



REVIEW ON ETHNOMEDICINAL USES AND BIOLOGICAL ACTIVITIES OF BOERHAVIA DIFFUSA

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ABSTRACT

Phytochemicals are a broad group of plant-derived compounds with diverse structures and functions, many of which exhibit biological effects when consumed by humans. They are most abundantly found in plant-based foods, including fruits, vegetables, whole grains, nuts, and seeds. *Boerhaavia diffusa* L. nom. cons., commonly known in traditional Indian medicine as Punarnava, is a perennial creeping herb widely distributed across India. In Ayurveda, *B. diffusa* is classified as a —Rasayanall herb, recognized for its rejuvenating, disease-preventive, and strengthening properties, which may contribute to reducing disease burden and improving healthcare accessibility. It is considered one of the earliest Ayurvedic remedies noted for treating a variety of health conditions. Extensive ethnopharmacological evidence highlights its therapeutic relevance in reproductive, gastrointestinal,

respiratory, urinary, hepatic, cardiovascular, and cancer-related disorders. Owing to its rich flavonoid and polyphenol content, the plant possesses significant medicinal value, warranting further scientific exploration to better understand its biological and therapeutic potential. This review article focuses on its taxonomy, geographical distribution, ethnobotanical significance, and diverse pharmacological activities.

KEYWORDS: *Boerhaavia diffusa*, Phytochemical, Punarnava, Ayurveda, Ethnobotanical, Pharmacological properties.

INTRODUCTION

Nature has provided an abundance of therapeutic plants, many of which still have unexplored medicinal properties or lack well-defined methods of use.^[1] Since ancient times, human societies have relied on plants to treat various ailments. Herbal medicines continue to be widely valued in both developing and developed nations because of their broad biological and therapeutic potential, greater safety margins, affordability, and extensive role in primary healthcare. Human existence is closely intertwined with the environment, which supplies essential needs such as food, shelter, and medicine through plants.^[2,3] Medicinal plants remain one of nature's most important sources of pharmaceutical agents. Traditional healing systems like Ayurveda, Siddha, Unani, and folk medicine are deeply rooted in the use of these plants. Around 3.3 billion people globally use herbal remedies on a regular basis. These medicinal species also serve as indicators of ecological well-being. Numerous ethnic communities worldwide employ medicinal herbs in diverse ways to support health and treat illnesses.^[4,6] Key phytochemicals found in these plants such as flavonoids, phenols, tannins, and alkaloids possess a wide range of biological activities and are used to manage various diseases and promote overall health. In Indian culture, Ayurveda contributes significantly to the treatment of obesity, cardiovascular disorders, liver ailments, and several oedematous conditions, often utilizing diuretics for management.^[7,10] With obesity recognized as a major global health problem by the World Health Organization (WHO), the role of Ayurveda becomes increasingly important.^[11]

Punarnava, scientifically known as *Boerhaavia diffusa* L. nom. cons., holds significant medicinal value in Sanskrit literature. For generations, India's indigenous and tribal communities have utilized the entire plant or specific parts such as the leaves, stem, and roots for various therapeutic purposes.^[12] Classical Ayurvedic texts, including the *Charaka Samhita* and *Sushruta Samhita*, highlight its importance in managing a wide range of ailments. Besides its extensive use in traditional medicine, the plant also serves several ethnobotanical functions; for example, its leaves are consumed as a vegetable, and its root juice is traditionally administered to treat conditions like leukorrhea, encephalitis, asthma, and urinary disorders.^[13] The plant was named in honour of Hermann Boerhaave, an eminent Dutch physician of the 18th century. The name —Punarnava|| likely originates from the Sanskrit expression —Karoti Shriram Punarnavam,|| meaning —that which revitalizes the body, or from its perennial nature, as it dries and becomes dormant during summer and regenerates from the same root system with the onset of the rainy season (Punah Punarnava

Bhagwati---that which becomes new again and again)). The genus *Boerhaavia* comprises several species distributed across temperate, subtropical, and tropical regions in the world.^[14]



