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Polypharmacological Constituents and Potential Activities of *Bergenia ciliata*: A Concise Review

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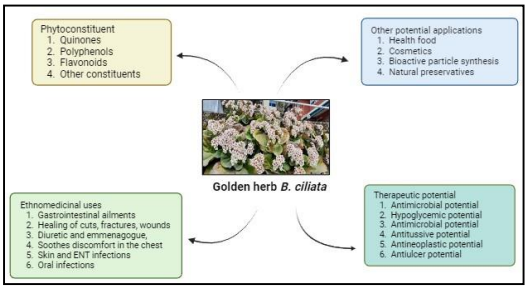
Abstract: *Bergenia ciliata* is an evergreen perennial herb belonging to the family Saxifragaceae and has been employed in traditional medicine since long. When compared to pharmaceutical medication, traditional herbal medicine is seen as the lifeline and the first option. Due to *Bergenia ciliata*'s wide range of biological activity, several traditional uses have been documented. Investigations into the discovery of its phytocompounds, chemistry, pharmacology, and medicinal use of *Bergenia* plants have been conducted in recent years. It is reported to be beneficial in breaking up bladder and kidney stones, it also aids in the removal of blockages and hazardous waste products from alimentary canal and urinary system. Additionally, it relieves pain in the ribs and chest brought on by too much cold humour and is a great emmenagogue and diuretic. It also exhibits hepato & nephro-protective, antidiabetic, antioxidant, and bio prospective qualities. *Bergenia ciliata* when subjected to a polypharmacological composition screening, identified the presence of tannins, steroids, flavonoids, terpenoids, alkaloids, and saponins. *Bergenia ciliata* has a potential use in pharmacology and medicine because of the presence of plethora of polyphenols. The purpose of this article is to compile and evaluate the existing data about the phytochemistry and potential activities of *Bergenia ciliata*.



Keywords: *Bergenia ciliata, ethnomedicine, phytocompounds, pharmacological potential.*

Contents

1. Introduction

Natural products are a crucial source of many important pharmacological compounds. In many developing countries 80% of population still exclusively depend on traditional or herbal medicine for treating diseases. Many contemporary medications are developed from ancient herbal medicine and are being utilized in modern pharmacotherapy as alternative or complementary medicine.[1] Traditional medicine system in many parts around the world have been using medicinal plants for thousands of years.[2,3] The empirical information regarding the beneficial impacts of medicinal plants and herbal products have been handed down along different ethnic communities throughout ages.[2]

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A vital step in the investigation of the bioactive compounds derived from plant sources is the extraction process. Modern extraction techniques, like ultrasound-assisted and supercritical fluid extraction methods, are currently being used in addition to more conventional approaches.[4] The ethnobotanical and ethnopharmacological research have drawn interest from scientists worldwide. Numerous medicinal plants' phytochemical makeup and possible health advantages have not yet been investigated or needs to be more deeply investigated, and thus has a hopeful future for further drug development and research.

The introduction of sophisticated instruments for the qualitative and quantitative evaluation of phytochemical, such as HPLC (high-performance liquid chromatography) and (LC/MS) (liquid chromatography/mass spectrometry) has greatly enhanced phytochemical research. Phytochemical though of various kinds can be broadly categorized as polyphenols, alkaloids, glycosides, flavonoids, tannins, resins, gums and terpenes.

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The synergistic effects of plant secondary metabolites together result in the useful therapeutic properties. The curative properties of medicinal plants present a mostly untapped pool of possible drug sources.[5] Bioactivity of phytochemical synergistically in a single plant extract is an unmatched challenge for individual synthetic medications to match. We propose that plant templates could be used to create "hybrid phytochemicals" that replicate this synergistic effect.

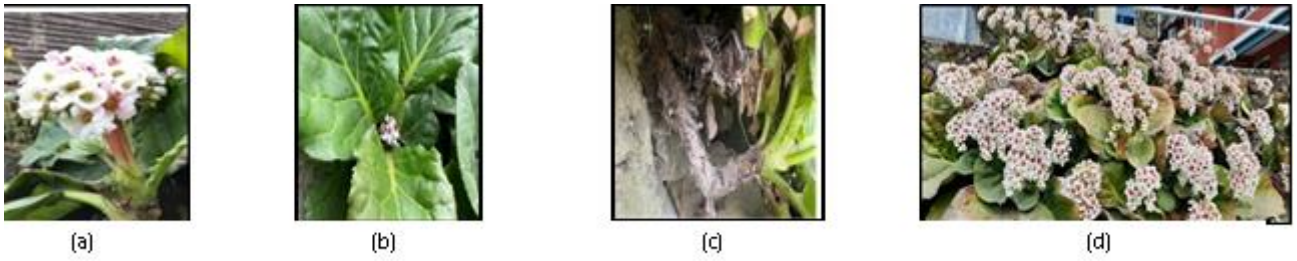


Figure 1. *Bergenia ciliata (a) Flowers (b) Leaves (c) Rhizome and (d) Whole plant*

