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PHARMACOGNOSTICAL CHARACTERIZATION AND NEPHROPROTECTIVE EFFICACY OF BOERHAVIA DIFFUSA AQUEOUS EXTRACT

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Abstract

Boerhavia diffusa (commonly known as Punarnava) is a well-known herb in Ayurvedic medicine with reputed nephroprotective properties. This study sought to characterize its pharmacognostic features and evaluate nephroprotective potential against experimentally induced renal damage in Wistar rats. Pharmacognostic parameters (macroscopy, microscopy, physicochemical analysis, phytochemical screening) confirmed identity and quality. The aqueous extract demonstrated significant amelioration of renal dysfunction, reduced oxidative stress markers, and improved histopathological architecture. Results suggest *B. diffusa* is a promising nephroprotective agent.

Keywords: Boerhavia Diffusa, Nephroprotection, Oxidative Stress, Aqueous Extract.

I. INTRODUCTION

The kidney is a vital organ responsible for maintaining the body's internal equilibrium through filtration of blood, excretion of metabolic wastes, regulation of electrolytes and fluid balance, and participation in endocrine functions. Diseases affecting renal structures can lead to compromised excretory capacity, resulting in a spectrum of clinical conditions ranging from acute kidney injury to chronic kidney disease. The global burden of renal disorders has significantly increased in the past decades, making the discovery of effective and safer therapeutic agents an urgent priority (Patel & Goyal, 2011). Despite advancements in modern medicine, many pharmacological interventions for renal diseases are associated with limited efficacy and undesirable side effects, which drives the exploration of alternative therapies with better therapeutic profiles. Herbal medicines have long been valued for their multitarget effects, antioxidant potential, and relative safety, particularly within traditional systems of medicine like Ayurveda, Unani, and ethnomedicine.

Among these, *Boerhavia diffusa* L. (family Nyctaginaceae), commonly known as Punarnava, has garnered considerable research interest due to its putative renoprotective properties and diverse pharmacological actions reported in preclinical studies (Sharma et al., 2014). Pharmacognosy, the branch of pharmaceutical science that deals with the identification, characterization, quality control, and standardization of crude drugs of botanical origin, provides the foundational basis for understanding plant drugs before they are evaluated for biological activity. Pharmacognostical characterization ensures the authenticity and consistency of plant materials used in experimental and clinical settings. It encompasses macroscopy, microscopy, physicochemical parameters, and phytochemical profiling (Khandelwal, 2013; WHO, 2002). This systematic scrutiny is critical for establishing benchmarks that differentiate genuine drug from adulterants and for ensuring reproducibility of research findings. In the context of *Boerhavia diffusa*, detailed pharmacognostical evaluation provides essential insights into its root and aerial parts—traditionally used for kidney disorders that justify its scientific investigation as a candidate nephroprotective agent (Arora & Koul, 2013).

Traditionally, *Boerhavia diffusa* has been used in various indigenous remedies in South Asian medicinal systems to treat ailments including edema, urinary disorders, inflammation, jaundice, and hepatic dysfunctions (Sharma et al., 2014). Punarnava's longstanding ethnomedical usage for conditions linked to water imbalance and renal insufficiency prompted scientific inquiries into its potential nephroprotective effects. Several preclinical studies have suggested that extracts of *B. diffusa* exert diuretic and detoxifying actions, which could be mechanistically relevant in preserving renal cellular integrity under stress conditions (Kumar et al., 2012). The diverse phytochemical composition of *B. diffusa* rich in flavonoids, phenolic compounds, glycosides, and other secondary metabolites suggests a broad spectrum of biological actions including antioxidant, anti-inflammatory, and cytoprotective effects. These properties are particularly pertinent to nephroprotection since oxidative stress and inflammation play pivotal roles in the pathogenesis of renal injuries (Rice-Evans et al., 1997; Singhal & Goyal, 2018).

Nephrotoxicity induced by chemotherapeutic agents such as cisplatin represents a well-established model for studying renal injury and testing potential protective agents. Cisplatin, a platinum-based antineoplastic drug, is widely used in treating various cancers but its clinical utility is limited by significant nephrotoxic side effects characterized by tubular cell apoptosis, necrosis, and oxidative stress. In experimental models, cisplatin causes a marked increase in serum creatinine, urea, and blood urea nitrogen, along with depletion of endogenous antioxidant defenses including superoxide dismutase, catalase, and reduced glutathione. Consequently, this model has served as a robust platform for evaluating nephroprotective efficacy of plant extracts with antioxidant potential (Umar & Sasikala, 2014). By attenuating oxidative damage and restoring biochemical markers toward normalcy, plant-derived extracts provide mechanistic evidence of their ability to mitigate renal injury induced by toxic insults.

