

Boerhavia diffusa-Loaded Nanofibers: Phytochemical Insights and Antimicrobial Potential

Smita Borkar^{1,2*}, Prashant Kumar Dhakad¹, Hemantkumar Singh Yadav³

¹School of Pharmacy, Suresh Gyanvihar University, Jaipur, Rajasthan, India.

²Arvind Gavali College of Pharmacy, Jaitapur, India.

³Department of Pharmaceutical Sciences, Indira Gandhi University, Meerpur, Rewari.

Received: 13th Aug, 2025; Revised: 15th Sep 2025; Accepted: 18th Nov, 2025; Available Online: 30th Nov, 2025

ABSTRACT

Boerhavia diffusa, commonly known as Punarnava, is a medicinal herb belonging to the Rubiaceae family, traditionally used in Ayurveda for its diuretic, hepatoprotective, anti-inflammatory, and antimicrobial properties. This study investigates the extraction, phytochemical screening, and development of nanofiber formulations using *Boerhavia diffusa* root and leaf extracts, followed by an evaluation of their antimicrobial activities. Ethanol extracts exhibited the highest yield (5.9% for roots and 5.2% for leaves), while chloroform extracts demonstrated the lowest yield (1.26% in leaves). Phytochemical analysis confirmed the presence of bioactive compounds, including carbohydrates, proteins, steroids, terpenoids, glycosides, saponins, flavonoids, alkaloids, and tannins. Antimicrobial assessments indicated that ethanol extracts exhibited the most potent inhibition against *Staphylococcus aureus* and *Candida albicans*, while aqueous extracts were most effective against *Aspergillus niger*. Nanofiber-based drug delivery systems were employed to enhance the bioavailability and targeted delivery of these bioactive compounds. The porous structure and high surface area of the nanofibers provided sustained drug release, demonstrating their potential in antimicrobial applications and wound healing. This study supports the further development of *Boerhavia diffusa*-based nanofiber systems as innovative therapeutic solutions in contemporary medicine.

Keywords: *Boerhavia diffusa*, nanofiber, antimicrobial, wound healing.

How to cite this article: Borkar S; Dhakad PK; Yadav HS, *Boerhavia diffusa*-Loaded Nanofibers: Phytochemical Insights and Antimicrobial Potential. Int J Drug Deliv Technol. 2025;15(4): 1771-1775, DOI: 10.25258/ijddt.15.4.29

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Boerhavia diffusa or Punarnava is a well-known medicinal herb of the Rubiaceae family. It has been used traditionally in Ayurveda and other traditional medicine practices for its diuretic, hepatoprotective, anti-inflammatory, and antimicrobial activity. The herb contains bioactive phytoconstituents which are responsible for its multifaceted therapeutic application¹. Punarnava has been studied in great detail for its application in treating liver ailments, kidney dysfunctions, and inflammatory diseases. Its antimicrobial property has been characterized by the presence of phytochemicals that have strong inhibitory activities against fungal and bacterial pathogens². With its broad pharmacological profile, *Boerhavia diffusa* is being considered in contemporary drug delivery systems for the controlled and targeted delivery of bioactive compounds³. Nanofibers are a viable platform in biomedical applications and drug delivery because they possess high surface area, porous structures that are easily tunable, and the ability to have controlled release⁴. The nanofibers, which are often made via electrospinning processes, are an effective and adaptable method of encapsulating therapeutic synthetic and natural drugs. Due to their nanoscale characteristics, the nanofibers facilitate improved bioavailability and controlled targeted delivery of encapsulated drugs, assembly them useful for applications as wound healing,

antimicrobial, and tissue engineering⁵. In addition, nanofibers create a suitable condition for long-term drug delivery, which leads to improved therapeutic efficacy and lower frequency of administration. Due to their capacity for modeling the extracellular matrix, they are very promising candidates for biomedical applications, such as antimicrobial dressings and tissue regeneration scaffolds⁶. The use of plant-derived bioactive compounds in nanofiber-based drug delivery systems has emerged as a focus area in recent years. Plant-based nanofibers provide a biocompatible and environmentally friendly solution to therapeutic uses, leveraging phytochemicals with strong pharmacological activity⁷.

Not only do these fibers increase the stability of bioactive molecules, but they also enhance their bioavailability and targeted delivery. The incorporation of natural plant extracts into nanofiber production offers a novel method to utilize traditional medicinal plants for contemporary healthcare uses⁸. Existing study attentions on extraction, phytochemical screening, and development of nanofiber formulations using *Boerhavia diffusa* extracts, followed by an evaluation of their antimicrobial activities.

