek to escape the drawbacks of allopathic medication. In this modern era, many medicinal plants are employed by individuals of all ages to address different health conditions.

A medicinal plant called *Boerhaavia diffusa* (Family: Nyctaginaceae) Figure 1 is utilized in traditional remedies around the world. The species "diffusa" was given this name because of its diffuse branching, and the genus "Boerhaavia" was called after the 18$^{th}$ century Dutch physician Hermann Boerhaave. Due to its capacity to regenerate during the rainy season with the aid of perennial roots after the aerial parts fully dry up in the summer, the plant is also known as "Punarnava," where Punar means -again, nava means -new. As a result, it is regarded as a rejuvenator in Ayurveda. To explain its pharmacological properties, it appears in historical texts such as Sharangdhar Samhita, Ayurveda Sara sangrah, Dhanvantri Nighantu, Kaideva Nighantu, Shodhal Nighantu, Madanpal Nighantu, Raj Nighantu, Adarsha Nighantu, Bhavprakash Nighantu, and Charaka Samhita, Sushruta Samhita, and Astanga Sangraha. According to Ayurveda, *B. diffusa* is used to make rasayanas for various medical conditions, and several commercially available pharmaceutical formulations contain *B. diffusa*. Punarnavadyarishta is one of them (used to cure jaundice, skin conditions, heart conditions, inflammation, constipation, and spleen enlargement). There are Siddha formulations in addition to Ayurvedic ones, which contain Punarnava as a key ingredient (Talakacenturam) used in the treatment of jaundice, heat-related issues, limb-related issues and skin-related problems.[3-6]

Punarnavine, liriodendrons, boeravinones A–F, flavonoids, amino acids, ß-sitosterols, esacosanoic, tetracosanoic, ursolic and stearic acids are among the essential alkaloids, rotenoids, and lignans found in Punarnava root.[7] The whole or part of the plant has many medicinal properties. It is used by the local people and tribes of India and has antibacterial, hepatoprotective, hypoglycaemic, antiproliferative, antiestrogenic, anti-inflammatory, anticonvulsant, antistress and antimetastatic activities, as well as curative properties for jaundice, indigestion, abdominal pain and infections. Many

scientists, researchers, and others have conducted a variety of experimental, phytochemical, pharmacological, and clinical studies on *B. diffusa* to gain a thorough understanding of the plant's traditional use in Ayurvedic, and tribal medicine.[8,9]

## Ayurvedic Properties

The plant is thought to have traits like Rasa-Madhura, Tikta, Kashaya; Veerya-Ushana; Vipaka-Katu; and Karma-Anulomana, Shothahara, and is thought to ease the three doshas. It is also believed to have heated potency (Ushna Veerya), dryness (Ruksha), and lightness (Laghu).[10]

## Plant Profile[11]

*Botanical name*

*Boerhaavia diffusa*

*Domain*

Eukaryota

*Kingdom*

Plantae

*Sub-kingdom*

Tracheobionta

*Phylum*

Spermatophyta

*Subphylum*

Angiospermae

*Family*

Nyctaginaceae

*Division*

Magnoliophyta

*Class*

Magnoliopsida

*Subclass*

Caryophyllidae

*Order*

Caryophyllales

*Genus*

*Boerhaavia* L.

*Species*

*diffusa* L.