BOERHAVIA DIFFUSA. TAXONOMIC CLASSIFICATION

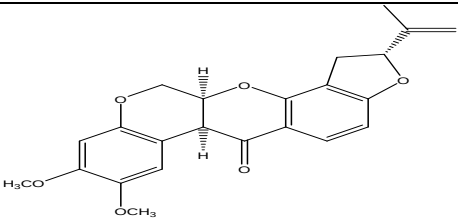
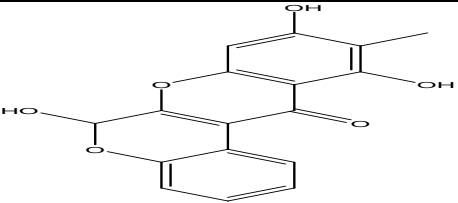
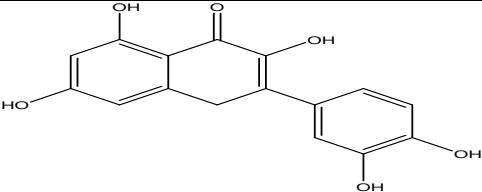
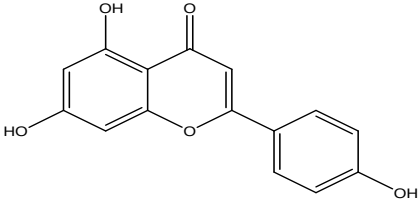
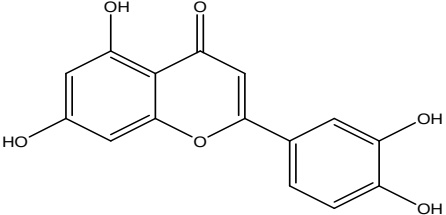
Taxonomic Rank	Classification
Kingdom	Plantae
Sub-kingdom	Tracheobionta (Vascular plants)
Superdivision	Spermatophyta (Seed plants)
Division	Magnoliophyta (Angiosperms)
Class	Magnoliopsida (Dicotyledons)
Subclass	Caryophyllidae
Order	Caryophyllales
Family	Nyctaginaceae
Genus	<i>Boerhavia</i>
Species	<i>Boerhavia diffusa</i> L.

Description

Common Names	Punarnava, Red Spiderling, Spreading Hogweed
Synonyms	<i>Boerhavia paniculata</i> , <i>Boerhavia repanda</i> , <i>Boerhavia diffusa</i> Linn.
Biological Source	Dried whole plant or roots of <i>Boerhavia diffusa</i>
Family	Nyctaginaceae
Geographical Source	Widely distributed in India; also found in tropical regions of Africa, Asia, South America, Sri Lanka, Pakistan, Myanmar
Major Chemical Constituents	Punarnava (<i>Boerhavia diffusa</i>) contains a wide range of phytochemicals that contribute to its medicinal value. The plant is rich in alkaloids such as punarnavine and related derivatives, along with rotenoids like boeravinones and the glycoside punarnavoside. It also possesses several flavonoids luteolin and Apigenin, including quercetin and kaempferol, which add to its antioxidant potential. Various phytosterols such as β -sitosterol and α -2-sitosterol are present, together with triterpenoids like ursolic acid and several fatty acids. Punarnava also contains lignan, biologically active glycoproteins, and significant amounts of inorganic salts like potassium nitrate. Additionally, the plant

	provides amino acids, phytohormone-like compounds such as β -ecdysone, and several minor phytochemicals that collectively support its therapeutic activities.
Uses Pharmacological Activities	Diuretic, Anti-inflammatory agent Hepatoprotective, Antioxidant, Anti-arthritic, Anticancer, Anti-diabetic, Nephroprotective, Used in oedema, anaemia, jaundice, and urinary disorders