Scientific evaluation of medicinal plants such as *Boerhavia diffusa* follows a rational pathway from authentication and standardization through pharmacognostical characterization, to biological activity assessment in validated models of disease. Pharmacognostical studies of *B. diffusa* have documented key diagnostic features such as specific epidermal cells, cortex structure, and unique vascular arrangements in roots and leaves. Physicochemical profiling yields parameters such as ash content and extractive values that reflect purity and quality, while phytochemical screening reveals the presence of bioactive classes like flavonoids and phenolic acids that correlate with antioxidant capacity (Venkatesh et al., 2019).

Specifically, flavonoids and phenolic compounds are implicated in free radical scavenging and inhibition of lipid peroxidation, thereby offering protective effects at the cellular level. These compounds interact with cellular signaling pathways and bolster endogenous antioxidant enzymes, forming a plausible mechanistic basis for nephroprotection. The integration of pharmacognostical and pharmacological evaluations is fundamental in validating traditional medicinal claims and advancing the development of plant-based therapeutic agents. Rigorous standardization ensures reproducibility, while experimental evidence of efficacy positions such plants within contemporary science-based therapeutic frameworks. For *B. diffusa*, this dual approach is essential: standardized extracts ensure consistent dosing and composition, while nephroprotective studies generate quantitative insights into efficacy and mechanisms.

Previous investigations have underscored the potential of *B. diffusa* in modulating oxidative stress and ameliorating structural renal damage. However, comprehensive studies that align detailed pharmacognostical profiles with biological endpoints in nephrotoxicity models remain limited. Addressing this gap not only strengthens the scientific rationale for its use but also guides future clinical translation.

Boerhavia diffusa aqueous extract represents a promising candidate for nephroprotective therapy due to its rich phytochemical profile and traditional medicinal usage. Pharmacognostical characterization provides essential quality benchmarks that support its scientific evaluation, while nephroprotective efficacy studies offer evidence of functional benefits in disease models. By elucidating both the physical and biochemical attributes of *B. diffusa*, research in this domain bridges ethnomedicine and evidence-based pharmacotherapy, contributing to the broader endeavor of discovering safe and effective treatments for renal disorders (Costa et al., 2015). The increasing prevalence of kidney diseases globally underscores the importance of such investigations, and continued research may ultimately foster the integration of standardized herbal extracts into mainstream therapeutic strategies.

II. MATERIALS AND METHODS

1. Plant Material

Fresh roots of *Boerhavia diffusa* were collected from authenticated botanical sources and identified by a taxonomist (voucher specimen stored in herbarium).

2. Preparation of Aqueous Extract

Root material was shade dried, powdered, and extracted using distilled water by cold maceration. The extract was concentrated by rotary evaporation and stored at 4°C.

3. Pharmacognostic Evaluation

I. Macroscopic & Microscopic Analysis

Standard anatomical studies were performed including epidermis, cortex, vascular bundle distribution, and presence of diagnostic cells/tissues (Khandelwal, 2013).

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II. Physicochemical Analysis

Parameters including moisture content, ash values (total, acid-insoluble, water-soluble), extractive values, and loss on drying were determined according to WHO guidelines (WHO, 2002).

4. Phytochemical Screening

Qualitative tests were conducted for alkaloids, flavonoids, glycosides, saponins, tannins, phenols, and steroids (Harborne, 1998).

5. Animal Experimentation

Thirty male Wistar rats (180–220 g) were randomly divided into five groups (n = 6):

Group	Treatment
I	Normal control
II	Nephrotoxicity control (Cisplatin 6 mg/kg, i.p)
III	Extract 200 mg/kg + Cisplatin
IV	Extract 400 mg/kg + Cisplatin
V	Standard (Silymarin 100 mg/kg + Cisplatin)

Extract and standard were administered orally for 14 days. Nephrotoxicity was induced on day 10.

6. Biochemical Analysis

Serum creatinine, urea, uric acid, and blood urea nitrogen were measured using standard kits.