## Vernacular Terms[12-14]

*Sanskrit*

Kahtilla, Raktakanda, Sophaghni, Sothaghni, Varshabhu

*Assamese*

Pananua, Ranga Punarnabha, Ponounua

*Bengali*

Punarnova, Rakta punarnava, Gadapushpa

*English*

Hog Weed, Pigweed, Spiderling, Horse Purslane, Red Spiderling, Tarvine

*Gujrati*

Dholisaturdi, Vasedo, Motosatodo

*Hindi*

Snathikari, Lalpunarnava, shothaghna, Biskhapara, Gadahpurna, Beshakapori

*Kannada*

komme gida, Kommeberu, Komma, Sanadika

*Kashmiri*

Vanjula Punarnava

*Malayalam*

Thamizhama, Chuvanna Tazhutawa, Talutama, Tavilama

*Marathi*

Satodimula, Ghetuli, Vasuchimuli, Tambadivasu, Punarnava, Khaparkhuti

*Oriya*

Nalipuruni, Lalapuiruni

*Punjabi*

Khattan

*Tamil*

Saarai, Sarandai, Mukurattai (Shihappu), Mukaratee-Kirei

*Telugu*

Atikamamidi, Raktakunda, Punernava, Erra galijeru

## Geographical Distribution and Habitat

The 40 species that make up the genus Boerhaavia are distributed throughout the world's warm, tropical, and subtropical climates. In addition to numerous countries in the Middle East, it can be found in Australia, China, South Africa, Sudan, Egypt, Pakistan, Sri Lanka, Ceylon, the Malay Peninsula, the United States, and the Pacific Islands. India is the residence of six of the forty known species of Boerhaavia: *B. diffusa, B. rubicunda, B. rependa, B. erecta, B. chinensis,* and *B. hirsute*. *B.diffusa* is native to India and can be found there as well as in the nation's drier regions, including the Himalayan region at an elevation of 2000 meters. It spreads widely in ditches, dumping grounds, and swampy regions during rainy seasons. The plant is occasionally also farmed.[15]

## Botanical Description

The eternal creeping weed *B. diffusa* has spreading branches and can grow up to one meter in length. The morphology of Punarnava is very peculiar and has interlocking patterns in their divaricately branched shoots.

### *Stem*

Prostrate or ascending, divaricately branched, woody or succulent, slender, cylindrical, minutely pubescent or nearly glabrous, hairy, enlarged at the nodes, and usually purple (Figure 1).

### *Leaves*

Green, opposite, thick, simple, hairy, fleshy, grouped in uneven pairs, and glabrous. The morphology of the leaves varies greatly; they might be oval, with whole edges, smooth above, white beneath, and pointed or obtuse tips. At the base, they are round-oblong, subcordate or suborbicular. The leaves undersides are hairy and pinkish-white, while their top surfaces are smooth, green, and glabrous (Figure 1).

### *Roots*

Large, stout, elongate, fusiform stalks that range in shape from cylindrical to narrow cigar-shaped to conelike or tapering. These herbaceous perennials are low spreading or creeping, with a variable diffusely branched, and they have an elongated, fusiform, or tapering tap root that is coloured from yellowish brown to brown. Although their surface appears smooth to the touch, it is rough as a result of tiny longitudinal striations and root scars (Figure 2).

### *Flowers*

Sub-capitate and minute. They grow in panicles of umbels with bracteoles and are hermaphrodite, pedicellate, and white, pink, or pinkish-red in colour. Bracts are involucrate and deciduous. In place of the calyx and corolla, there is a tubular perianth that is constricted above the ovary and is short and narrow at the base and funnel-shaped at the top. Five tiny, acute lobes make up the structure. The stigma is peltate, and there are two or three partially extended stamens. Winter is when the blossoming occurs (Figure 1).

### *Fruits*

Round, clavate, blunt and broad, five-ribbed, highly glandular and viscid, minuscule, single-seeded, and enclosed in the longer bottom portion of the perianth. The perianth is covered with clinging glandular hairs that readily adhere to passing animals and clothing. Fruits proliferate swiftly and readily.[16-19]

## Ethno-Medicinal Uses

In Ayurvedic herbal therapy, the roots, leaves, aerial parts, or entire plant of Punarnava have been used to cure a variety of ailments.[5] The Punarnava roots are mostly used as a diuretic, liver, gallbladder, and stomach pain remedy. A decoction of Punarnava root parts is used to cure intestinal worms, convulsions, and gastrointestinal discomfort. It can also be used to treat corneal ulcers and night blindness The diverse ethnomedicinal applications of *B. diffusa* across different countries are detailed in Table 1.[20,21]

*B. diffusa* leaf juice is used as an ophthalmic ointment. It is also taken orally to treat discomfort in the muscles and as a blood purifier.

