International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 3609-3613

Received: 23-03-2018
Accepted: 30-04-2018

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Bergenia ciliata: The medicinal herb of cold desert

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Abstract
Bergenia ciliata belongs to the family Saxifragaceae, commonly known as Kodiya or Pashanbheda in Uttranchal. It contains the very high amount of bergenin content after *Bergenia ligulata*. It has large number of medicinal properties such as antibacterial, anti-inflammatory, anticancer, antidiabetic. *Bergenia ciliata* is mainly used to cure kidney disorder. Its phytochemical constituents are afzelechin, (+) catechin, β-sitosterol, Gallic acid, Tannic acid, (-)-3-0- Galloylepicatechin, (-)-3-0-Galloylcatechin, (+)-Catechin, Gallicin. This review paper highlighted the pharmaceutical, phytochemical and medicinal uses of *Bergenia ciliata.*

Keywords: Bergenin, afzelechin, gallic acid, (+)-catechin, gallicin, anticancer

Introduction
Bergenia ciliata is the member of family Saxifragaceae. It consists of about 30 genera and 580 species worldwide. The plant is commonly known as Pashanbheda because it is the main source of Pashanbheda which is highly used in indigenous system (Yaginuma *et al.* 2003) [38]. It itself shows that the plant originate between rocks and appears to break them or that it possesses lithotriptic property. It is found in Afghanistan, South Tibet, and Bhutan. In India it is found in Himalayas (Kumaon), Meghalaya, Lushai hills West Bengal (Darjeeling, Labha, Takdah, Rimbick(Kalimpong), Arunachal Pradesh (Nyam Jang Chu), Kyongnosla, Changu, Karponanag, Lachen to Thongu, Nathang, Prekchu-Tsokha, Pangolakha-Subaney Dara, Gangtok (domesticated) in Sikkim (Hafidh *et al.* 2009) [13]. It is considered as a miracle herb because it is used to cure several diseases viz; gastrointestinal problems, kidney stone, malaria etc.

Vernacular Names
Arabian: Junteyenah
Assamese: Patharkuchi
Bengali: Patharchuri
English: Rock- foil
German: Steinbrech
Gujarati: Pashanbheda
Hindi: Pakhenbhed
Japanese: Yukinoshita
Kannada: Alepgaya, Pahanbhedi, Hittaga, Pasanaberu, Hittulaka
Kashmir: Pashanbhed
Malayalam: Kallurvanchi, Kallurvanni, Kallorvanchi
Marathi: Pashanbheda
Nepalese: Pakanabadha
Oriya: Pasanbhedi, Pashanabheda
Persian: Gashah
Punjabi: Kachalu, Pashanbhed
Sinhalese: Pahanabeya
Sanskrit: Pashanbheda
Tamil: Sirupilai
Telugu: Kondapindi
Unani: Mukha

Scientific Classification
Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Saxifragales
Family: Saxifragaceae
Genus: *Bergenia*
Species: *ciliata*

Morphology
Geographical Distribution
Bergenia ciliata is a perennial climbing plant. It is mainly found in the cold and temperate regions. It is found throughout temperate Himalayas from Kashmir to Bhutan at an altitude of 900-3000m (Handa 1997) [15]. It is also present on rocks in and around the Murree area, especially in the Galis. The members of Saxifragaceae family are primarily found in north temperate, while these are not present in southern hemisphere. It is well grown in moist and shady areas of Afghanistan, Himalayas, South Tibet, Meghalaya, Lushai hills, Arunachal Pradesh (Nyam Jang Chu), Bhutan. It is also covers many areas of Sikkim such as Kyongnosla, Changu, Karponanag, Lachen to Thongu, Nathang, Prekchu - Tsokha, Pangolakha- Subaney Dara, Gangtok etc. (Panda 2002) [24].