Materials and methods

Materials

*Author for Correspondence: smita.borkaragcop@gmail.com

This *Boerhavia diffusa* plant was collected in the Maharashtra district of Pune and then left to dry in the shade for a full day. Dried plant components, including roots and leaves, were ground in a grinder and screened through a 120 mesh (#) screen to extract powders. An expert from the Botanical Survey of India in Pune, D. L. Shirodkar, confirmed the plant's legitimacy by analysing its morphological features. The botanical sample was confirmed at Botanical Survey of India, Pune, on April 6, 2021. Its receipt specimen no. is CDP-01 (Ref. No. BSI/WRC/IDEN.CER./2021/H3).



Figure 1. *Boerhavia diffusa*

Methods

Weight accurately 100 gm dry course size crud drug material separately (Root and Leaves). Pulverized with chloroform and loaded in soxhlet extraction assembly. Further extraction proceeds with first solvent chloroform. Continuous method chosen for completion of extraction step. Decolorized solvent at siphon tube indicate completion of dissolved components in respective crude drug material. Further solvent ethanol treated with same crude drug once it dried and free from previous solvent. At last refluxed same plant material with distilled water and report percent yield of extract. Above method used for both parts it result chloroform, ethanol and aqueous extract obtained. Details reported in characterization.

Preliminary Phytochemical Screening

The extract was tested for carbohydrates, proteins, amino acids, steroids, terpenoids, and saponins. Carbohydrates were identified by Molosch test, while proteins were identified through the Biuret test and Millon's test. Amino acids were detected through the Ninhydrin test. Steroids were detected through the Salkowaski test and the Liebermann-burchard test. Terpenoids were detected through the foam formation test, and saponins were detected through the dissolved extract solution. These tests were conducted to determine the presence of various compounds in the extract⁹.

Boerhavia diffusa extract loaded nanofiber

At doses of 8 mg/ml, an active methanolic extract of the plant root (0.4 mg/ml) was dissolved in PVA and PEO solution (Table 1). All of the solid ingredients were fully dissolved by stirring the mixture for 72 hours at room

temperature. The extracts dissolved quickly at the specified concentration, creating a transparent solution with a consistent colour and viscosity. The following parameters were used when electrospinning the solution into solid fibre mats: 0.3 ml/h flow rate, 20 kV DC offset, 15 cm air gap & 18 ga blunted needle. Five millilitres of solution and a circular collecting mandrel with a diameter of 6.5 mm were utilised in a standard spinning run. Prior to any additional testing, scaffolds were vacuum-dried for three hours to eliminate any remaining solvent¹⁰.

Table 1. Formulation table of nanofiber

Formulation Batches	PVA(mg/ml)	PEO(mg/ml)
BDRNF1	6.00	14.00
BDRNF2	10.00	6.00
BDRNF3	14.00	6.00
BDRNF4	14.00	10.00

Antibacterial Activity:

The antibacterial action of nanofibres was done using the Agar Well Diffusion Technique. *P. vulgaris* (NCIM 2813), *A. niger* (NCIM 501), *Candida albicans* (NCIM 3471), *Staphylococcus aureus* (NCIM 2079), *Escherichia coli* (NCIM 2065), and *B. subtilis* (NCIM 2063) have all had their own 24-hour cultures created. Nutrient Agar Sterile Chloramphenicol Yeast Glucose Agar was made for fungal cultures, and plates were organized for cultures. Every microorganism was given a 0.2 ml culture on separate plates using sterile swabs. One 8.0 mm cork borer plate was used to make four or five wells in the agar. A stock solution of dimethyl sulfoxide (DMSO) was made for a test material suspension of 10 mg/ml. 50 µl of stock solution was put into each well. Cisplatin was added at 0.5 mg/ml (Std) as usual. Plates were incubated at 37°C for a whole day & analyzed¹¹.

Result and discussion

Extraction:

The extracts from *Boerhavia diffusa* roots and leaves contain chloroform, ethanol, and aqueous extracts, with varying percentage yields based on their nature and color.

