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Review Article

PHYTOCHEMICAL AND PHARMACOLOGICAL PROFILE OF THE MEDICINAL HERB: *BRYOPHYLLUM PINNATUM*

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ABSTRACT

Worldwide, *Bryophyllum pinnatum* is extensively used to treat the various ailments in folk medicine. The plant is enriched with a diverse range of active therapeutic constituents which are responsible for various significant pharmacological effects. The objective of current study is to highlight the latest evidence-based information regarding pharmacognostical, phytochemical and pharmacological profile of the medicinal plant. Data for the present study was taken from previously published work and to ensure the credibility only indexed research and review articles were used. The databases were included: Scopus, Google Scholar, PubMed, Science Direct, and MEDLINE. *Bryophyllum pinnatum* contains valuable phytochemicals such as polyphenols, tannins, glycosaponins, flavonoids, steroidal glycosides and many other important chemical constituents that are responsible for its anti-oxidant, anti-pyretic, anti-inflammatory, anti-arthritic, anti-allergic, analgesic, anti-septic, sedative, anti-depression, wound healing, hepatoprotective, nephroprotective, tocolysis, urolithic, anti-psychotic, muscle relaxant, anti-protozoal, anti-microbial and anti-diabetic effects. Bufadienolides have been isolated from the leaves of plant which could be the potential chemotherapeutic agents and hence plant has anti-tumor activity as well. Although, many aspects of the herb have been explored still there is need to carry out a more comprehensive investigation in order to confirm its therapeutic efficacy and to appraise rationale behind its use in folk medicines.

Key words: *Bryophyllum pinnatum*, *Kalanchoe pinnatum*, pharmacognostical, phytochemical, pharmacological, bufadienolides.

INTRODUCTION

Globally, medicinal plants are extensively used for the treatment of various diseases (Gover *et al.,* 2002). According to the World Health Organization (WHO), medicinal plants are the great source to offer a diverse range of potential therapeutic drugs and these drugs can be relatively safe and economical as compared to the synthetic medicines (Mekuria *et al.,* 2017; Ekor, 2014; Bahmani *et al.,* 2014). Since the last many years, herbal drugs are increasingly focused by the researchers and several plants are being monitored for their prospective therapeutic effects (Uprety *et al.,* 2010). Based on the therapeutic value of medicinal plants the current study provides an updated insight of *Bryophyllum pinnatum* which is extensively used in folk therapeutics.

Bryophyllum pinnatum (family: Crassulaceae) is also known as *Kalanchoe pinnatum* or *Bryophyllum calycinum* (Sadhana *et al.,* 2017). It is 3 to 5 meters high perennial herb and has opposed glabrous leaves (Afzal *et al.,* 2012; Kamoj and Saluja, 2017). It has a sour taste, hot strength and sugary post digestive effect. The herb contains a wide range of valuable chemicals that could be responsible for its various pharmacological effects (Jaiswal and Sawhney, 2006).

Vernacular names
English: Air plant
Hindi: Zakhmhaiyat, Patharchur
Bengali: Koppatha, Patharkuchi
Sanskrit: Parnabeeja, Asthibhaksha

Other common names include: Miracle leaf, Mexican Love plant, Panfutti, Divine herb, Wonder of the World (Pattewar, 2012), Canterbury bells, life plant, air plant and Cathedral bells (Plangger *et al.,* 2006; Naz *et al.,* 2009; Kamoj and Saluja, 2017). In Pakistan, it is famous as Pathar Chat and Zakham-e-Hayat (Mahmood *et al.,* 2011; Gilani *et al.,* 2014).

Taxonomy
Kingdom: Plantae
Vascular plants Division: Spermatophyta
Order: Rosales
Family: Crassulaceae – stonecrop
Genus: Bryophyllum
Species: *Bryophyllum pinnatum* (Lam.) Kurz

Distribution: *Bryophyllum pinnatum* is indigenous to Madagascar. It grows naturally and found in the temperate regions of Asia, Galapagos, West Indies, New Zealand, Macaronesia, Mascarenes, Caribbean and

Pacific, Melanesia, Polynesia, Hawaii and Australia (Zamora *et al.,* 1998).