Botanical Discription
B. ciliata is a small perennial herb. In autumn season, it grows upto 30 cm, but these herbs are well grown in moist and shady areas. Leaves are less in number, spreading, 4-11×3-10 cm, glabrous or hirsute, suborbicular to orbicular broadly obovate, base cordate or sometimes rounded, apex round or sometimes abruptly acuminate; margin entire to occasionally denticulate at top, Petiole 1-5 cm long, glabrous or hirsute. Inflorescence is of raceme or corymbose type, often subtended by an ovate leafy bract; bractglabrous or sparsely ciliate; scape and inflorescence greenish or pink tinged. Peduncle up to 10 cm long; flowers pink to purplish, pedicellate. The colour of sepals is pink to reda and 7mm long. Carpels and styles green or pinkish in colour and 7mm long. Capsule 13×6 mm in size, including styles. Seeds are 1 mm long, minutely tuberculate, usually numerous, albuminous. Stamens inserted with the petals, equaling or double their number, Ovary of 2 or 3-5 united carpels, usually 2 or 3-5 celled with axile placentas, occasionally 1-celled with parietal placentas ovules numerous, anatropous.

Table 1: Plant parts, traditional uses, ailments and its methods to usee

Sr. No.	Part used	Ailments	Methods used
1.	Rhizome	Kidney and gall bladder stone	Dried powder is used to treat kidney stones
2.	Rhizome and leaves	Wounds	To treat old wounds dried powder of leaves and rhizomes are used
3.	Rhizome	Septic	Paste of rhizome used as antiseptic
4.	Rhizome and leaves	Cough and Cold	To cure cold and cough, boiled water of leaves and rhizomes are given
5.	Rhizome	Cut and Burns	Mixture of powdered form of rhizome and curd are placed on burns
6.	Rhizome	Dysentery and Diarrhoea	Oral intake of infusion of rhizome to cure diarrhoea and dysentery
7.	Rhizome	Fever	To cure fever dried powder is used
8.	Rhizome	Asthama	In case of acute asthama, juice of rhizome is taken
9.	Rhizome	Gasto-intestinal problems	All types of intestinal disorders are cured by chewing fresh rhizome
10.	Rhizome	Eye ailments	Crushed rhizome sap is applied in eye diseases
11.	Rhizome	Septic pimples developed on the head of new born baby (Laizi)	Rhizome paste is applied
12.	Rhizome	Chronic ulcers	The rhizome is crushed and used in all kinds of ulcers
13.	.Rhizome	Cutaneous infections	Rhizome paste is effective in cutaneous diseases
14.	Rhizome	Inflammation	Paste of fresh rhizome is used
15.	Rhizome	Rheumatic	Rhizome paste is anti-rheumatic
16.	Rhizome	Helmintic	Fresh & dried rhizome extract is used orally
17.	Rhizome	Piles	Fresh & dried rhizome extract is used orally
18.	Rhizome and leaves	Tonsils	Rhizome & leaves paste is applied externally
19.	Rhizome	Cardiac problems	Rhizome powder is given
20.	Rhizome	Colitis	Rhizome paste cure internal wounds including colitis
21.	Rhizome	Aphrodisiac	Rhizome powder is given to increase spermatozoa
22.	Rhizome	Urinary diseases	Rhizome sap is taken orally in all kind of urinary problems

Phytochemistry of *Bergenia Ciliata*
This plant showed the prescence of various pphytochemicals viz; tannins, terpenoids, flavonoids, steroids, saponins, coumarins and glucosides. The rhizome is the rich source of alkaloids, tannins and coumarins. There are approximate 58 phytochemicals present in *Bergenia ciliata* species. Out of these 48 volatile organic compounds are classified into 11 categories such as phenols, terpenoids, fatty acids, carboxylic acid, flavonoids, nitro compounds, cinnamic acid, glycosides, alcohols, volatile organic compounds and sterol. Some important chemical constituents are mentioned in following Table 2.

Table 2: Chemical constituents and their activity

S. No	Compounds Name	Chemical formula	Class of compound	Activity	References
1.	Bergenin	$C_{14}H_{16}O_9.H_2O$	Phenol	Antioxidant activity against ascorbic acid	(Chauhan *et al.* 2013) [6]
2.	Tannic acid	$C_{76}H_{52}O_{46}$	Phenol	Pharmaceutical application	(Chauhan *et al.* 2012) [7]
3.	Gallic acid	$C_6H_2(OH)_3COOH$	Phenol	Antifungal, Antiviral,	(Pokhrel *et al.* 2014) [27]