Table 2. Characteristics of extracts

Extra cts	<i>Boerhavia diffusa</i> Roots			<i>Boerhavia diffusa</i> Leaves		
	Co lor	Natu re	Perce ntage Yield (% W/W)	Co lor	Natu re	Perce ntage Yield (% W/W)

Chloroform extract (CLE)	Green	Semi solid and sticky	5.1 %	Green	Semi solid and sticky	3.8 %
Ethanol extract (ETE)	Dark Green	Semi solid	5.9 %	Dark Green	Semi solid	5.2 %
Aqueous (Water) extract (AQE)	Dark Green	Jelly like	3.3%	Dark Green	Sticky powder	1.26%

Preliminary Phytochemical Screening: -

The study on *Boerhavia diffusa* root and leaf extracts revealed a diverse range of bioactive compounds. Ethanol extracts showed the most diverse phytoconstituents, including carbohydrates, proteins, steroids, terpenoids, glycosides, saponins, flavonoids, alkaloids, and tannins. Chloroform extracts mainly contained terpenoids, alkaloids, and steroids. Aqueous extracts showed carbohydrates, saponins, and glycosides. The study suggests ethanol is the most effective solvent for extracting bioactive compounds from *Boerhavia diffusa*.

Table 3. Phytochemical screening of extracts of *Boerhavia diffusa*

Extracts	<i>Boerhavia diffusa</i> Roots			<i>Boerhavia diffusa</i> Leaves		
	Chloroform	Ethanol	Aqueous	Chloroform	Ethanol	Aqueous
Carbohydrates						
Benedict Test	-	+	-	-	-	-
Fehling Test	-	+	-	-	-	-
Molish Test	-	+	+	-	+	+
Non-reducing polysaccharides						
Iodine Test	-	+	-	-	+	-
Monosaccharide						
Barfoed's Test	+	-	-	+	-	+
Proteins						
Millions test	+	-	-	-	-	-
Biuret test	-	+	-	-	+	-
Steroids						
Liebermann Burchard reaction	+	-	-	-	-	-

Salkowski reaction	-	+	+	-	+	+
Tests for Terpenoids	+	+	-	+	+	-
Glycosides						
Killer-Killani Test	-	+	-	-	-	-
Borntraeger's Test	-	-	-	-	+	-
Saponin						
Foam test	-	-	+	-	+	+
Flavonoids						
Lead acetate Test	-	+	-	-	+	+
Shinoda test	-	+	-	-	+	-
Sod-hydroxide Test	-	-	+	-	-	+
Alkaloids						
Hager's Test	-	-	-	+	+	-
Wagner's Test	+	-	-	-	-	-
Meyers Test	-	+	-	-	+	-
Dragendorff Test	-	+	+	-	+	+
Tannins & Phenolic compounds						
FeCl ₃	-	+	-	-	+	-
Lead acetate	-	-	-	+	-	-

+ Indicates presence & - Indicates absence of phytoconstituents

Antibacterial activity

Antibacterial activities against various bacteria and yeasts, measured in millimetres of zone of inhibition.

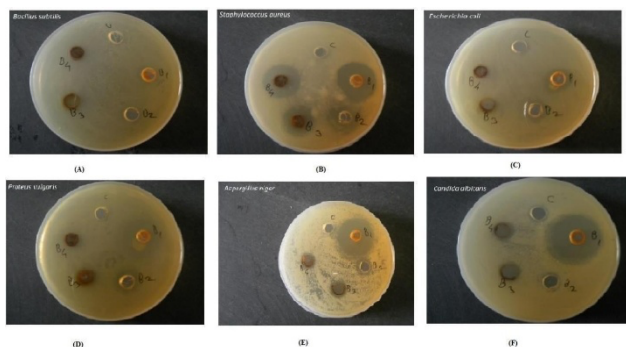


Figure 2:A- Microbial activities against *Bacillus subtilis* (B1 to B4), B- Microbial activities against *Staphylococcus aureus* (B1 to B4), C- Microbial activities against *Escherichia coli* (B1 to B4), D- Microbial activities against *Proteus vulgaris* (B1 to B4), E- Microbial activities against *Aspergillus niger* (B1 to B4), F- Microbial activities against *Candida albicans* (B1 to B4)

