IJMPR 2024, 8(6), 99-104

International Journal of Modern Pharmaceutical Research
www.ijmpronline.com

ISSN: 2319-5878
IJMPR
Review Article
SJIF Impact Factor: 6.669

EXPLORING THE PHYTOCHEMICAL COMPOSITION AND THERAPEUTIC POTENTIAL OF BERGENIA CILIATA: A COMPREHENSIVE REVIEW

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Article Received on: 23/04/2024
Article Revised on: 13/05/2024
Article Accepted on: 02/06/2024

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ABSTRACT

Bergenia ciliata, a perennial herb belonging to the family *Saxifragaceae*, is widely recognized for its therapeutic potential in traditional medicine. This comprehensive review explores the phytochemical composition and pharmacological activities of *Bergenia ciliata*. The plant contains various bioactive compounds, including flavonoids, terpenoids, glycosides, and sterols, which contribute to its medicinal properties. *Bergenia ciliata* exhibits significant therapeutic efficacy against numerous conditions such as gastrointestinal disorders, respiratory ailments, and urinary diseases. Additionally, the plant demonstrates promising antioxidant, anti-diabetic, anti-cancer, and antimicrobial activities. The review highlights the importance of further research to fully elucidate the therapeutic potential and mechanisms of action of *Bergenia ciliata's* phytochemicals.

KEYWORDS: *Bergenia ciliata*, phytochemicals, therapeutic potential, traditional medicine, antioxidant activity, anti-diabetic, anti-cancer, antimicrobial, *Saxifragaceae.*

INTRODUCTION

The majority of aromatic and medicinal plants are found in forested areas, with only a few of them being grown in fields of agriculture. The indigenous people use some of these plants for food, medicine, and other household uses. In India, medicinal plants are a major source of medicine and are utilized for therapeutic, preventive, and promotional purposes. Around 11% of the 252 medications are derived from plant sources, and the World Health Organization (WHO) has acknowledged herbal medicines as a crucial part of primary healthcare. This review tries to hypothesize *Bergenia ciliata's* potential medical value.[1]

The family *Saxifragaceae*, which includes *Bergenia ciliata (Haw.)* Stern is made up of roughly 30 genera and 580 species globally. The plant is called Rockfoil in English, which suggests that it has lithotriptic properties or grows between rocks and looks to shatter them. In Hindi, it is called Pashanbheda (Pashan = rock stone, bheda = piercing).[2] The ciliate edge of the few spreading leaves is present. The raceme-shaped flowers range in color from pink to purple. The fruit is a capsule that holds many long seeds. Each of the two or three carpels on the plant possesses axile placentation.[3]

Bergenia root is believed to possess all the advantageous properties of Gentian root, in addition to being demulcent and obstruent, reducing pain in the chest and ribs caused by strong cold odors, and acting as an effective diuretic and emmenagogue. Remove obstructions, dangerous waste products in the alimentary canal and urine excretory system, and stones in the kidneys and bladder. It is said that the infusion is more active than the root, in children suffering from spasmodic disorders, asthma, bronchitis, epilepsy, and flatulent colic. Roots are a powerful weapon against recurrent vaginal infections.[4] Medicinal plants' distinct microbiome produces a range of bioactive secondary metabolites, such as flavonoids, terpenoids, glycosides, and sterols.[5] It is regarded as a miracle herb because of its ability to treat a variety of illnesses, including malaria, kidney stones, and gastrointestinal issues. Numerous phytochemicals, including tannins, terpenoids, flavonoids, steroids, saponins, coumarins, and glucosides, were present in this plant. Rich in coumarins, tannins, and alkaloids is the rhizome. *B.Ciliata* species contain about 58 different phytochemicals.[6]

PLANT PROFILE

B. ciliata is a perennial herb that grows to a height of 50 cm (about 1.64ft.). Its leaves are suborbicular and have rounded tips and bases. Soft hairs skirt the delicately denticulate leaf edges. Leaves are ex-stipulate, opposite, and alternating. The showy pinkish-white flowers have obovate petals, lobes that are acute and lenticular near the apex, are hermaphrodite, have four or five petals that are perigynous and imbricate, indefinite stamens, an ovary that is four or five and united, fruit that is capsular or occasionally baccate, and many seeds. The flowers bloom in the spring, from February to April. Fruiting occurs from March to July.[7] Flowers pedicellate, pink to purplish; peduncle up to 10 cm (about 3.94 in) long. Sepals are oblong and around 7 mm (about 0.28 in) long.