Herbal remedies represent the medical industry's future. Worldwide, traditional medicine and phytomedicines are becoming more and more well-known. In 2012, it was estimated that the yearly value of the global export of plants with potentially therapeutic qualities and traits was around USD 2.2 billion.[6] Three main types of benefits are frequently associated with medicinal plants: economic gains for those who harvest, process, sell, or distribute them; health benefits for those who use them as medications; and societal benefits like increased tax revenue, employment possibilities, and a more robust labor force.[7] Herbal nutritional supplements, herbal cosmetics, and herbal health care formulations are being produced with renewed interest in the pharmaceutical sector due to the growing demand for items derived from medicinal plants. Herbal remedies represent the medical industry's future. Worldwide, traditional medicine and phytomedicines are becoming more and more well-known.

Bergenia ciliata (haw.) Sternb is a member of the family Saxifragaceae, which comprises of 30 genera and 580 species.[8,9,10] Within the family Saxifragaceae, the three genera *Saxifrage*, *Heuchera*, and *Bergenia* hold the greatest economic significance. *Bergenia* refers to a genus of around 10 distinct species of flowering plants.[11] Three species of *Bergenia* have been documented from India, by Hooker in the Flora of British India (1888). Similar reports have also been documented by Wehmer in The Wealth of India (1948). *Bergenia ciliata*, *Bergenia ligulata* and *Bergenia stracheyi* are the impotant species of *Bergenia* found in India.

Bergenia is a hardy perennial plant indigenous to the cold and temperate Himalayan region at an altitude of around 4000 to 12000 feet stretching from Central to East Asia.[12,13] It remains distributed in Afghanistan, Pakistan, South Tibet, China, Mongolia, India, Nepal, Bhutan.[14,15,16,17] In India it remains distributed in the Himalayan regions of Eastern states such as West Bengal, Sikkim, Uttarakhand, Meghalaya, Jammu and Kashmir. [15,17,18] In Bhutan it occurs in districts of Ha, Phuntsoling, Mongar, Deothang. In Nepal it is found to be distributed in districts of Dolakha, Karepalanchwok, Makanwanpur.[14,19,20] In Pakistan it occurs in northern regions mainly, Chitral, Poonch valley, Swat, Abbottabad, Galliyat.[13,21,22]

Bergenia thrives well even under unfavorable weather conditions and nutrient deficient soil. It exhibits lithotrophic characteristic, as it grows between the rocks and gives the impression that it is breaking them. As a result, the plant is sometimes referred to as rock foil in English and Paashanbheda (bheda = perforating, paashan = rock stone) in Hindi. These evergreen perennials which are around 50 cm in height gracefully occupies the shaded or dappled areas of the garden that other plants like to avoid. They make useful cover plants. While plants can withstand direct sunlight, they thrive well in location with moisture-retaining soil that is shaded in the afternoon. They have broadly obovate, thick leaves, which are rounded at the base and apex. Soft hairs skirt the delicately denticulated and densely ciliated leaf edges. Leaves are opposing, alternating, and ex-stipulative. Flowers are beautiful pinkish white, purple with obovate petals, lobed acute and denticulated near the apex. The basal whorl does not instantly support the bunch of blossoms in the plant, rather it lies well above. Flowers bloom in springtime from the months of February to April. Fruiting period is March to July.[15,17,23] Rhizomes exhibits a woody texture and are coated in leaf bases. The plant can grow all year round. The whole plant and its parts are shown in **Figure 1**. Numerous traditional applications of *Bergenia* have been reported due to its diverse biological activity. It is widely utilized in traditional medicine systems throughout many different locations, particularly in Asian nations like India, Pakistan, Nepal, China, Bhutan. Of the three species of *Bergenia* listed, *Bergenia ciliata* is the one that is most frequently used in traditional medicine and has been shown to have antibacterial, antioxidant, antitussive, antiulcer, hypoglycemic, toxicological, anticancer, and ant-adiabatic properties.[24]