Significance of Chemical Constituents Receptor- Target Interaction

Chemical Constituents Structure	Receptor-Target Interaction
 Rotenoids	Rotenoids bind to NADH dehydrogenase (Complex I), impairing cancer cell metabolism. Estrogen receptor (ER) interaction. Microtubule depolymerisation.
 Boeravinone B	Boeravinone B binds to the drug-binding domain of P-gp reverses multidrug resistance (MDR) in cancer cells. Tyrosine kinase receptor modulation. Topoisomerase I and II binding. NF-κB pathway inhibition
 Quercetin	Quercetin binds to the ATP-binding pocket of PI3K, suppressing Akt phosphorylation induces apoptosis. Topoisomerase II inhibition. Estrogen receptor (ER) modulation. NF-κB suppression.
 Apigenin	CDK1/CDK5 inhibition Apigenin binds to cyclin-dependent kinases induces cell cycle arrest in G2/M phase. Estrogen receptor β agonist. PI3K/Akt pathway inhibition.
 Luteolin	JAK/STAT3 inhibition Luteolin directly binds STAT3 and blocks its activation, suppressing cancer cell proliferation. PI3K/Akt and MAPK suppression. Aryl hydrocarbon receptor (AhR) antagonist. TNF-α and IL-6 receptors.

Morphological Characteristics

Boerhavia diffusa, is prostrate or ascending, perennial, and trailing. The thick, meaty, and tapering roots (in some cases brown, reddish in colour) are widely used in traditional medicine due to their phytochemical richness.^[15] The cylindrical, striped, verdant, and inflated stems sprawl over the floor and are purplish green. Smooth or slightly wavy borders, oval to oblong in shape, simple, opposite, paired. There could be either a smooth or somewhat rough surface. The tiny, tuberos blossoms are pink to purple, clumping at the plant's terminal or axillary nodes with the group defined by an involucre surrounding each one.^[16]

ANTICANCER ACTIVITY

According to recent research, *Boerhaavia* can have anticancer properties. A study demonstrated that administering *B. diffusa* aqueous methanol (3:7) extract effectively inhibited production of metastases in the highly metastatic melanoma cell line B16F10.^[17,18] Hexosamines, uric acid levels, lung collagen hydroxyproline, and other biochemical markers were considerably decreased in the mice treated. Rats treated with tumour plus extract exhibit decreased levels of serum sialic acid and γ -glutamyl transpeptidase, which indicate cancer proliferation. Furthermore, the animals' survival rate after extract therapy was more than duplex that of the untreated control group.^[19,24] Many structural polysaccharides and glycosaminoglycans (GAG) begin in the extracellular matrix (ECM) ground substance want glutaric acid and hexosamines in order to function properly. malignant cells can stimulate stromal cells in the host to add on the matrix materials required for expanding tumour. Hyaluronic acid (HA) is a glycosaminoglycan (GAG) composed of repeating D-glucuronic acid and N-acetyl-D-glucosamine disaccharides. It is a well-known promoter of metastasis, and higher levels are reported in a variety of cancer forms, regardless of tumour grade. It binds with HA cell surface receptors to assist tumour cells to pass across extracellular matrix (ECM) gaps.^[25,30]

Boerhavia diffusa binds with different types of receptors such as

1. EGFR / ErbB-2 (HER2)

A docking study showed that extracts (or constituents) of *B. diffusa* interact with **EGFR** (epidermal growth factor receptor) and **VEGFR-2**.

Another study (LC-MS / HRMS) found that **boeravinone B**, a rotenoid from *B. diffusa*, causes reduced cell survival and apoptosis in colon cancer lines by internalizing **ErbB2**

(HER2) and EGFR receptors.

2. Apoptotic Pathway (Caspases)

In cervical cancer (HeLa / similar) cells, ethanolic root extract of *B. diffusa* induced apoptosis via activation of **caspase-9** (upstream) and **caspase-3** (effector).

This suggests that rather than acting via a typical —receptor, some of the anti-cancer effects are mediated by triggering the **intrinsic (mitochondrial) apoptotic pathway**.