## Therapeutic Applications

*B. diffusa* is applied to treat jaundice, loss of digestive function, spleen expansion, and stomach discomfort. They are also used as diuretics, stomachics, and expectorants.[22,23]

## Phytochemistry

Bioactive, non-nutritive plant-based substances known as phytochemicals are frequently included in the diet of humans and can have either favourable or unfavourable impacts on health. Through phytochemical analysis of extracts made from *B. diffusa* roots, the presence of phenolic compounds, alkaloids, glycosides, flavonoids, saponins, terpenoids, tannins, and steroids were determined. Using the Harborne method, *B. diffusa* extracts made with diethyl ether, chloroform, ethyl ethanoate, methyl alcohol, ethyl alcohol, and water were examined for the presence of several phytochemicals.[24-26]

## Phytochemical screening

Water, chloroform, and ethanol extracts with moderate inhibition of trypsin contained bioactive flavonoids, which show anti-inflammatory activity.[27] The ethyl acetate extract

**Figure 1:** Aerial parts of *Boerhaavia diffusa*

**Figure 2:** Roots of *Boerhaavia diffusa*

**Table 1:** Country and ethno-medicinal uses of Punarnava

| *Name of the Country* | *Ethno-Medicinal uses of Punaranava* |
|---|---|
| Brazil | Used for kidney stones, beriberi, gallstones, bile insufficiency, cystitis, laxatives, edema, liver disorders, gallbladder problems, albuminuria, gonorrhea, guinea worms, urinary disorders, hepatitis, hypertension, jaundice, nephritis, renal disorders, sclerosis, snakebite, spleen enlarged, urinary retention. |
| Guatemala | Used for erysipelas, and guinea worms. |
| India | Used for urinary disorders, weakness, abdominal pain, impotence, anemia, ascites, asthma, blood purification, anasarca, hepatoprotective, cancer, cataracts, childbirth, laxative, cholera, constipation, cough, debility, as a wound healer, digestive sluggishness, dropsy (swelling in tissue), dyspepsia, edema, eye problems, fever, gonorrhea, ascites, guinea worms, heart disease, hemorrhages (childbirth and thoracic), hemorrhoids, internal inflammation, internal parasites, jaundice, renal disease, renal stones, lactation relieve, hepatic disorders, liver support, menstrual disease, rheumatism, snakebite, splenomegaly and as a diuretic and expectorant. |
| Iran | Used for edema, poisoning, gonorrhea, hives, intestinal gas, jaundice, joint pain, ascites, lumbago, glomerular nephritis, and as an appetite stimulant, anasarca, diuretic and expectorant. |
| Nigeria | Used for asthma, boils, renal insufficiency, convulsions, abscesses, epilepsy, fever, jaundice, guinea worms, and as an expectorant and laxative. |
| West Africa | Used for guinea worms, urinary disorders, menstrual irregularities, abortion, and as an aphrodisiac. |
| Philippines | Used for diuretic, fever, purgative, and vermifuge. |
| Ghana | Used for asthma and Boils. |
| Elsewhere | Used for childbirth, guinea worms, jaundice, sterility, and yaws. |

has the most phenolic chemicals, followed by the methanol extract and the n-hexane extract.

Phytochemical analysis results showed that gum, mucilage, and quinines (Sulfuric Acid Test) were absent, whereas alkaloids (Tannic Acid Test), saponins (Froth Test), glycosides (Keller Killiani Test), polysaccharides (Molisch Test), flavonoids (Alkaline Reagent Test), steroids (Libermann-Burchard Test), and tannins (anillin Hydrochloride Test) were present.[28]

The chemical components present are, Boeravinone A-H, Alkaloids-Punarnavine, Phytosterols- ß-sitosterol, Rotenoids-Punarnavoside, Lignans-liriodendrin, syringaresinol, ursolic acid, hypoxanthine 9-L-arabinose, Boerhaavic and Boerhavin acid, Dihydroisofuroxanthone-borhavine, 4''7-dihydroxy-3'-methylflavone, 3,3''5-trihydroxy-7- methoxyflavone, 3,4-dimethoxyphenyl-1-O-beta-D-apiofuranosyl (1""--> 3'' O-beta-D-gluco- pyranoside. Some of the chemical components present in B. diffusa are mentioned in Figure 3.[29]

## Hepatoprotective Activity

*B. diffusa* has been the subject of numerous studies investigating its possible effects on liver function. And a study was conducted on Albino Wister rats. A (2,2 diphenyl 1 picrylhydrazyl) DPPH assay, a hydroxyl radical scavenging assay, and a reducing power assay were used to examine the extract's ability to scavenge free radicals[30] and ethyl ethanoate extract had a significantly higher IC50 value than chloroform extract. Rats were given the hepatotoxic substance CCl4 via oral administration, which caused the rats to develop liver problems.