Many rural populations in the Himalayan area employ *B. ciliata* for treating a variety of illnesses. Over the past few years, efforts have been undertaken to investigate the compound identification, chemistry, pharmacology, and therapeutic use of *Bergenia* plants.[12,25] *It has been demonstrated that B. ciliata* rhizome extracts possess antimicrobial and antitussive qualities.[26, 27] Bergenin, an important constituent of *Bergenia* is used to manufacture expectorant and antitussive medications in China. Furthermore, fresh leaf paste is applied to the skin in Tibet to shield from UV radiation. Traditionally in the Himalayan regions, the leaf or leaf juice is used to ease earaches and constipation. *Bergenia* species are used in ayurvedic treatments to dissolve kidney and bladder stones in India.[3] However, because people use drugs differently in different countries and areas, the pharmacological consequences vary significantly as well. As a result, contemporary pharmacological research based on the plant's traditional applications is required.

Table 1. 3 Pharmacological constituents *Bergenia ciliata*

Groups	Bioactive compounds	References
Quinones	Hydroquinone, Aloe emodin, Chrysophanein, Aloe emodin 8-O-glucoside, Emodin 1-O-β-D-glucopyranoside, Hydroquinone monomethylethe	31,74
Polyphenols	Bergenin, Tannic acid, Gallic acid, Catechin, 3-O-galloylcatechin,3-O-galloylepicatechin, Arbutin, β-sitosterol, Stigmasterol, Methyl gallate, Paashaanolactone	18, 15, 37
Flavonoids	Kaempferol, (+) Afzelechin, quercetin 3-o-*β*-D xylopyranoside, quercetin 3-o-α-L-arbinofuranoxide, 4',5 –dihydroxy 6,7–dimethoxyflavone, Luteolin -7-O-glucoside A, Acacetin-7-O- α - L – rhamnopyranoside	15, 17
Others	Saponin, Terpenes, Glycoside, Amino acids, Volatile oils, Sterols.	18, 19, 20

It is reported to be beneficial in clearing kidney-stones and bladder stones. Additionally, it aids in the removal of waste materials and obstacles that are still present in the urinary system and alimentary canal. Certain species are used to treat

gastrointestinal ailments in various South East Asian folk medicine.[15] Additionally, plants are used as a demulcent and deobstruent, it also works as an excellent diuretic and emmenagogue and soothes discomfort in the chest and ribs caused by excessive cold humours. There are also reports on the anti-oxidant and the DNA protection abilities of the extracts.[28] The antioxidant, antidiabetic, hepato & nephro-protective, and bio prospective properties of *Bergenia ciliata* were investigated. Histological investigations showed that daily treatment of the extract in a dose-dependent manner also resulted in the regeneration of islets of Langerhans α-cells were investigated. Histological investigations showed that daily treatment of the extract in a dose-dependent manner also resulted in the regeneration of islets of Langerhans α-cells.[29]

2. Review Methodology

Searching pertinent literature on *B. ciliata* was the first step in our information gathering process. To provide succinct and creative information about the geographical distribution, phytochemistry, indigenous medicinal uses, and pharmacological characteristics of the *Bergenia* species, a systematic review of the current literature (abstracts, blogs, full-text articles, PhD theses, and books) was conducted. Google Scholar, Web of Science, Science Direct, Scopus, PubMed as well as CAB abstracts, INMEDPLAN, NATTS, EMBASE, SciFinder, and MEDLINE, were among the several online databases and search engines that were employed for this purpose. Only publications that were published in the English language were considered for this review and thus a total of 75 references were selected for detailed analysis.

3. Polypharmacological Constituents

The natural world contains a vast reservoir of incredibly creative and diverse phytoconstituents. There has been a noticeable growth in demand for herbal medications over the past 20 years, making it necessary to guarantee the efficacy, safety, and quality of these products. Phytochemical evaluation, which comprises chemo profiling, phytochemical screening, and marker compound analysis, is a tool for quality evaluation.[30,31] Polypharmacological composition characterization of *B. ciliata*, revealed the presence of steroids, tannins, flavonoids, terpenoids, alkaloids and saponins.[12,31,32] Eleven major groups of phytochemicals found in *B. ciliata* were reported.[8] The roots, stems, and leaves of *B. ciliata* are rich in various bioactive components which can be broadly divided into three major groups viz., quinones, flavonoids, and polyphenols as shown in Table 1