3. TRPM8 (Transient Receptor Potential Melastatin 8)

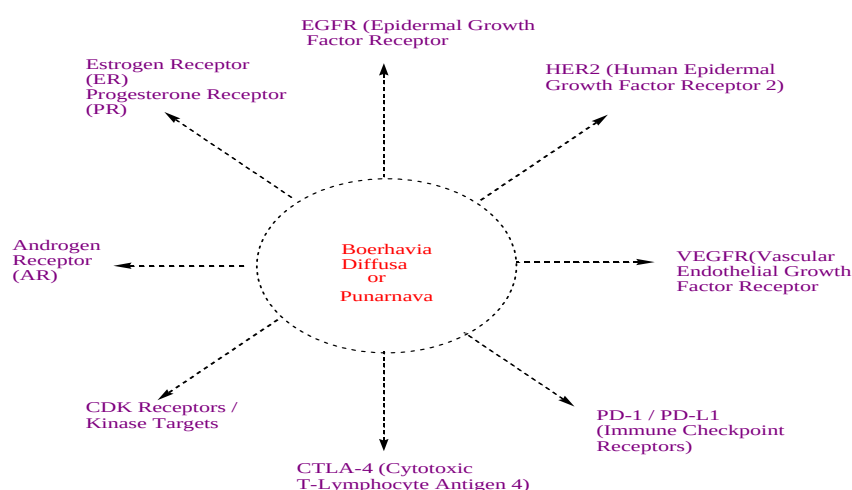
A review mentions that in colon cancer HCT116 cells, *B. diffusa* extracts may downregulate **TRPM8** gene expression, which is potentially involved in colon carcinogenesis.

This is more of a gene-expression effect rather than a direct ligand-receptor binding, but could be relevant to anticancer action.

4. Ribosome-inactivating Protein

B. diffusa is known to contain a ribosome-inactivating protein (RIP), named **BDP-30**. Such proteins can inhibit protein synthesis in cells, which may contribute to cytotoxic / anticancer effects, but this is not —receptor binding in the classical sense.^[31,35]

Punarnava's anticancer action arises from its key phytochemicals, which collectively induce apoptosis, inhibit cell growth, prevent metastasis, reduce oxidative stress and inflammation, reverse multidrug resistance, suppress angiogenesis, and strengthen immune defenses.^[36]



Significance of Boerhavia Diffusa Binding to AntiCancer Receptors-Target Interaction

NEPHROPROTECTIVE ACTIVITY

The kidneys are highly susceptible to toxic damage due to their distinctive structure and function. They receive nearly 20% of the cardiac output, concentrate urine—thereby exposing renal cells to elevated levels of solutes and toxins—and possess active tubular transport systems that can accumulate harmful substances.^[37,38] Toxic renal injury can range from mild biochemical changes to severe conditions such as acute kidney injury (AKI), and may eventually progress to chronic kidney disease (CKD) or end-stage renal disease (ESRD).^[39]