Petals: 10 × 4 mm (about 0.16 in), unguiculate, orbicular limb. Filaments, approximately 1 centimeter (about 0.39 in) in length, range from pink to crimson. Carpels 2. Styles c. Measure 7 mm (about 0.28 in) in length. Green or pinkish-colored carpels and styles. 13 x 6 mm (about 0.24 in) capsule with styles included. The seeds are dark, slightly tuberculate, elongated, and about 1 mm (about 0.04 in) long.[8] The plant, blooms, and dried rhizome are displayed in Fig 1.

Fig. 1. *Bergenia ciliata,* leaves, dried rhizomes and flowers.

CLASSIFICATION

Kingdom	**Plantae**
Subkingdom	**Tracheobionta**
Superdivison	**Spermatophyta**
Division	**Magnoliophyta**
Class	**Magnoliopsida**
Subclass	**Dilleniidae**
Order	**Saxifragales**
Family	***Saxifragaceae***
Genus	***Bergenia***
Species	***Bergenia ciliata***

VERNACULAR NAMES

Distinct regions have distinct colloquial names for *B. ciliata.* It goes by the name Sadpottar in India.[9]

SL.No.	Languages	Common names
1.	Sanskrit	Amabhedaka
2.	Hindi	Pakhanabheda
3.	Bengali	Patharkuchi
4.	Kannada	Alepgaya
5.	Punjabi	Kachalu
6.	English	Hairy bergenia
7.	Telugu	Kondapindi
8.	Tamil	Sirupilai
9.	Nepali	Pakhanbhed
10.	Pahari	Butpawh
11.	Urdu	Zahkm -e- hayat

THERAPEUTIC MODALITIES OF *BERGENIA CILIATA*

Bergenia ciliata was proven to be effective in treating 104 different conditions. The major disease categories that are addressed are ENT, fever, cancer, gastrointestinal, skin, respiratory, muscular/skeletal, eye, oral, worm, and gynecological infections, as well as respiratory, eye, and respiratory diseases. The largest percentage (23%), followed by gastrointestinal disorders, skin conditions (17%), urinary/renal disorders (14%), muscular/skeletal disorders (10%), respiratory disorders (8%), fever (7%), eye conditions, oral infections, worm infections, gynecological disorders (3%), ENT, and cancer (1%), among these groups. Given that gastrointestinal diseases account for the largest percentage of cases, Bergenia ciliata rhizome's therapeutic capabilities are highly valuable.[10]

This herb holds great potential and has a great deal of medicinal usefulness. It has been reported that it is used to treat fever and diarrhea, as well as bruises and boils, in Swat and Kashmir. Postpartum women have been taking one teaspoon of the juice from the dried rhizome of *Bergenia ciliata*, mixed with the same amount of honey, two or three times a day; this mixture has been used as a tonic and carminative for digestive disorders. Adults have internally ingested rhizomes as an anti-helminthic. In Jammu and Kashmir State's northwest and trans-

Himalayan regions, a decoction of boiled roots and salt is used to treat asthma.[11]

The herb is also used as a demulcent and deobstruent; it also functions as an excellent diuretic and emmenagogue and soothes pain in the chest and ribs caused by excessive cold hormones. Get rid of any blockages, kidney stones, bladder stones, or toxic waste products that are still in the alimentary canal and excretory system of the urine.[12]

Rhizome-bearing Himalayan herbs are found at elevations of 1500-3000 meters (about 1.86 mi). Rhizome serves as an antiscorbutic and cures lung infections, boils, vomiting, diarrhea, and fever.[13]