3.1 Polyphenols

While the entire *Bergenia* plant can be utilized medicinally, the majority of its active components have been found to be polyphenols, among which bergenin is one that has been researched and most widely used.[33] Bergenin and gallic acid were simultaneously determined in many *Bergenia* species. The highest amounts of bergenin were detected in *B. ciliata* and *B. stracheyi*, at 3.28 and 3.28%, respectively while *B. ligulata* had 2.42 %.[34] Terpenoids, tannins, flavonoids, saponins, minerals, wax, mucilage and ketone, two -containing compounds, are some prominent constituents found in *B. ciliata*.[35,36] The most significant components of *B. ciliata* are phenols. *B. ciliata* contains a variety of phenolic compounds, including bergenin, paashaanolactone, tannic acid, gallic acid, catechin. The primary component of the *Bergenia* species is the important phenolic chemical "bergenin," which makes up over 0.9% of the total. Other phenolic compounds are present in smaller amounts.[37] Afzelechin, leucocyanidin, gallic acid, tannic acid, paashaanolactone, 7-O-ß-Dglucopyranoside and methyl gallate are among the phenolic chemicals that have been included.

Bergenin is the most prevalent and significant phytochemical found in the family Saxifragaceae. Bergenin containing plants are beneficial for arrhythmias.

In several animal models, bergenin at different doses proved beneficial for treating arrhythmias.[38] Bergenin shown germicidal effects against *Pseudomonas aeruginosa* and *E. coli*. Due to its ability to inhibit yeast alcohol dehydrogenase, an enzyme essential for fermentation activities, bergenin is also efficient against fungi.[39] Bergenin has a significant function in the breakdown of fats, which is why it is a common ingredient in dietary supplements that promote thermogenic fat burning. Although it doesn't directly contribute to lipolysis, it does boost norepinephrine activity.

Gallic acid is another important phenolic compound present in *B. ciliata*. Gallic acid is commonly used as a standard in the Folin-Ciocalteau test to measure the phenol concentration. Gallic acid present in the plant confers it with properties such as antiviral, antifungal, and antioxidant. In ointments, it is used to treat psoriasis. For the purpose of simultaneously determining the bioactive compounds bergenin and gallic acid in three species of *Bergenia-B. ligulata, B. ciliata, and B. stratcheyia*-a straightforward and extremely accurate approach has been developed through the use of highly precise photodiode-array paired with RP-HPLC technique. From this method the highest amount of bergenin were detected in *B. ciliata* and *B. stracheyi*, with 3.28 and 3.28%, respectively, while *B. ligulata* had 2.42%.[30,33,40] Tannic acid is essentially a polyphenol called tannin that is found in *B. ciliata*. There are several other names for tannic acid, including digallic acid, gallotannin, tannimum, quercotannic acid, Because of the many phenol groups that are present in its structure, tannic acid exhibits modest acidity. Tannic acid has the ability to protect iron objects from corrosion. It is also used as a natural clarifying agent, colour stabiliser and flavour enhancer. Tannic acid can be effectively used to treat burns and injuries. Pharmaceutical companies employ tannic acid as an antihistamine, anti-diarrhoea and anti-tussive.[27,41,42,43]

Catechin or Flavan-3-ol is a kind of phenol that is linked to epicatechin or (+)-catechin and is found in plants as a secondary metabolite. As a histidine decarboxylase inhibitor, catechin helps to reduce potentially harmful histamine-related local immunological responses by blocking the conversion of histidine to histamine. Both epicatechin and (+)-catechin are inhibitors of monoamine oxidase. With these, Alzheimer's and Parkinson's disease can be managed.[10,17,44,45,]

β-sitosterol is a white, waxy, hydrophobic powder with a distinct scent.[46] As β-sitosterol has a significant role in lowering blood cholesterol levels, preventing intestinal absorption of cholesterol it is used to treat hypercholesterolemia. Benign prostatic hyperplasia is also treated with β-sitosterol.

Arbutin is found to be present in the rhizome of *B. ciliata* and is also known as hydroquinone β-D-glucopyranoside.[47] Arbutin inhibits the production of melanin, which is why it is employed as a skin-lightening agent. It is also traditionally utilized for treating urinary tract infection.[48,49]

3.2. Flavonoids

Numerous biological activities, including antibacterial, antioxidant, anti-inflammatory, and anticancer properties have been widely linked to flavonoids. (+) Afzelechin a flavonoid present in the rhizome of *B. ciliata* exhibits inhibitory action against α-glucosidase.[18,50]

Quercetin exhibits antioxidant, anti-radical and iron chelating properties. Additionally, quercetin lowers oxidative stress and lipid peroxidation, which helps control diabetes and its consequences[12,51,52]