Table 4. Antimicrobial Activity

Sample ID	Conc. of Stock solution	Zone of inhibition in mm					
		<i>Escherichia coli</i> NCIM 2065	<i>Staphylococcus aureus</i> NCIM 2079	<i>Proteus vulgaris</i> NCIM 2813	<i>Aspergillus niger</i> NCIM 501	<i>Bacillus subtilis</i> NCIM 2063	<i>Candida albicans</i> NCIM 3471
B1	10mg/ml	12	15	10	23	9	30
B2		12	19	9	24	4	30
B3		12	12	11	20	9	28
B4		10	11	13	18	8	29
Std.	0.5mg/ml	17	23	18	28	18	33

Conclusion

The study on *Boerhavia diffusa* root and leaf extracts revealed significant findings regarding extraction yield, phytochemical composition, and antimicrobial activity. Ethanol extracts showed the highest yield, with 5.9% for roots and 5.2% for leaves. Chloroform extracts had the lowest yield, with only 1.26% in leaves. Ethanol extracts contained a diverse range of bioactive compounds, including carbohydrates, proteins, steroids, terpenoids, glycosides, saponins, flavonoids, alkaloids, and tannins. Both ethanol and chloroform extracts showed considerable effectiveness against bacterial and fungal strains, with ethanol showing a strong zone of inhibition against *Staphylococcus aureus* and *Candida albicans*. Aqueous extracts demonstrated moderate antimicrobial effects, but were most effective against *Aspergillus niger*. Further research is recommended to support its therapeutic use.

REFERENCE

- Das S, Singh PK, Ameeruddin S, Kumar Bindhani B, Obaidullah WJ, Obaidullah AJ, Mishra S, Mohapatra RK. Ethnomedicinal values of *Boerhavia diffusa* L. as a panacea against multiple human ailments: a state of art review. *Frontiers in chemistry*. 2023 Nov 14;11:1297300. <https://doi.org/10.3389/fchem.2023.1297300>
- Gaur PK, Rastogi S, Lata K. Correlation between phytochemicals and pharmacological activities of *Boerhavia diffusa* Linn with traditional-ethnopharmacological insights. *Phytomedicine Plus*. 2022 May 1;2(2):100260. <https://doi.org/10.1016/j.phyplu.2022.100260>
- Mishra S, Aeri V, Gaur PK, Jachak SM. Phytochemical, therapeutic, and ethnopharmacological overview for a traditionally important herb: *Boerhavia diffusa* Linn. *BioMed research international*. 2014;2014(1):808302. <https://doi.org/10.1155/2014/808302>
- Rasouli R, Barhoum A, Bechelany M, Dufresne A. Nanofibers for biomedical and healthcare applications. *Macromolecular bioscience*. 2019 Feb;19(2):1800256. <https://doi.org/10.1002/mabi.201800256>
- Akombaetwa N, Bwanga A, Makoni PA, Witika BA. Applications of electrospun drug-eluting nanofibers in wound healing: current and future perspectives. *Polymers*. 2022 Jul 20;14(14):2931. <https://doi.org/10.3390/polym14142931>
- Da LC, Huang YZ, Xie HQ, Zheng BH, Huang YC, Du SR. Membranous extracellular matrix-based scaffolds for skin wound healing. *Pharmaceutics*. 2021 Oct 27;13(11):1796. <https://doi.org/10.3390/pharmaceutics13111796>
- Liu Q, Luo S, Peng J, Chang R. Electrospun nanofibers from plant natural products: a new approach toward efficient wound healing. *International Journal of Nanomedicine*. 2024 Dec 31:13973-90. <https://doi.org/10.2147/IJN.S501970>
- Huesca-Urióstegui K, García-Valderrama EJ, Gutierrez-Urbe JA, Antunes-Ricardo M, Guajardo-Flores D. Nanofiber systems as herbal bioactive compounds carriers: current applications in healthcare. *Pharmaceutics*. 2022 Jan 14;14(1):191. <https://doi.org/10.3390/pharmaceutics14010191>
- Khandelwal K. *Practical pharmacognosy*. Pragati Books Pvt. Ltd.; 2008 Sep 7.
- Shahid MA, Khan MS, Hasan MM. Licorice extract-infused electrospun nanofiber scaffold for wound healing. *OpenNano*. 2022 Nov 1;8:100075. <https://doi.org/10.1016/j.onano.2022.100075>
- Adamu BF, Gao J, Tan S, Gebeyehu EK. Comparison of

antibacterial property of herbal plant-based bio-active extract loaded polymer electrospun nanofibrous mat wound dressings. *Journal of Industrial Textiles*. 2022 Jun;51(2_suppl):1793S-814S.

<https://doi.org/10.1177/15280837221086899>