A calcium concentration gradient is typically maintained across the plasma membrane of hepatocytes. However, acute exposure to CCl4 causes rapid loss of the cell'ssability to maintain low intracellular calcium concentration. Defects in calcium regulation appear to be linked to CCl4 metabolic activation, lipid peroxidation, and liver coagulative necrosis.[31]

Bernstein and Santacana revealed that the $Na^+/Ca^{2+}$ antiport in the hepatocyte only moves sodium out of the cell in exchange for external calcium. As a result, calcium is moved in the opposite direction as required to maintain the concentration gradient.[32] The $Ca^{2+}$-ATPase in the plasma membrane may be the factor determining intracellular calcium levels in hepatocytes. A plasma membrane impairment is a result of acute exposure to CCl4 in the liver. This is reflected changes in the lipid content of the membrane. Plasma membrane enzymes activity varies by their lipid environment.

The active metabolite of $CCl_4$, trichloromethyl radical, is responsible for the hepatotoxic effects. Free radical metabolites, which interact with unsaturated lipid membranes to cause cell damage and LPO of cellular membranes, follow $CCl_4$-induced hepatotoxicity.[33]

Following $CCl_4$ administration, there was an increase in TG, ALP, GOT, GPT, and direct and total bilirubin levels, due to necrosis of hepatic cells (SGOT and SGPT). The extracts reversed the above-mentioned elevated levels of biochemicals and enhanced the activity of enzymes such as catalase and superoxide dismutase, that protect the body from reactive oxygen species.

In rats exposed to $CCl_4$-induced hepatotoxicity, which causes a shift in the depletion of the concentration of serum ALT, Cholesterol, TG, and Total lipid, Rajkumari and colleagues also examined the hepatoprotective qualities of the plant's root extract.[34]

Research shows that if there is liver damage, the duration of missed responses is noticeably extended when short-acting barbiturates are administered. Research indicates that