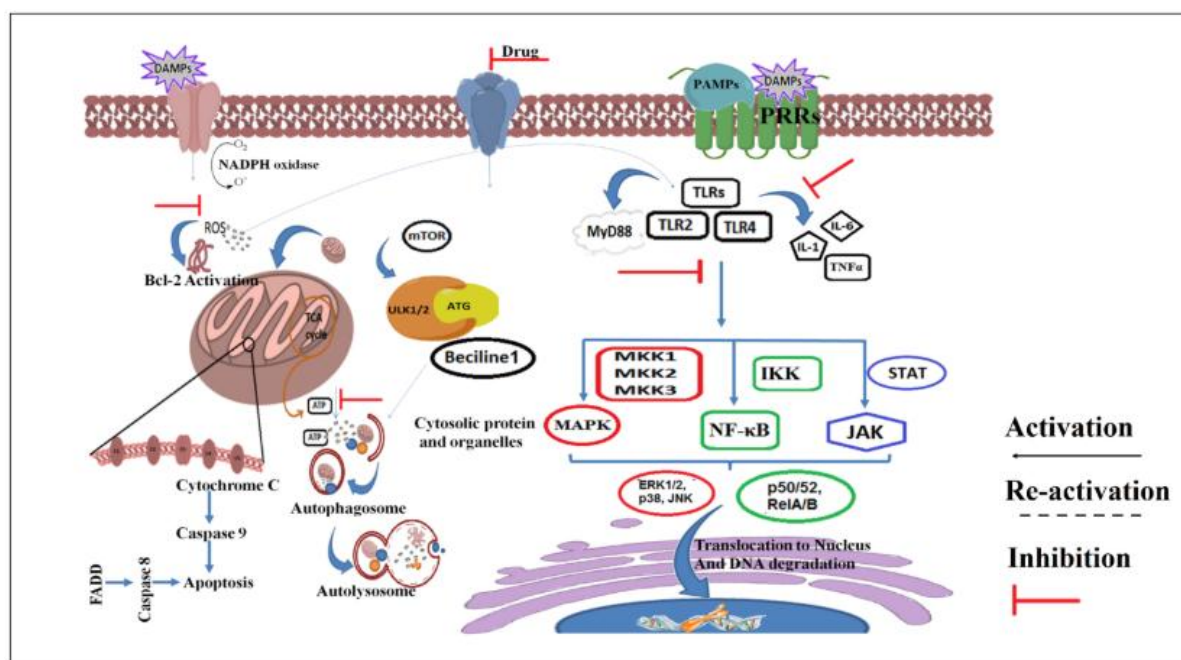
2. Types of Nephrotoxicity

Nephrotoxicity: Renal damage caused by exposure to toxic compounds.

Acute kidney injury (AKI): A sudden impairment of kidney function, identified by rising serum creatinine or reduced urine production.

Chronic nephrotoxicity: Long-term or progressive kidney damage that contributes to the development of CKD.^[40]

Punarnava (*Boerhaavia diffusa* L.) is well recognized in both Ayurveda and contemporary pharmacological studies for its notable nephroprotective effects. The plant is rich in active phytochemicals such as punarnavine, boeravinones, flavonoids, alkaloids, and sterols, all of which play important roles in safeguarding kidney function. Research shows that Punarnava demonstrates strong antioxidant properties that help lower oxidative stress and prevent lipid peroxidation in renal tissues—key factors involved in nephrotoxic injury.^[41,42] Its anti-inflammatory capabilities, achieved by downregulating cytokines like TNF- α and IL-6, contribute to reducing tubular damage and glomerular inflammation. Punarnava also exhibits marked diuretic activity, enhancing the excretion of excess fluids, electrolytes, and waste products, which aids in maintaining fluid–electrolyte balance and decreases renal strain. Furthermore, the herb provides protection against drug-induced kidney damage, particularly from agents such as gentamicin, cisplatin, and acetaminophen, by stabilizing renal cell membranes, preventing tubular degeneration, and supporting mitochondrial health. Evidence also indicates that Punarnava possesses anti-fibrotic properties that limit extracellular matrix accumulation and slow the advancement of chronic kidney disease.^[43,44]



Boerhavia diffusa binds to receptors such as;

SGLT2 transporter (possible binding in docking studies)

Nephrin protein (upregulation in podocytes)

Na⁺ /K⁺ -ATPase (modulation)

Aquaporin-1 (AQP1) channels

Nrf2 pathway (activation, not a receptor but a key signaling target).^[45]

Owing to these diverse therapeutic actions, Punarnava is beneficial in managing kidney-related conditions including chronic kidney disease, nephritis, nephrotic syndrome, renal oedema, and urolithiasis.^[46]

HEPATOPROTECTIVE ACTIVITY

Punarnava (*Boerhaavia diffusa* L.), a well-known medicinal plant in Ayurveda, has been widely recognized for its potent hepatoprotective activity. Traditionally used in formulations such as *Punarnavasava* and *Punarnavadi Kwath*, the plant has gained scientific interest due to its ability to protect the liver from a variety of toxic insults. Its hepatoprotective properties are attributed to a rich array of phytoconstituents, including punarnavine, boeravinones, flavonoids, alkaloids, lignans, sterols, and phenolic compounds.^[47,50]

Punarnava (*Boerhaavia diffusa*) exhibits strong hepatoprotective activity through multiple complementary mechanisms. Its bioactive constituents, such as boeravinones, punarnavine

and flavonoids, help reduce oxidative stress by scavenging free radicals and enhancing antioxidant enzymes like SOD, CAT and glutathione.^[51,52] The herb also suppresses pro-inflammatory cytokines, thereby minimizing liver inflammation and preventing further tissue injury. By stabilizing hepatocyte membranes, Punarnava prevents leakage of liver enzymes and maintains structural integrity of liver cells.^[53] Additionally, it enhances detoxification pathways, promotes hepatocyte regeneration, and inhibits hepatic stellate cell activation, which helps reduce collagen formation and protects against fibrosis. Through these combined actions, Punarnava effectively supports liver repair, regeneration and overall hepatic function.^[54]