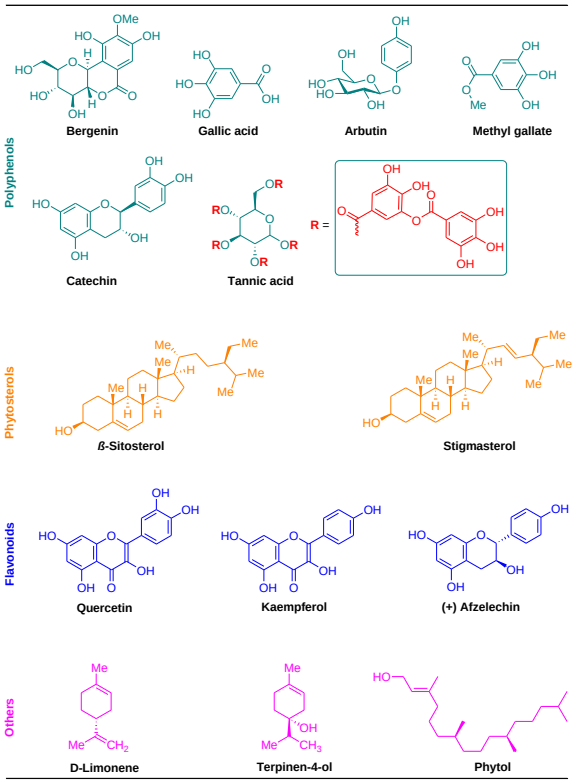
Kaempferol is shown to have antimicrobial, neuroprotective, anti-inflammatory, antioxidant, anti-anxiety, and cognitive-enhancing properties.

3.3. Other phytochemicals

Terpene present in *B. ciliata* is limonene which has antibacterial properties and is also used in chemotherapy. Lianalool is a food additive that exhibits bioactivities. β-caryophyllene and α-Terpineol are also present in *B. ciliata*.[35] Due to spicy and woodsy aroma, β-caryophyllene is utilized as a fragrance ingredient while α-Terpineol exhibits antispasmodic, anti-inflammatory, antitumor properties and is a myrorelaxent.[53,54,55]

The fatty acids found in *B. ciliata* are decanoic acid, nonanoic acid.[20] While nonanoic acid has herbicidal properties, decanoic acid demonstrates antibacterial and antifungal properties.

Table 2. *Structures of important phytochemicals found in Bergenia ciliata.*



4. Ethnomedicinal Uses

The last ten years have seen a phenomenal resurgence in interest and use of therapeutic plant products. Herbal remedies are more efficient than allopathic remedies in treating a variety of illnesses and have no adverse effects. Compared to the contemporary synthetic medications, their method of therapy is more affordable and accessible.[56]

B. ciliata has historically been used for a variety of medical purposes in traditional medicine systems across the globe, especially in Asian countries like Pakistan, Nepal, and India.

Given its wide range of applications in the treatment of ailments such gastrointestinal issues, lung infections, cardiac conditions, ophthalmic conditions, haemorrhoids, kidney, and gall bladder stones, B ciliata is regarded as a "miracle herb."

Studies have indicated that the species is utilized to cure gastrointestinal ailments in some South East Asian traditional medicine.[15,57] Chronic dysenteries may be effectively treated with boiling the juice of crushed *B. ciliata* rhizome in water. The rhizome of *Bergenia* has long been used in the Himalayan region to heal cuts, fractures, wounds, treat respiratory infections, treat gastrointestinal disorders, diarrhoea.[20,58] In the state of Sikkim and the regions under the Darjeeling district of West Bengal, traditional healers and residents have been employing the rhizome of *B. ciliata* in the form of juice as an antitussive medication.[59] Additionally, it was used to cure ophthalmia, haemorrhoids, stomach problems, and heart disease. Adults in Nepal have been using the rhizomes of *B. ciliata* as an antihelmintic. In Nepal, postpartum women take one tea spoonful of the juice from the dried rhizome of *B. ciliata* with honey orally two to three times a day as a carminative and tonic for digestive issues. Asthma has reportedly been treated using boiled B ciliata roots combined with salt. In Manipur, *B. ciliata* leaves and roots were also utilized to cure blood cancer.[60] The extracts offer great potential for the production of medications that may target tumours and further inhibit the growth and aggressiveness of neoplastic growth.[3] The plant also functions as an excellent diuretic and emmenagogue, soothes discomfort in the chest and ribs caused by severe cold humours, and is demulcent and deobstruent. *Bergenia* is combined with other plants in the Indian Ayurvedic polyherbal preparation "Cystone," which is used to treat urolithiasis. To promote the growth of milk teeth, the root and honey combination is administered. The leaves are crushed in a mortar and the juice is used to treat ear infections in the Indo-Chinese region.