				Cytotoxicity, Antioxidant	
4.	Catechin	$C_{15}H_{14}O_6$	Phenol	Histidine decarboxylase inhibitor	(Pokhrel *et al.* 2014) [27]
5.	(-)-3-0-galloylcatechin	$C_{22}H_{18}O_{10}$	Phenol	-	(Ruby *et al.* 2102) [29]
6.	(-)-3-0-galloylepicatechin	$C_{59}H_{46}O_{26}$	Phenol	-	(Ruby *et al.* 2102) [29]
7.	Gallicin	$C_8H_8O_5$	Phenolic acid	-	(Pokhrel *et al.* 2014) [27]
8.	β-Sitosterol	$C_7H_{50}O$	Sterol	Inhibit cholesterol level	(Masood *et al.* 2006) [21]
9.	Arbutin	$C_{12}H_{16}O_7$	Glycoside	Prevent the formation of melanin	(Kumar and Tyagi 2013) [20]
10.	Leucoanthocyanidin 4-(2-galloyl)	$C_{15}H_{14}O_7$	Glucoside	-	(Pokhrel *et al.* 2014) [27]
11.	(+)-Afzelechin	$C_{15}H_{14}O_5$	Flavonoid	-	(Chauhan *et al.* 2012) [7]
12.	Camphor	$C_{10}H_{16}O$	Terpenoid	Antinociceptive,Antispasmodicc, Antimicrobial	(Gyawali 2014) [11]
13.	Glucoside	$C_{15}H_{24}$	Terpenoid	-	(Chauhan *et al.* 2013) [6]
14.	2-pentanone	$C_5H_{10}O$	VOCs	-	(Gyawali and Kim 2012) [12]
15.	2,4-Dimethyl-3-pentanone	$C_7H_{14}O$	VOCs	-	(Gyawali 2014) [11]
16.	Hexanal	$C_6H_{12}O$	Organic compound	Antifungal	(Gyawali 2014) [11]
17.	2-methyl-1-propanol	$C_4H_{10}O$	Organic compound	-	(Gyawali and Kim 2012) [12]
18.	Acetic acid	$C_2H_4O_2$	Organic compound	Therapeutic activity	(Gyawali and Kim 2012) [12]
19.	Heptanol	$C_7H_{16}O$	Alcohol	-	(Han *et al.* 1998) [14]
20.	2-ethyl hexanol	$C_8H_{18}O$	Alcohol	-	(Chauhan *et al.* 2013) [6]
21.	3-pentanol	$C_5H_{12}O$	Alcohol	-	(Gyawali 2014) [11]
22.	2-pentanol	$C_5H_{12}O$	Alcohol	-	(Gyawali and Kim 2012) [12]
23.	Octanol	$C_8H_{18}O$	Alcohol	-	(Gyawali and Kim 2012) [12]
24.	Pentanol	$C_5H_{11}OH$	Alcohol	Antibacterial and antifungal	(Gyawali and Kim 2012) [12]
25.	Heptanal	$C_7H_{14}O$	f,g, Alcohol	-	(Peana *et al.* 2002) [25]
26.	Limonene	$C_{10}H_{16}$	Terpene	Antiseptic and Chemotherapeutic agent	(Moreau *et al.* 2002) [23]
27.	Linalool	$C_{10}H_{18}O$	Terpene alcohol	Food additives and shows bioactivity	(Peana *et al.* 2002) [25]
28.	3-methyl-4-hexen-2-one	$C_7H_{12}O$	-	-	(Khan *et al.* 2014) [18]
29.	2-Nitropropane	$C_3H_7NO_2$	Nitro compound	Shows hepatotoxicity	(Masood *et al.* 2006) [21]
30.	Hexanol	$C_6H_{14}O$	Isomeric organic compound	Therapeutic activity	(Kumar and Tyagi 2013) [20]