PHYTOCHEMICAL CONSTITUENT

A variety of phytochemicals, including anthraquinones, steroids, flavonoids, saponins, tannins, and terpenoids, were discovered by chemical analysis of extracts from *B.ciliata.* Polar phytoconstituents were found in higher concentrations in the methanol fraction. Because of the inclusion of terpenoids, tannins, flavonoids, steroids, and water extracts, the fractions' levels of radical scavenging activity varied. Methanol and water extracts exhibited the highest levels of activity. Flavonoids were absent from the chloroform fraction, which showed modest activity. The fraction that contained solely steroids, hexane, showed the least amount of activity. This implies that the many bioactive chemicals found in *B.ciliata* preparations may have therapeutic value.[14]

43 volatile substances, including acids, alcohols, aldehydes, esters, hydrocarbons, ketones, N-containing compounds, and other chemicals, were found in the oil of Bergenia ciliata during analysis. The acid group, which was mostly composed of pelargonic (nonanoic), caproic (hexanoic), and capric (decanoic) acids, made up 34.06% of the total content. Ketones (33.01%) came in second, with 5,6-dihydro-2-pyranone serving as the primary ingredient. Notable additions were alcohol and hydrocarbons. β-caryophyllene, limonene, and linalool were among the main ingredients. To summarize, the main volatile molecule was 5,6-dihydro-2-pyranone, while other important chemicals were hexanal, β-caryophyllene, linalool, decanoic acid, and nonanoic acid.[15]

PHENOLS

Qualitative chemical tests showed that different extracts of *Bergenia ciliata* contained proteins and amino acids, carbohydrates, steroids, glycosides, and phenolic poisonous substances.[16]

BERGENIN

With a molecular weight of 328.27 g/mol, Bergenia was identified by spectroscopic fingerprinting (UV–vis and IR spectroscopy) and melting point determination. Cross-referencing the acquired data was done with the body of current literature. After being produced as a KBr disc, 1 mg of bergenin was dissolved in 1 mL of methanol and serially diluted to 25 µg/mL for analysis using UV–vis spectrophotometry (190–350 nm) and IR spectroscopy (400–4000 cm–1).[17]

FLAVONOIDS

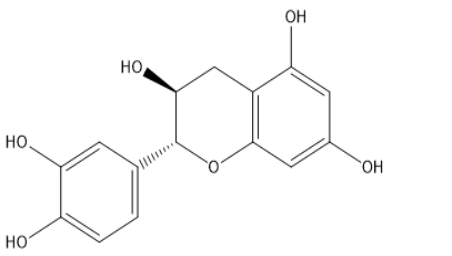
The aluminum chloride calorimetric method was slightly modified to assess the total flavonoid content. After dissolving the samples in methanol, 2 mL of the sample solution and 2 mL of 2% AlCl3 were combined. Using a spectrophotometer (UV-1800, Shimadzu, Kyoto, Japan), the absorbance was measured at 435 nm after 10 minutes of incubation at room temperature. Milligram quercetin equivalent (mg QE/g extract) was used to quantify the amount of flavonoids present.[18]

CATECHIN

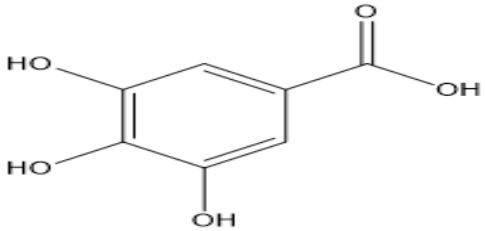
With a solvent system of toluene: ethyl acetate: formic acid (4:6:1), catechin demonstrated a clear resolution at RF 0.54, essentially isolating it from other constituents of the sample extract. By superimposing UV absorption spectra with reference standards using CAMAG TLC Scanner 3 with WINCATS software, its identity was confirmed. Comparing the absorption spectra obtained at the band's starting, middle, and end positions allowed for the confirmation of the catechin bands' purity in the sample extract.[19]

GALLIC ACID

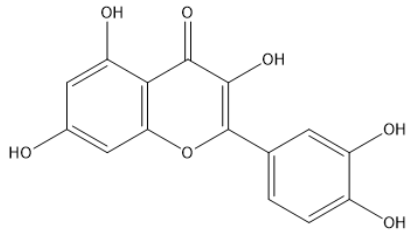
Gallic acid equivalents per gram of extract were measured in 2,2-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) tests, where the extract showed half-maximal inhibitory concentration values of 10 µg/ml and 1.0 µg/ml, respectively, indicating outstanding efficacy.[20]