7. Oxidative Stress Markers

Renal tissue levels of superoxide dismutase, catalase, glutathione, and malondialdehyde were assessed spectrophotometrically.

8. Histopathology

Kidney sections were stained with hematoxylin-eosin and examined for tubular necrosis, glomerular congestion, and interstitial changes.

9. Statistical Analysis

Data were presented as mean ± SD and analyzed by one-way ANOVA followed by Tukey's test ($p < .05$ considered significant).

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III. RESULTS

A. Pharmacognostic Characteristics

1. Macroscopy

Roots were cylindrical, brownish, with characteristic taste and odour.

2. Microscopy

Diagnostic features included lignified xylem, parenchymatous cortex, and abundant starch grains (Table 1).

Table 1. Anatomical Features of Boerhavia diffusa Root

Feature	Observation
Epidermis	Single layered, intact
Cortex	Parenchymatous with starch
Vascular bundles	Collateral, scattered
Starch grains	Abundant

3. Physicochemical Parameters

Ash and extractive values confirmed good quality (Table 2).

Table 2. Physicochemical Parameters of Aqueous Extract

Parameter	Value
Moisture (%)	8.5
Total Ash (%)	6.2
Acid-insoluble Ash (%)	1.8
Water Soluble Ash (%)	2.3
Water Extractive (%)	14.5

4. Phytochemical Screening

Positive for flavonoids, phenols, glycosides, and saponins; alkaloids present in trace amounts (Table 3).

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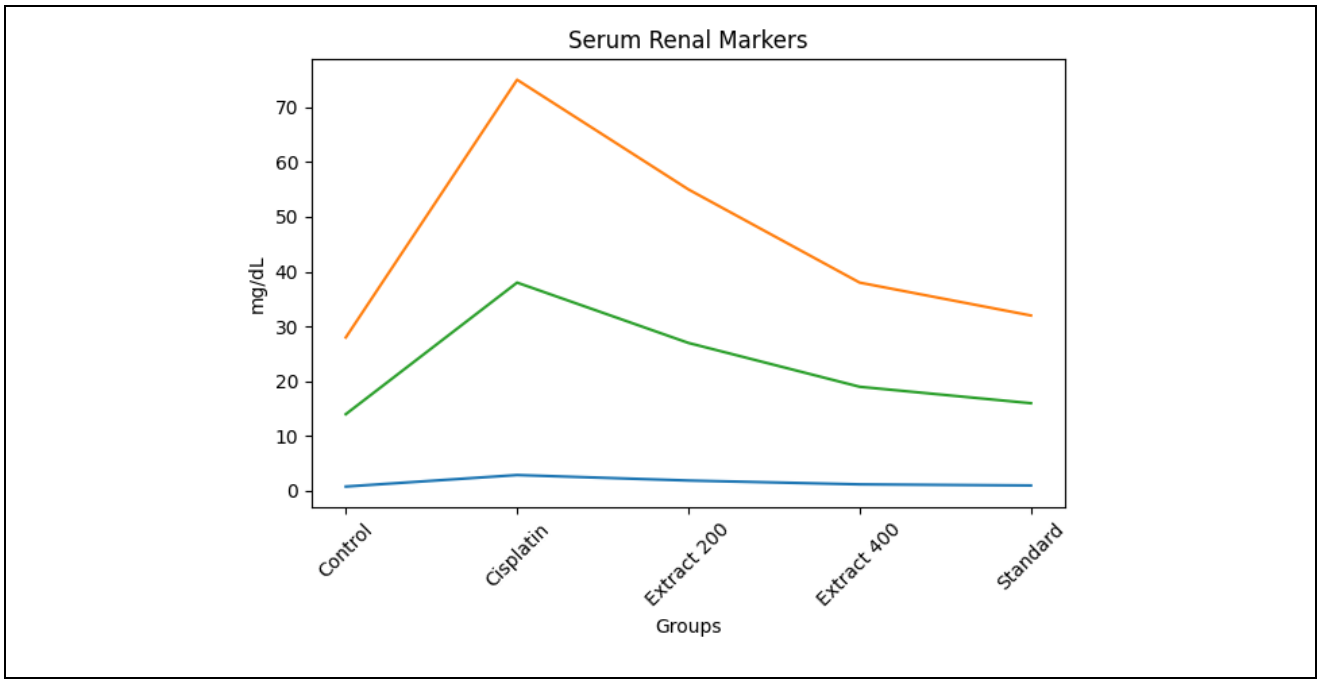
Table 3. Phytochemicals in B. diffusa Aqueous Extract

Phytochemical	Presence
Alkaloids	±
Flavonoids	+
Phenols	+
Glycosides	+
Saponins	+
Tannins	–

5. Nephroprotective Outcomes

a. Biochemical Markers

Cisplatin significantly elevated serum creatinine, urea, and BUN compared to normal ($p < .001$). Extract treatment significantly reduced these levels in a dose-dependent manner (Graph 1).