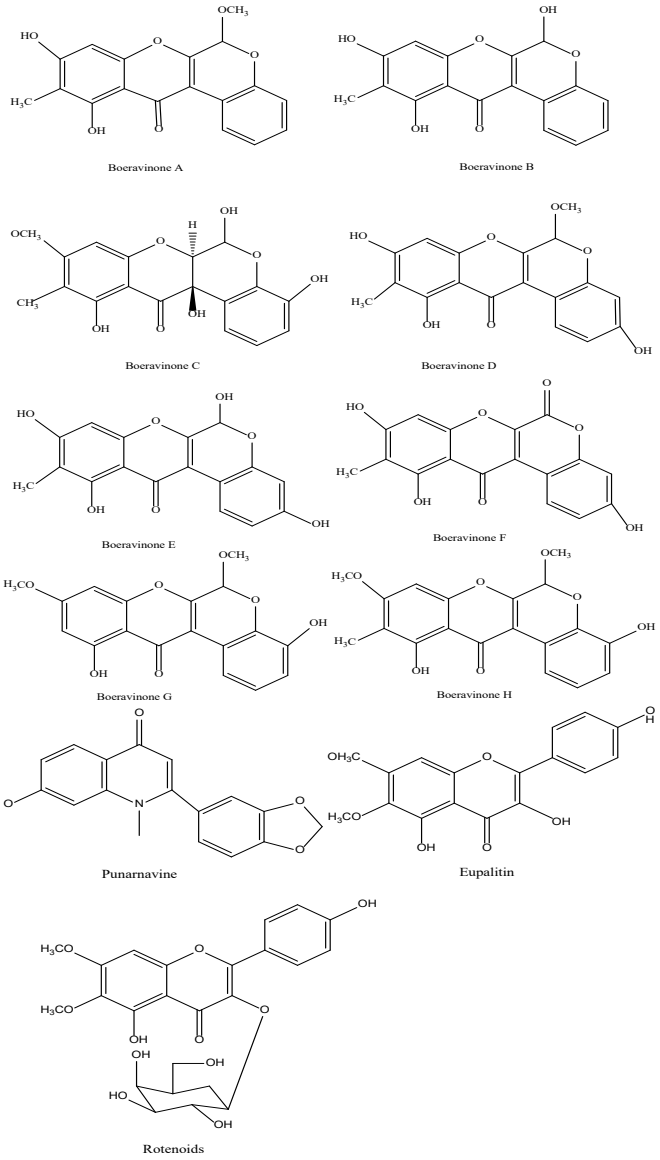


**Figure 3:**Structures of the components present in *Boerhavia diffusa*

*B. diffusa* significantly decreased the amount of "sleeping time" that hexobarbitone caused in rats and mice, as well as the amount of time that SGOT and SGPT levels rose when exposed to $CCl_4$.[35]

The protective properties of *B diffusa* again paracetamol-induced hepatotoxicity in rats was examined. High doses of paracetamol, a commonly used painkiller and antipyretic, have been reported to be known to cause hepatotoxicity in both humans and experimental animals. An overdose of paracetamol leads mitochondrial issue, followed by acute hepatic necrosis.

Loss of cell membrane integrity occurs due to functional and morphological changes, which lead to elevated serum marker enzyme levels. This occurs as a result of hepatocellular damage caused by decreased antioxidant enzyme activity and disruption of $Ca^{2+}$ homeostasis. Aminotransferases (ALT and AST) are liver-specific enzymes that can detect both the hepatotoxic and protective effects of substances. Paracetamol-induced hepatic necrosis is characterized by increased blood enzyme levels, indicating cellular leakage and loss of membrane function in the liver.

GSH is a non-protein thiol that coordinates the body's antioxidant defence system. GSH levels affect tissue sensitivity to oxidative damage and depletion has been linked to increased toxicity to drugs such as paracetamol.

The liver eliminates creatinine, an end product of muscle catabolism, at a constant rate. The serum creatinine level is the most routinely used measure of liver function. When the liver is not functioning properly, the level of creatinine in the blood rises.

In the study conducted by Venkatalakshmi and coworkers, higher levels of ALT and AST were found in the paracetamol-induced group. *B diffusa* lowered the toxicity of paracetamol and administration of *B diffusa* increased the decline in GSH concentration in the serum of rats intoxicated with paracetamol. Creatinine levels increased in rats treated with paracetamol. Oral dosing of *B. diffusa* reduced creatinine levels in rats treated with paracetamol.[36]

M. Muthulingam's study examined the effect of *B. diffusa* on the hepatotoxicity caused by the antituberculosis drug rifampicin. While treating tuberculosis, rifampicin is used, but it damages the liver.[37] Hepatotoxicity was induced in male albino Wistar rats. Compared to the control, there was an enhancement in the activities of aspartate aminotransferase, Gama glutamyl transpeptidase, bilirubin, lactate dehydrogenase, alanine aminotransferase, and alkaline phosphatase, whereas there was a decrease in the amount of protein in serum. The methanolic extract of *B. diffusa* was given orally the normalized levels of the above mentioned biochemicals showed that rifampicin toxicity had been reduced. The extract with a 200 mg/kg body weight concentration was the most effective. Therefore, the trials show that *B. diffusa* extracts can treat liver issues, which was assumed to be because the plant contains flavonoids that have antihepatotoxic properties.[38]

Seasonal effects, root thickness, and dosage type (either aqueous or powder) were investigated for their potential hepatoprotective effects. Intoxicated rats were used to test the hepatoprotective effects of roots with different diameters obtained in the three seasons of rainy, summer, and winter. Here, thioacetamide was injected into adult male albino rats to induce hepatotoxicity. The results of this study indicated that an aqueous extract (2 ml/kg) of roots with a diameter of 1-3 cm, collected in May (Summer), significantly decreased the majority of serum parameters, such as GOT, GPT, ACP, and ALP, but not GLDH and bilirubin. This suggests that an appropriate size and timing for collecting *B. diffusa*. roots are essential for achieving optimal results. Also, the trials demonstrated that administering the drug in its aqueous form (2 ml/kg) has greater hepatoprotective action than administering it in powder form; this is likely because the liquid form is more readily absorbed through the digestive tract.[39]