31.	2,4-Hexadienal	C_6H_8O	-	Therapeutic activity and sesquiterpene	(Khan *et al.* 2014 [19]
33.	α-Terpinol	$C_{10}H_{18}O$	-	Myorelaxant and antispasmodic effects	(Gyawali and Kim 2012) [12]
34.	Pentanoic acid	$C_5H_{10}O_2$	Carboxylic acid	Fragrant causing agent	(Gyawali and Kim 2012) [12]
35.	2,4-nonadienal	$C_9H_{14}O$	-	Bioantimutagenic	(Gyawali and Kim 2012)[12]
36.	Hexanoic acid	$C_6H_{12}O_2$	Carboxylic acid	Antifungal activity	(Gyawali 2014) [11]
37.	Hexalactone	$C_6H_{10}O$	-	-	(Bhandari *et al.* 2008) [4]
38.	Isobutyrophenone	$C_{10}H_{12}O$	-	-	Dhalwal *et al.* (2008) [9]
39.	5,6-Dihydro-2-pyranone	$C_5H_6O_2$	-	-	(Rajkumar *et al.* 2010)[28]
40.	Decanoic acid	$C_{10}H_{20}O_2$	Fatty acid	Antimicrobial and antifungal activity	(Sinha *et al.* 2001) [33]
41.	Nonanoic acid	$C_9H_{18}O_2$	Fatty acid	Herbicidal activity	(Fujii *et al.* 1996) [10]
42.	2-methyl butanoic acid	$C_5H_{10}O_2$	Fatty acid	-	(Chauhan *et al.* 2012) [7]
43.	Methyl nonanoate	$C_{10}H_{20}O_2$	-	Antimicrobial and Antifungal activity	(Bhandari *et al.* 2008) [4]
44.	Methyl cinnamate	$C_{10}H_{10}O_2$	Cinnamic acid	Antimicrobial activity	(Mazhar-Ul-Islam *et al.* 2002) [22]
45.	β-phellandrene	$C_{10}H_{16}$	Terpene	Used in fragrances	(Byahatti *et al.* 2010) [5]
46.	[E]-4-Hepten-2-one	$C_7H_{12}O$	Ketones	Used in fragrances	(Gyawali 2014) [11]
47.	Quercetin 3-o-β-D-xylopyranosides	$C_{20}H_{18}O_{11}$	Flavonoid	-	(Kumar and Tyagi 2013) [20]
48.	Quercetin 3-o-α-Larbinofuranoxide glycosides	$C_{20}H_{18}O_{11}$	Flavonoid	-	(Kumar and Tyagi 2013) [20]
49.	Tannins, saponins, coumarins	-	-	Antimicrobial activity	(Shanker *et al.* 2016) [31]
50.	Phenolic and flavonoid	-	-	Antimicrobial and antifungal activity	(Agnihotri et at 2015; Pereira *et al.* 2016) [1,26]
51.	Terpenoids and cardiac glycoside	-	-	Phytotoxic activity	(Ullan *et al.* 2015) [36]
52.	Epicatechin, catechin	-	-	Anti-inflammatory, antioxidant activity	(Srivastava *et al.* 2015) [35]
53.	Terpenoid	-	-	-	(Ahmad *et al.* 2016) [2]
54.	Bergenin, p-hydroxy-benzoyl bergenin	-	-	Antioxidant	(Sadat *et al.* 2015) [30]
55.	Alkaloid, saponin, glycoside, tannin and phenol, reducing sugars, flavonoid	-	-	-	(Sadat *et al.* 2015) [30]