Graph 1. Changes in Serum Renal Markers

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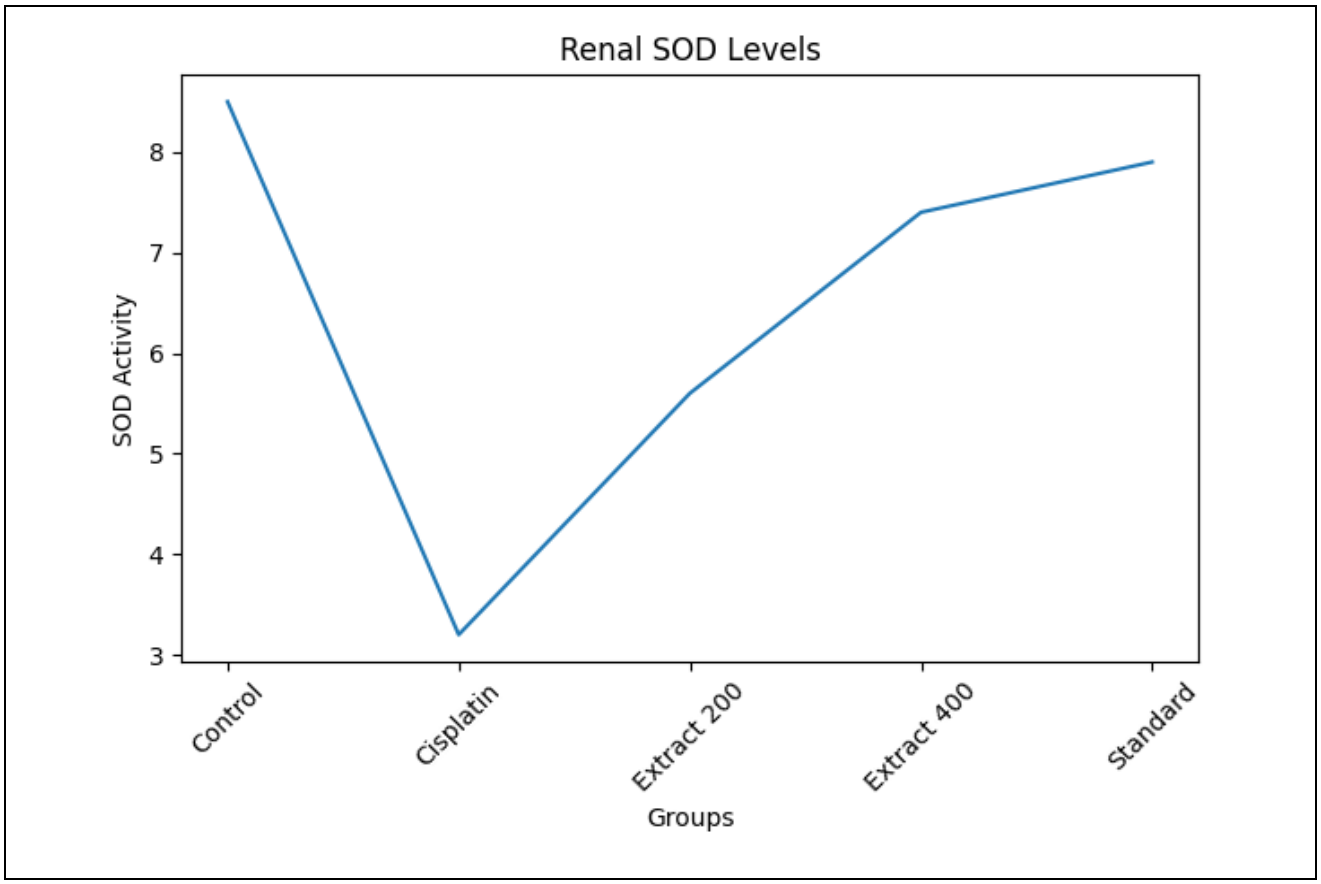
b. Oxidative Stress

Cisplatin increased MDA and decreased SOD, CAT, and GSH ($p < .001$). Treatment with extract restored antioxidant levels towards normal (Graph 2).