Reportedly, *B ciliata* plant is maximally used for treating gastrointestinal infections (23%), followed by skin illnesses (17%), respiratory diseases (8%), muscular/skeletal disorders (10%), eye diseases, oral infections, worm infections, gynecological infections (3%), ENT, and cancer.[8,53] *B. ciliata* reportedly had the highest UV (0.87) and RFC (0.36) values which is an indication of a plant being widely distributed and well known by the indigenous community for their therapeutic potentials. There are reports of the use of *B. ciliata* rhizome for treating toothache and tooth decay.[55] Decoction, juice, paste, powder, tea, and extract were among the methods of use or preparations. It was seen that powder was the most widely used form, this might be because roots and rhizome are hard.[61]

5. Pharmacological and Therapeutic Potential

5.1. Antimicrobial Potential

The primary global cause of the rising incidence of infectious illnesses is bacteria which is a serious public health issue.[43] The increasing demands for natural antioxidants and antimicrobial medications has necessitated the need to look for new natural sources. Different extracts of *B. ciliata* plant were utilized to combat human pathogens. Aqueous, ethanol, butanol, ethyl acetate, chloroform and hexane extracts of *B. ciliata* roots and leaves when subjected to antibacterial activity exhibited promising outcomes against both gram positive and gram-negative bacteria.[26,62,63,]

Comparably, it was shown that extracts of *B. ciliata* roots and leaves has antifungal properties and worked well against *Candida albicans, Pleuroetus oustreatus*, and *Microsporum canis*.[13] By preventing yeast alcohol dehydrogenase, an enzyme essential for fermentation processes, bergenin has germicidal activity against a variety of fungi and has been shown to be efficient against *E. coli* and *Pseudomonas aeruginosa*. [64,65]

Methanolic extract from *B. ciliata* suppressed HSV-1, influenza virus, herpes simplex virus. *B. ciliata* methanolic and methanolic aqueous extract showed potent anti-influenza viral activity. The findings suggest that *B. ciliata* could be a powerful source of antiviral drugs.[27,32]

The antibacterial activity of *B. ciliata* root extract is reported to be much higher than that of the leaf extract.[10,15] This might be because *B. ciliata*'s roots and rhizome have higher concentrations of active chemicals than its leaves.

5.2. Hypoglycemic Potential

The mode of action of *B. ciliata* as an anti-diabetic plant was first published in literature by some researchers.[66] They proposed that the plant's ability to reduce glucose levels is due to its suppression of the digestive enzymes α-glucosidase and α-amylase. The ability of *B. ciliata* extracts to reduce blood sugar levels in rats treated with streptozotocin (STZ) was used to assess their hypoglycemic activity. The ethanolic extract of *B. ciliata* leaves was shown to bring about a 70.13% reduction in blood glucose levels, aqueous extract decreased blood glucose levels by 71.34%, ethyl acetate extracts by 45.67 %. However, there has been no discernible drop in glucose levels or hypoglycemic action in the extract treated with hexane and butanol. Similarly, the ethanolic extract of *B. ciliata* rhizomes was shown to bring about a 71.34 % reduction in blood glucose levels, hexane extract decreased blood glucose levels by 70.13 %, ethyl acetate extract by 57.88 %.[13] These investigations show that the *Bergenia ciliata* has promising antidiabetic property. Two active compounds, (-)-3-O-

galloylepicatechin and (-)-3-O-galloylcatechin, which were isolated showed potential anti-diabetic activity.[4,34,66]

Table 3. *Some important phytoconstituents of the golden herb B. ciliata and its uses*