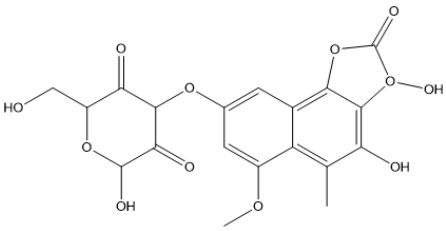
(2R,3S)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol



3,4,5-trihydroxybenzoic acid



2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxy-4H-chromen-4-one



4-[(3,4-dihydroxy-6-methoxy-5-methyl-oxo-2H-benzo[g][1,3]benzodioxol-8-yl)oxy]-2-hydroxy-6-(hydroxymethyl)oxane-3,5-dione

Table 1.1: List of Phytochemicals And Biological Activity.[21],[22],[23]

SL.No.	Phytochemical	IUPAC Name	Pharmacological Activity
1. .	Phenols	(+)-Afzelechin: (2R,3S)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol Leucocyanidin: (2R,3S)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol Gallic acid: 3,4,5-trihydroxybenzoic acid Tannic acid: 3,3',4',5,5',7-hexahydroxyflavone-3-gallate Methyl gallate: Methyl 3,4,5-trihydroxybenzoate (+)-Catechin: (2R,3S)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol	Traditionally used to treat diarrhea and wounds, it exhibits antioxidants, anti-inflammatory, anti-cancer, and antimicrobial activities.
2.	Bergenin	1,2,3,4,6-Pentahydroxy-5-(hydroxymethyl)cyclohexyl β-D-glucopyranoside α-Resorcylic acid: 2-Hydroxybenzoic acid	Anti-inflammatory, immunomodulatory, and antimicrobial
3.	Flavonoids	(+) Afzelechin: (2R,3S)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-2H-chromen-3-ol Avicularin: (2R,3R,4S,5R,6S)-2-{[(2S,3R,4R,5R,6S)-3,4-Dihydroxy-6-(hydroxymethyl) oxan-2-yl] oxy}-6-(hydroxymethyl) oxane-3,4,5-triol Catechin: (2R,3S)-2-(3,4-Dihydroxyphenyl) chroman-3,5,7-triol Eriodictyol-7-O-β-D-glucopyranoside: (2S)-5,7-Dihydroxy-2-(4-hydroxyphenyl)-2,3-dihydrochromen-4-one 7-O-β-D-glucopyranoside	Anti-inflammatory, immunomodulatory, and antimicrobial properties
4.	Catechin	(2R,3S)-2-(3,4-Dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol	Neuroprotective, antimicrobial, and anti-inflammatory
5.	Gallic acid	3,4,5-Trihydroxybenzoic acid	Hepatoprotective, anticancer, antimicrobial, and antioxidant properties

PHARMACOLOGICAL ACTIVITY

Anti-Diabetic Activity

Several solvent fractions showed moderate to strong inhibitory effects, with the ethyl acetate fraction showing the strongest activity against α-amylase, according to the observations. Important activity against α-glucosidase was also seen in the crude, aqueous, and ethyl acetate fractions. Using acarbose as a positive control, the IC50 values for α-amylase and α-glucosidase were 3.13 ± 0.14 µg/mL and 2.06 ± 0.07 mg/mL, respectively.[24]

Antioxidant activity

With an IC50 value of 11.21±1.8 µg/mL against DPPH radicals, the plant extract from the bark of *Bergenia ciliata* demonstrated strong antioxidant activity. For additional medicinal plants, Khalaf et al. (2008) demonstrated comparable antioxidant effects. In contrast, several plant extracts were discovered by Nikolova et al. (2011) to have lesser antioxidant potency. The rich antioxidant activity of a few Nepalese medicinal herbs was emphasized by Sharma et al. (2015). To prevent damage caused by oxidative stress, plant extracts are a viable source of antioxidant molecules.[25]