Punarnava binds to a single, specific liver receptor. Instead, its hepatoprotective action occurs through the modulation of several cellular signaling pathways:

- **NF-κB inhibition** – reduces inflammatory cytokines.
- **p53/caspase activation** – supports removal of damaged cells.
- **VEGF downregulation** – limits abnormal angiogenesis.
- **AMPK activation** – improves cellular energy balance.
- **Nrf2-linked antioxidant response** – enhances oxidative stress protection.^[55,57]

CARDIOPROTECTIVE ACTIVITY

Congestive Heart Failure (CHF) is a long-term disorder in which the heart is unable to pump enough blood to meet the body's needs. This leads to fluid accumulation, decreased cardiac output, swelling, and poor organ circulation. The condition is commonly linked to oxidative damage, structural changes in the heart, increased circulatory load, impaired kidney function, and persistent inflammation.^[58,59]

Traditional herbal remedies have long been utilized to relieve symptoms of CHF, including swelling, weakness, and shortness of breath. Among these, *Punarnava* (*Boerhaavia diffusa* Linn.) is a widely recognized Ayurvedic herb known for its strong anti-edema, diuretic, cardioprotective, nephroprotective, and anti-inflammatory actions.^[60] Ayurveda classifies Punarnava under “Shothahara” (agents that reduce swelling), highlighting its traditional use in conditions involving fluid buildup, similar to modern presentations of CHF.

Punarnava acts as a cardioprotective agent through multiple interrelated mechanisms that help preserve heart structure and function. Its strong antioxidant activity scavenges free radicals and enhances endogenous enzymes such as SOD, catalase, and glutathione,

protecting cardiomyocytes from oxidative stress and lipid peroxidation.^[61,63] The herb also exhibits significant anti-inflammatory effects by suppressing cytokines like TNF- α , IL-1 β , and IL-6, along with inhibiting COX and LOX pathways, thereby preventing inflammatory damage to cardiac tissues. Punarnava stabilizes cell membranes and maintains ionic balance, reducing toxin-induced myocardial injury. Its anti-fibrotic constituents help inhibit fibroblast proliferation and collagen deposition, which delays myocardial remodeling and fibrosis. Additionally, its mild vasodilatory and potent diuretic actions lower preload and afterload, improving hemodynamics and decreasing the heart's workload. By modulating the renin–angiotensin–aldosterone system, it further reduces vasoconstriction and blood pressure, offering additional cardioprotection. Collectively, these actions enable Punarnava to protect the myocardium, enhance cardiac efficiency, and prevent progression of cardiac damage.^[64]

Boerhavia diffusa binds to receptors such as

AT1 receptor modulation via ACE inhibition → reduces vasoconstriction and cardiac stress.

β -adrenergic receptor modulation → lowers sympathetic load on the heart.

eNOS–NO pathway activation → improves vasodilation and myocardial perfusion.

L-type calcium channel modulation → prevents Ca²⁺ overload in cardiomyocytes.

NF- κ B inhibition → reduces cardiac inflammation and oxidative damage.

Possible PPAR- γ activation → decreases fibrosis and supports lipid balance.^[65]

ANTI FUNGAL ACTIVITY

Punarnava's therapeutic effects on skin disorders are largely due to its diverse phytochemical composition. In Ayurvedic medicine, Punarnava is regarded as a *rakta shodhaka* (blood purifier), which is vital for addressing skin issues caused by toxin buildup, poor circulation, or systemic imbalances.^[66] By purifying the blood and improving circulation, it helps manage chronic skin conditions, reduce pigmentation, and enhance overall skin tone. Additionally, its wound-healing and tissue-regenerative properties aid in repairing damaged skin, preventing scar formation, and accelerating the recovery of ulcerative or non-healing lesions.^[67]