Sl.No	Compound name	Chemical Formula	Activity	References
1	Bergenin	$C_{14}H_{16}O_9$	Antioxidant, antimicrobial, norepinephrine, lipolysis anarchic effect	38, 39
2	Gallic acid	$C_7H_6O_5$	Antioxidant, Antifungal, Antiviral, Cytotoxicity	33
3	Tannic acid	$C_{76}H_{52}O_{46}$	Anti-corrosive, clarifying agent, colour stabiliser, flavour enhancer, pharmaceutical applications	32
4	Catechin	$C_{15}H_{14}O_6$	histidine decarboxylase inhibitor, monoamine oxidase inhibitor.	10
5	β-sitosterol	$C_{29}H_{50}O$	Treating hyper cholesterolemia, Benign prostatic hyperplasia, lowering cholesterol	46
6	Arbutin	$C_{12}H_{16}O_7$	Melanin inhibitor	48
7	(+) Afzelechin	$C_{15}H_{14}O_5$	α-glucosidase inhibitor	18, 50
8	Quercetin	$C_{15}H_{10}O_7$	Antioxidant, anti-radical, iron chelating	12
9	Kaempferol	$C_{15}H_{10}O_6$	Antimicrobial, neuroprotective, anti-inflammatory, antioxidant, anti-anxiety	10
10	β-caryophyllene	$C_{15}H_{24}$	Fragrance ingredient	53, 54
11	α-Terpineol	$C_{10}H_{18}O$	Antispasmodic, anti-inflammatory, antitumor, myrorelaxent	20
12	Fatty acids (decanoic acid, nonanoic acid)		Anticonvulsant, fragrance ingredient	20, 35

5.3. Antioxidant Potential

It was shown that *B. ciliata* rhizome extracts, both methanolic and aqueous, have antioxidant properties, such as the ability to reduce, scavenge free radicals, and prevent lipid peroxidation. All of the antioxidant tests showed that the methanolic extract had more potential. The aqueous extract did, however, show much more DNA protection, even though it was not as effective as its methanolic counterpart in terms of antioxidant activity. [13,26,66]

5.4. Antitussive Potential

The antitussive potential of *B. ciliata* methanolic rhizome extract has been assessed through a cough model in mice induced by sulphur dioxide gas. With codeine phosphate being used as a standard it has been observed that the extract exhibited a substantial dose-dependent anti-tussive effect. Within 90 minutes of the trial, the extract at dosages of 100, 200, and 300 mg/kg body weight significantly inhibited the cough reflex by 28.7, 33.9, and 44.2%, respectively.[10,15,18]

5.5. Antineoplastic Potential

B. ciliata methanolic and aqueous extracts has been shown to possess strong anti-neoplastic potential and concentration dependent cytotoxicity, with IC50 value for both extracts falling well within the prescribed threshold (except the aqueous extract with higher IC50).[18] Thus, the extracts efficacy demonstrates that it has great promising potential for the synthesis of medications that target tumours for chemoprevention and chemotherapy, the goal being to limit the development, growth and malignancy of lesions.[3]

5.6. Antiulcer Potential

In several parts of South East Asia, traditional medicine utilizes *Bergenia ciliata* to cure gastrointestinal problems. Rats with stomach ulcers caused by pylorus ligation, indomethacin, and ethanol/HCl were used in the antiulcer activity experiment of *B. ciliata* to assess its gastroprotective effects. One hour following ulcerogenic therapy, doses of the rhizome's aqueous and methanol extracts, ranging from 15, 30, and 60 mg/kg, were given. It was observed that although the impact was diminished at higher dosages, the aqueous extract significantly reduced the ulcer lesion in all rat compared to the methanol extract. Furthermore, rather than inhibiting the release of stomach acid or reducing pH and acidity, the antiulcer action seems to be mediated by cytoprotective benefits provided by improvement of the mucosal barrier. [18,67,68]

6. Other Potential Applications of *Bergenia Ciliata*

6.1 Health Food

Bergenia being a rich reserve of a plethora of nutrients, amino acids, phenolic compounds and minerals can be used in a variety of gourmet preparations, cuisines, various kinds of herbal tea, syrups, beverages. Arbutin present in *Bergenia* is also known to prevent the breakdown of insulin.[69] The food industry uses a variety of essential oils derived from plants as effective flavourings and antibacterial agents. Today's balance leans towards using natural dietary components instead of the already accessible synthetic antioxidants.[70] Due to the aforementioned points, it is possible that the *Bergenia* species be utilized as a natural preservative, flavouring ingredient in international trade and food manufacturing.