The phenolic composition of BGE, which indicates increased polarity, is responsible for its solubility in aqueous extract. The identity of the chemical was verified using nuclear magnetic resonance characterization. When its antioxidant activity was evaluated against DPPH using ascorbic acid as the reference, mild-to-moderate scavenging potential was found. Free radical stabilization is probably aided by the hydroxyl groups in BGE through conjugation and charge delocalization. Docking studies indicate that by interacting with host targets, BGE may have the potential for urinary support.[26]

Anti-cancer activity

Afzelechin, β-sitosterol, paashaanolactone, and stigmasterol were found to have a significant affinity

towards ER-α, PR, HER2, and EGFR when fifteen compounds from *Bergenia ciliata* were molecularly docked to breast cancer targets. When compared to natural ligands, stigmasterol showed higher binding affinities for PR and EGFR. The interaction between β-sitosterol, stigmasterol and ER-α was similar to the binding pattern of tamoxifen. With PR and ER-α, paashaanolactone established hydrogen bonds. All four compounds exhibited affinity towards EGFR, however, only β-sitosterol and stigmasterol efficiently interacted with HER2. Their potential as multitargeted therapeutic candidates for breast cancer is shown by these findings, which call for more research to be done on drug development.[27]

Anti-bacterial activity

Many bacterial strains were tested in-depth to determine the antibacterial properties of *Bergenia ciliata* extracts. Significant inhibition of pathogens like *Bacillus subtilis*, *Staphylococcus aureus*, and *Escherichia coli* was demonstrated by extracts from various plant components. In several tests, methanolic and ethanolic extracts shown especially encouraging antibacterial activity against various bacterial strains, with inhibition zones ranging from 11.8 to 29.4 mm. These results highlight the potential of *B.ciliata* extracts as potent medicines against a wide range of bacterial illnesses, hence indicating the need for additional research toward future pharmaceutical uses.[28]

B.ciliata extracts were biologically screened, and the results showed strong antibacterial activity, mainly in the ethanol leaf extract, which was linked to the high solubility of secondary metabolites. Antimicrobial action is enhanced by secondary metabolites such as gallic acid and afzelechin. The extracts were more effective against Paenibacillus polymyxa and other Gram-positive bacteria. The fact that the ethanol leaf extract has the highest activity suggests that *B. ciliata* has the potential to be a source of antibacterial compounds.[29]

Anti-microbial

In the high-altitude areas of Shimla district, *Bergenia ciliata*, an ethnomedicinal plant used by indigenous populations to treat kidney stones, grows well. Through antimicrobial evaluation and phytochemical study, the scientific examination has confirmed its medical usefulness, as explained in the following sections. Significant antibiotic efficacy against a range of pathogens was established by methanolic extracts of the rhizomes and leaves of *B.ciliata*, with a pronounced peak of activity reported at 100 mg/ml. The antibacterial activity of these substances was probably enhanced by the presence of alkaloids, terpenoids, and flavonoids. Steroids and saponins damage membranes, terpenoids weaken microbial cell walls, and flavonoids form complexes with proteins and cell walls. Methanolic extracts outperformed acetone and water extracts in terms of dose-dependent activity.[30]

CONCLUSION

Bergenia ciliata holds significant promise as a medicinal herb due to its diverse phytochemical composition and broad-spectrum therapeutic activities. Its traditional use in treating various ailments is supported by modern scientific research demonstrating its efficacy in antioxidant, anti-diabetic, anti-cancer, and antimicrobial applications. The rich presence of bioactive compounds like flavonoids, terpenoids, and glycosides underscores the plant's potential as a source of natural therapeutic agents. Future research should focus on detailed pharmacological studies and clinical trials to confirm these findings and facilitate the development of novel treatments derived from *B.ciliata*.

SUMMARY

Bergenia ciliata is a perennial herb known for its medicinal properties, traditionally used in various cultures, particularly in India. The plant's roots and rhizomes are rich in phytochemicals such as flavonoids, terpenoids, glycosides, and sterols, which contribute to its therapeutic potential. *B.ciliata* is effective against a range of health conditions, including gastrointestinal, respiratory, and urinary disorders. The plant exhibits strong antioxidant, anti-diabetic, anti-cancer, and antimicrobial activities, making it a valuable resource in herbal medicine. The comprehensive review underscores the need for further research to explore the full range of its therapeutic applications and the mechanisms by which its phytochemicals exert their effects.

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