Pharmacological Uses

- **Toxicology**

B. ciliata showed acute systematic *and* intracutaneous toxicity when applied in animals. It exhibited symptoms of various diseases such as erythema, edema, breathing problem, starting of bloody diarrhea, blood in stool and gastero-intestinal problems in acute systematic case. *B. ciliata* can also create in some diseases (Islam *et al.* 2002) [16]. In showed cardio-toxic, anti-diuretic and depressant action on CNS (Central Nervous System) in case of higher dose.

- **Anti-pyretic activity**

The methanol extract of *B. ciliata* showed anti-pyretic activity on normal body temperature. The methanolic extract of rhizome part showed beneficial effects on normal body temperature and causes pyrexia in rats. It significant results when applied standard doses of 100, 200 and 300 mg/kg. At 300 mg/kg this plant significantly decreased the normal body temperature in rats for up to 5 h after its administration. While in second model yeast-induced pyrexia, the extract significantly lowered body temperature for up to 4 h after its administration in a dose-dependent manner and the effect was comparable with that of paracetamol, a standard antipyretic agent (Sinha *et al.* 2002) [32].

- **Anti-diabetic activity**

B. ciliata showed anti-diabetic activity and proved that glucose inhibit the activity of two digestive enzymes α-glucosidase and α- amylase and lower the effect of this plant. The two active compounds (-)-3-O-galloylepicatechin and (-)-3-O-galloylcatechin isolated from the 50% aqueous methanol extract of rhizome part and these two enzymes showed strong inhibitory action against α- glucosidase and α- amylase in rat intestine. The standard IC50 value for sucrose, maltase and α-amylase were 560, 334 and 739 μM, respectively for [(-)-3-O-galloylepicatechin] and 297, 150 and 401 μM, respectively for (-)-3-O-galloylcatechin (Bhandari *et al.* 2008) [4].

- **Anti-bacterial activity**

The methanolic extract of *B. ciliata* rhizome showed a wide spectrum of concentration dependent antibacterial activity of methanolic extract of *B. ciliata* rhizomes at a concentration of 200-1000 μg/disc (Sinha *et al.* 2001) [33]. The broad spectrum and concentration dependent antibacterial activity was also confirmed in aqueous extract of crude drug.

- **Anti-tussive activity**

The methanolic extract of rhizome part of the plant showed anti-tussive activity in rat. This shows anti-tussive activity in dose dependent manner only. The qanti-tussive activity when compared with anti-tussive agent (codeine phosphate) showed significant results.extract exhibited significant anti-tussive activity in a dose-dependent manner, as compared with control. The standard doses of extract at 100, 200 and 300 mg/kg body wt. showed significant inhibition of cough reflex by 28.7, 33.9 and 44.2%, respectively, within 90 min of the experiment (Sinha *et al.* 2001) [34].

- **Anti-ulcer activity**

B. ciliata plant highly used to cure gastro disorders in folk medicines. The aqueous and methanolic extract of rhizome showed antiulcer activity at standard doses of 15, 30 and 60 mg/kg. The aqueous extract reduced the ulcers and wounds in stomach than methanol extract. But at higher doses these shows negative effects (Kakub and Gulfraz 2007) [17].

- **Antioxidant activity**

The methanolic extract of rhizomes showed a crucial effect to scavange free radicals of superoxide ions and nitric oxide ions. Some observers showed that extract was a good scavenger of DPPH radical at an EC of 36.24 μg/ml. The methanolic extract scavenged superoxide ions at a standard dose with EC of 106.48 μg/ml (Bagul *et al.* 2003) [3]. In another case both the methanolic and aqueous extracts of *B. ciliata* showed that both extracts have antioxidant activity and scavange active radicals. Both the assays of reducing power and lipid peroxidation inhibition efficiency showed preventing activity in lipid peroxidation and oxidative damages to biomolecules (Rajkumar *et al.* 2010) [28].

- **Antimalarial activity**

The extraction of part exhibited good antiplasmodial activity, with an IC50 <10 μg/ml. Different concentrations of the extract (250 to 1,000 mg/kg) exhibited considerable chemosuppression on day 7, in a dose-dependent manner. Maximum chemosuppression was observed to be 87.50 % at 1,000 mg/kg. Administration of (750 and 1,000 mg/kg) significantly ($p < 0.0005$) increased the mean survival time of rice in comparison to infected control, which exhibited a mean survival time of 8.6 ± 1.5 days (Walter *et al.* 2013) [37].

Conclusions

The present study explores the detailed information of *B. ciliata* and its therapeutic efficiency about the medicinal uses explained in medicinal systems. The phytochemical, pharmaceutical and biological investigation of *B. ciliata* reports the versatility and explains its diverse role. It is concluded that this miracle herb had been used traditionally among the various communities across the tribal region of worldwide for ailment of urinary, gastrointestinal, skin, pulmonary, hepatics, gynecological, inflammatory and infectious diseases. In total of 104 different disease disorders were reported to be treated by this species while its highest potential was observed to cure gastrointestinal disorders primarily. In addition to this, the species is also well known to treat kidney stones and kidney disorders by the traditional and local medicinal practitioners. Almost all parts of the plant are used for curing different but the most frequent part used is rhizome followed by root. In recent times, the old traditional practices are at gradually decline very rapidly and under risk due to rapid modernization hence there is urgent need for documentation of such tribal species and help to find innovative ways for untap its efficiency used for human welfare in future.

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