Olaleye co-investigated the hepatoprotective properties of *B. diffusa* leaf extracts against acetaminophen-induced liver damage in rats. It has been shown that high doses of paracetamol elevate ALT and AST blood levels. Intoxication with paracetamol can cause fulminant hepatotoxicity, which is characterized by significant elevations in bilirubin and transaminases. One of the main indicators of *B. diffusa*'s potential is its capacity to inhibit these enzyme'ssactivities by increasing hepatoprotective effects.[40]

## Mechanism involved in the hepatoprotective activity of *Boerhaavia diffusa*

The gastrointestinal tract is especially abundant with the enzymatic machinery essential for producing huge amounts of oxygen radicals, for example, mucosal xanthine oxidase and NADPH oxidase, which exist in chronic phagocytotic leukocytes of the lamina propria.[41] A number of studies have found that various oxidative stress indices (e.g., malondialdehyde, phospholipase A2, and myeloperoxidase) are elevated in the intestinal tissues of individuals with digestive disorders.

Lipid peroxidation is a complex process that occurs across membranes in organisms that contain oxidation susceptible polyunsaturated fatty acids, leading to the synthesis of lipid hydroperoxides and their metabolites.[42] The cellular levels of malondialdehyde and its catalytic equivalents are appropriate indications of lipid peroxidation. The current study not only reports for the first time the antioxidant effects of Boeravinone G in intestinal cells by the TBARS assay, but also confirms the antioxidant activity with a more precise assay. Specifically, using a fluorescence method, we proved that Boeravinone G inhibited ROS production resulting from Fenton's reagent. Importantly, Boeravinone G's antioxidant action occurs at nanomolar levels, whereas other known antioxidant substances, such as vitamins C and E, exhibit antioxidant activity at micromolar levels.

To study the potential targets, present in the Boeravinone G antioxidant/genoprotective action, we investigated the effect of this plant ingredient on an antioxidant defence enzyme (SOD) and two signaling pathways (MAP kinase and NF-kB) which play an important part in the oxidative stress-induced gastrointestinal disorders. SOD is one of the most powerful intracellular enzymatic antioxidants, acting as a catalyst for the disintegration of radicals into oxygen and hydrogen peroxide.[43] Boeravinone G prevented the lowered SOD activity, indicating that this compound has a stimulatory effect on the cell's defence mechanisms. When ROS levels exceed the capacity of the cellular defence systems, many signaling protein kinases and transcription regulatory factors are triggered.[44] In fact, oxidative stress activates extracellular signal-related kinases (ERKs), which belong to the mitogen-activated protein kinase (MAPK) family, as well as nuclear factor kB (NF-kB). NF-kB and MAPK are separate signal transduction pathways. In this study found that exposing Caco-2 to Fenton's reagent activates ERK1 and ERK2. More notably, demonstrated that Boeravinone G, at doses of 0.3 and 1 ng/ml, inhibited the enhanced ERK phosphorylation caused by H2O2/$Fe^{2+}$ exposure. the influence of Boeravinone G on the ERK phosphorylation was effective only for the 44-kDa isoform pERK1 (and not for the pERK2 isoform), indicating a selective activity.[45]

## Safety Studies

Different groups of ten mice each were given 250 - 2000 mg/kg graded doses of an alcoholic extract of whole plant *B. diffusa* orally. These animals were observed for any changes in behavioural patterns, incoordination of movement by rotarod and analgesic effect by tail clip method. None of the doses tested produced muscular weakness, ataxia or any gross behavioural disturbances. No incoordination of movements or analgesia was observed. There was no mortality up to the end of the 72-h observation period even with the highest dose of 2000 mg/kg. The 50% alcoholic extract of *B. diffusa* whole plant has been shown to be a potent and safe antihepatotoxic drug.