6.2. Cosmetics

A naturally occurring derivative of hydroquinone is arbutin, which is a *β*-D-glucopyranoside. It is a powerful inhibitor of melanin synthesis and is not linked to the cytotoxicity or mutagenicity of melanocytes. *Bergenia* being rich in arbutin is thus utilized in the field of cosmetics.[62] Arbutin inhibits tyrosinase activity and lowers melanin (pigment) in the skin, that might lead to skin whitening.[28,42] Evidently, *Bergenia* might also be used in the pharmaceutical or cosmetic industries as a possible skin-whitening or brightening agent, anti-wrinkle agent and under eye cream.[37]

6.3. Synthesis of Bioactive Nanoparticles

Furthermore, as *B. ciliata* is rich in a large number of phenolic compounds it has a great potential to be utilized for creating metallic nanoparticles. Nanoparticles have become significant in recent years, as the matter at this scale presents a more compact arrangement of atoms and molecules, acquiring or enhancing properties that are entirely distinct from those of their macroscopic counterparts in the areas of mechanical, electrical, magnetic, optical, catalytic and antibacterial.[71]

6.4. Natural Preservative

Consumers today expect the food preservative used to be ecologically friendly and biobased. The bacteriostatic and antioxidant qualities of Bergenia extracts have been shown to extend the shelf life of the produced items while at the same time maintaining its physico-chemical and organoleptic properties. The assessment of the economically significant attributes of biologically active substances from this plant

source could be a promising preservative with excellent consumer qualities.[72,73,74,7]

7. Discussion and Way Forward

There is a continued prevalence of plant-based medicine and the critical role that local traditional knowledge plays in meeting basic healthcare needs. When compared to pharmaceutical medication, traditional herbal medicine is seen as the lifeline, the first option, and cultural recognition. Social life in rural communities has always included medicinal plants and their traditional formulations, which have shown to be quite beneficial in treating a variety of health-related conditions. The integration of traditional knowledge into high-level decision-making processes and the expanded use and modification of ethnomedicinal plant applications are crucial. Pharmaceutical medicines treat a wide range of illnesses, but their uses are limited by their greater costs and adverse effects.

Clinical trials should be carried out in the future to evaluate *B. ciliata*'s effectiveness against a variety of illnesses as well as the appropriate use and advancement in medication. Future clinical applications of *B. ciliata* in contemporary medicine will be strongly supported by the findings of these studies. There is an urgent need for experimental research and proof in the future even in the face of scientific data about pharmacological and medical purposes.

Due to disorganized methods of passing on information to the next generation, the fast changes in urbanization and its impact on cultural contexts in recent decades have resulted in the loss of traditional knowledge in a number of regions, including the Himalayas. If appropriate documentation is not maintained, this situation may result in the extinction of a significant amount of ethnomedical knowledge about the area. Compiling this data and creating a database of therapeutic plants are therefore crucial for future studies and the possible development of novel herbal remedies. Medicinal plants are vulnerable to both specific threats such as over-collection and general threats including habitat destruction and climate change. Thus, government authorities and agencies should develop more effective conservation and management plans for the medicinal plants.

8. Conclusion

The main goal of this review was to compile the most polarized work about the ethnobotany, ethnopharmacology, and phytochemistry of *Bergenia ciliata*. This review aims to shed light on the various diseases that the golden herb *Bergenia ciliata* may effectively treat, as well as the chemicals that hold its significant medicinal properties. This would strengthen the link between modern knowledge and the folktales that have been passed down through the years, serving as inspiration for future research that may uncover new, unique substances and drugs derived from the three species. It comes to light that many people throughout the Himalayan area of the world have been long employing this miraculous plant for treating various disorders and diseases. Nearly every component of the plant is utilized to treat various illnesses, with the rhizome being the most utilized. The species possesses antifungal, antiviral, antibacterial, antioxidant, antitussive, anti-inflammatory, anti-neoplastic, and anti-ulcer properties as proven by various biological and pharmacological research. The primary phytochemicals identified in this species are phenols, flavonoids, fatty acids, and terpenoids, among others. In addition, the plant has fewer adverse effects on living organisms than contemporary medications.

Further clinical research on this plant is required for the future discovery of drugs because some pharmaceutical activities have also been observed *in vitro* and *in vivo*, and deficiencies in clinical trials of some activities have also been noted. The current medicinal potential of *B. ciliata* may be expanded with more phytochemical research. We further recommend that thorough ethno-pharmaceutical and toxicological research be done in light of the current assessment. These investigations will yield important information about many illnesses and aid in the development of novel medications. In addition, this paper would fill in logical gaps in current understanding and facilitate international research collaboration on projects including the identification of new chemicals and pharmaceuticals derived from *Bergenia ciliata.*

Author Contribution Declaration

Nirza: engaged in data curation, writing, conceptualization, and production of the initial draft. **Anindita**: involved in supervision, editing and reviewing.

Data Availability Declaration

There are no new data was created.

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