Punarnava (*Boerhavia diffusa*) demonstrates a comprehensive approach in managing skin disorders through multiple mechanisms.^[68] The herb exhibits strong antimicrobial effects, targeting bacteria and fungi responsible for skin infections, including *Staphylococcus aureus*, *Pseudomonas*, *Candida*, and dermatophytes, which makes it useful in treating acne, boils, and ringworm. Punarnava's rich antioxidant content, including polyphenols and flavonoids,

neutralizes free radicals, lowers lipid peroxidation, and boosts the activity of endogenous antioxidant enzymes, protecting skin cells from oxidative damage.^[69] Additionally, it modulates the immune system, preventing excessive inflammatory responses that exacerbate chronic and autoimmune skin conditions.^[70] The herb further supports wound healing and tissue regeneration by enhancing fibroblast activity and collagen production, aiding recovery from ulcers, burns, and minor injuries. Its mild diuretic and detoxifying effects may also help improve skin health by reducing fluid retention and eliminating toxins. Together, these actions make Punarnava an effective remedy for both infectious and non-infectious skin ailments.^[71]

There is no direct evidence that Punarnava (*Boerhavia diffusa*) binds to specific skin receptors to treat skin diseases. Its effects are largely indirect, mediated through:

- **Cytokine modulation** (reduces TNF- α , IL-1 β , IL-6)
- **Antioxidant pathways** (protects keratinocytes and fibroblasts)
- **Antimicrobial effects** (inhibits bacteria and fungi)
- **Immune modulation** (affects macrophages and T-cell).^[72]

ANTIINFLAMMATORY ACTIVITY

Punarnava (*Boerhavia diffusa*) is a potent anti-inflammatory herb, traditionally recognized in Ayurveda as "**Shothaghni**" (inflammation alleviator).^[73] Scientific studies support this use, demonstrating that extracts significantly inhibit acute inflammation, such as carrageenan-induced paw edema, and chronic inflammation models, often acting synergistically with its well-known diuretic and analgesic effects. Its therapeutic action is attributed to key compounds like **boeravinones**, **Punarnavine**, and **Liriodendrin**, which are believed to modulate inflammatory pathways by inhibiting pro-inflammatory enzymes like sPLA2 and reducing the levels of pro-inflammatory cytokines such as TNF- α and IL-6.^[74,75]

Punarnava's anti-inflammatory efficacy is not mediated by binding to a single, classical receptor, but through a **multi-target mechanism** that primarily regulates **intracellular signaling pathways** and **key enzymes** central to inflammation. The active compounds, notably the alkaloid **Punarnavine**, inhibit the activation of the **NF- κ B pathway**, a critical transcription factor that drives the expression of numerous pro-inflammatory genes.^[76,77]

Furthermore, extracts have demonstrated an ability to inhibit enzymes like sPLA2 and COX-1/2, which are responsible for generating potent inflammatory mediators like prostaglandins.

By suppressing these central regulatory points and enzyme activities, Punarnava effectively limits the overall inflammatory response, rather than blocking a specific surface receptor.^[78,80]

CONCLUSION

Punarnava is a widely used Ayurvedic herb known for its remarkable benefits in managing renal and urinary disorders, its protective effects on vital organs, particularly the liver, kidneys, and heart, support its use as a holistic rejuvenating agent. It possesses strong anti-inflammatory and diuretic properties, making it valuable as both a kidney and heart tonic. Commonly found across India, especially during the monsoon season, Punarnava has a bitter and pungent taste and offers medicinal value throughout the entire plant, with the roots being particularly potent. In Ayurveda, it is frequently used to treat kidney ailments and urinary tract infections. The Himalaya Punarnava formulation is also employed for managing jaundice, fever, and obesity. Externally, the herb helps relieve pain and swelling, while its root juice is beneficial for individuals with night blindness. Punarnava aids in clearing mucus from the respiratory tract, making it useful in conditions like asthma, and its roots are known to expel intestinal worms. It serves as an effective natural remedy for various respiratory disorders. Recent research supports its role in managing fever, including malaria, as well as jaundice and constipation. Overall, Punarnava stands out as a promising natural remedy with broad pharmacological benefits, warranting further scientific exploration to fully validate its clinical applications.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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