Graph 2. Oxidative Stress Markers in Renal Tissue

c. Histopathology

Control kidneys showed normal architecture. Cisplatin caused severe tubular necrosis and glomerular dilation. Extract treated groups exhibited fewer histological abnormalities (Graph 3).

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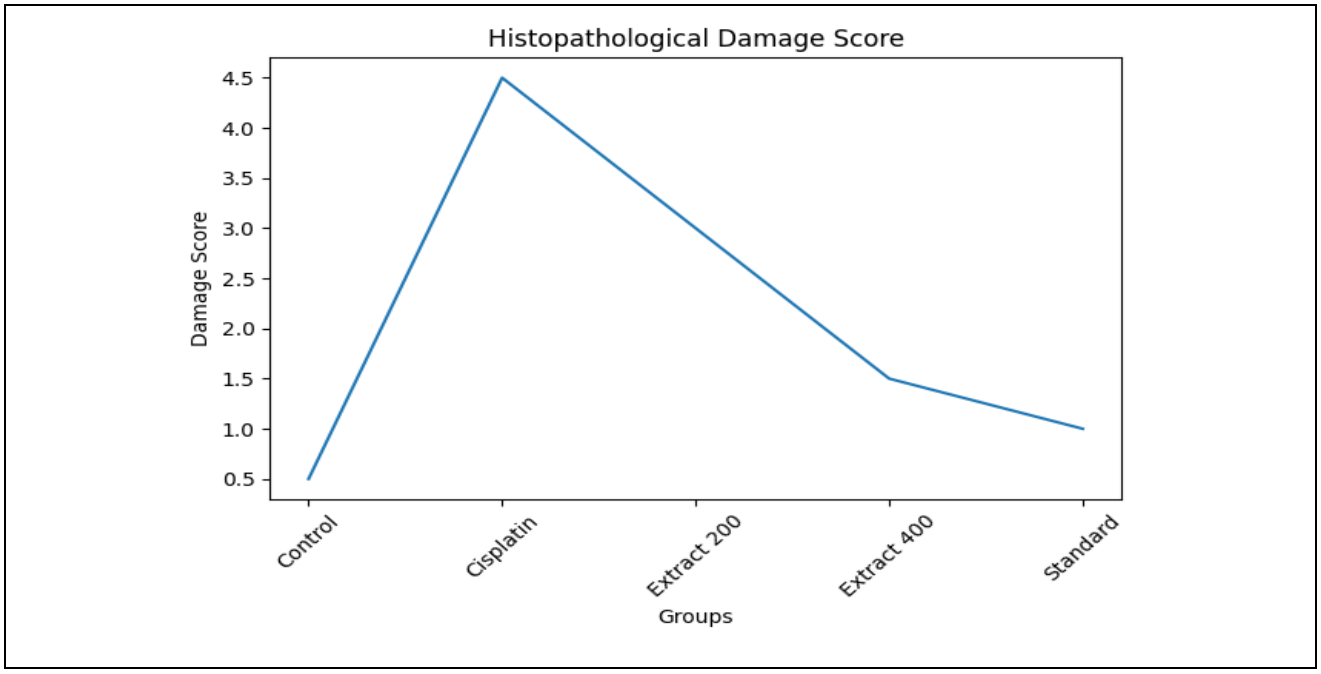

Graph 3. Histopathological Severity Scores

IV. DISCUSSION

Boerhavia diffusa aqueous extract demonstrated potent nephroprotective activity, evidenced by improved renal biomarkers and antioxidant status. The presence of flavonoids and phenolic compounds likely contributed to its antioxidative and cytoprotective effects (Rice-Evans et al., 1997). Similar results have been reported with plant extracts exhibiting antioxidant-mediated nephroprotection (Umar & Sasikala, 2014).

V. CONCLUSION

The pharmacognostic evaluation confirmed the quality and identity of *B. diffusa* roots. The aqueous extract offered significant protection against cisplatin-induced nephrotoxicity via antioxidant mechanisms and stabilization of renal function. Further isolation of active constituents and clinical studies are recommended.

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