The hydroalcoholic extract of *Boerhaavia diffusa* (HAEBD) was subjected to acute, subchronic, and chronic toxicity evaluations. Mice didn't show any acute toxicity, including mortality and abnormal behavior, up to 2000 mg/kg over 14 days. The rats in the subchronic toxicity trial received oral dosages of 50, 100, 200, and 400 mg/kg daily for 20 days. In chronic toxicity studies, HAEBD was administered to all three groups except the normal control for 90 days at doses of 200, 400, and 600 mg/kg. In this study, no acute, subchronic, subchronic or chronic toxicity was observed.[46]

Alkaloid is not particularly very toxic. A cat that weighed 2 1/2 kilos was given 50 mg intravenously, while a guinea pig that weighed 450 gms was given 20 mg subcutaneously, neither of which resulted in any severe symptoms.[47]

In a study conducted on the protective effect of *Boerhaavia diffusa* against cisplatin-induced kidney injury in rats and examined its safety. Study suggests that B. diffusa is safe up to 1000 mg/kg with no adverse effect. At doses of 50, 100, 200 mg/kg, the root extract reduced Kidney injury and the highest reduction was observed at 200 mg/kg. This indicates that B. diffusa is a safe and effective in preventing kidney injury.[48]

In a study, 29 patients were divided into two groups and given either Livwin which contains Ashwagandha, Arjuna, Bhumyamalaki, Daruharidra, Guduchi, Kutki, and Punarnava or a placebo which contains Lactose powder 500 mg. After an eight-week treatment-free interval, the two medications were taken orally in two capsules twice daily. Measurements of blood bilirubin, AST, ALT, and alkaline phosphatase at baseline, 2, 4, 8, and 12 weeks were used to evaluate the patient's recovery in addition to noting clinical improvement. The outcomes are Comparing Livwin to a placebo at 2, 4, and 8 weeks, a significant early recovery of weakness was noted. Much higher percentages of Livwin patients had serum bilirubin and ALT in the normal range. AST was within the normal range at 2 and 4 weeks in a significantly larger proportion of Livwin-treated individuals than placebo-treated patients.[49]

Investigations into the acute and subchronic toxicity of *B. diffusa* leaves in albino mice and rats were conducted. Additionally, a phytochemical analysis was done. The aqueous leaf extract dosages of 500, 1000, and 2000 mg/kg were given orally to the test groups while distilled water was provided to the control group. Food and fluid intake, body weight, the absolute and relative weight of different organs, haematological parameters WBC and PCV, and tests for liver function (GOT, GPT, alkaline phosphatase, and total bilirubin) are among the parameters that are measured. In both mice and rats, it was discovered that the fatal dose (LDS) was higher than 2000 mg/kg (p.o.). When rats were given the extract, their body weight gradually increased. Between the control and test groups, there were no appreciable differences in the absolute or relative organ weights. The haematological markers and liver enzymes were statistically equivalent across all groups. In albino rats, *B. diffusa* aqueous leaf extract is non-toxic.[50]

In an acute toxicity trial, the polyherbal formulation was given orally once for 15 days at doses ranging from 250 mg/kg to 2000 mg/kg. Throughout the research period, food consumption and body weight were recorded. Each day, the behaviour and harmful consequences of each group of animals were observed. Blood was taken at the conclusion of the study for haematology and biochemical analyses. After the animals were sacrificed, the organs- liver, kidney, heart, and brain were dissected and checked for any obvious morphological changes. Organ weights were also recorded. It has been determined that the developed polyherbal formulation is safe for the long-term treatment of renal problems when administered at a dose of 2000 mg/kg.[51]

## Conclusion

In summary, our comprehensive investigation highlights the remarkable therapeutic properties of *Boerhaavia diffusa* Linn, a plant that has been proven effective in protecting the liver. Combining traditional knowledge with scientific research, we have delved into the plant's characteristics, historical uses, chemical composition, and its effectiveness in safeguarding the liver through experimental models. With safety assessments confirming its lack of negative reactions or adverse effects at specific dosages, *B. diffusa* proves to be a promising natural solution for liver ailments. As *B. diffusa* gains recognition for its hepatoprotective abilities, this review paper provides a solid basis for further studies, promoting a comprehensive understanding of its therapeutic potential. Furthermore, since *B. diffusa* has strong hepatoprotective action, additional studies can be done further to identify the lead compounds responsible for the hepatoprotective activity.

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