Ethnophramacological relevance: Around the globe, it is consuming for the treatment and management of various pathologies such as conjunctivitis, edema, piles, cuts, eczema, constipation, epilepsy, cholera, asthma, chest colds, menstrual disorders, chicken pox and fever (Quazi *et al.,* 2011). The plant parts are frequently applied for the cure of burns, rheumatoid arthritis, anti-septic, blisters, cough suppression, insect bites, psychiatric disorders and abdominal discomforts (Sadhana *et al.,* 2017). It is well-known for its anti-inflammatory, wound healing, analgesic and hemostatic qualities (Ferreira *et al.,* 2014). Leaves extracts are useful for the remedy of jaundice, hypertension, renal stones and diabetes. Slightly heated leaves are applied on superficial skin infections and also used for the dropping of placenta in Southeast Nigeria, hence it act as a tocolytic agent to prevent the premature labor (Gupta *et al.,* 2016; Mouhssin *et al.,* 2015). The plant is also used for the cure of leg edema, fever, gout, abscesses, otitis and palpitations (Afzal *et al.,* 2012). *Bryophyllum pinnatum* is widely utilized in ayurvedic medicines for the treatment of numerous conditions such as menorrhagia, hemorrhoids, vomiting, corns, ophthalmia and hematemesis. Root extract is being used for its hepatoprotective, laxative, diuretic and anti-psychotic effects (Afzal *et al.,* 2013). Paste of the crushed leaves is applied on skin for the treatment of boils and abscess (Saikia *et al.,* 2006). In Germany, anthroposophic physicians prescribed *Bryophyllum pinnatum* preparations for tocolysis and behavioral disorders (Simões *et al*., 2012).

MATERIALS AND METHODS

Data for the current study was taken from previously published work and to ensure the credibility only indexed research and review articles were used. The databases were included: Scopus, Google Scholar, PubMed, Science Direct, and MEDLINE.

RESULTS AND DISCUSSION

PHYTOCHEMICAL CONSTITUENTS: Numerous important chemical constituents and secondary metabolites of the plant have been documented in which the most significant are bufadienolides and flavonoids (Fürer *et al.,* 2016). From leaves, bryophyllin B and A have been isolated which are major bufadienolides (Potterat *et al.,* 2013). In leaves and their extracts various flavonoids are separated, included: quercitrin, kapinnatoside, 8-methoxyquercetin-3, 7-di- O-rhamnopyranoside and 3', 4'-dimethoxy quercetin. Other flavonoid compounds i.e. Afzelin and α-rhamnoisorobin were also found. In ethanol extract of the plant, fatty acids such as stearic acid, palmitic acid and traces of the arachidic and behenic acid were also spotted (Milad *et al.,* 2014). The presence of alkaloids, saponins, glycosides and tannins has been confirmed in the plant (Telefo *et al.,* 2011). Moreover, phytochemical screening of root chloroform extract has shown the occurrence of different flavonoids and steroids however a thorough research is still required (Majaz *et al.,* 2011). It has also found that the presence of different flavonoids, polyphenols, triterpenoids and other chemical constituents in the plant are responsible for its various therapeutic activities such as anti-nociceptive, anti-inflammatory, anti-bacterial and anti-diabetic effects (Ferreira *et al.,* 2014). The herb is an excellent reserve of vitamins such as ascorbic acid, niacin and thiamine and also has minerals i.e. Ca, Mg, Na, Fe, P, K and Zn (Milad *et al.,* 2014). It contains essential oils and about twenty four compounds were isolated out of which nonanal and (E)-geranylacetone are the most abundant (Adeyinka *et al.,* 2017). *Bryophyllum pinnatum* is enriched with a diverse variety of the pharmacological active chemicals (Kamoj and Saluja, 2017) and therefore it is necessitate carrying out further scientific research in order to confirm the justification behind its use in folk therapeutics (Hamburger *et al.,* 2017).

BIOLOGICAL AND PHARMACOLOGICAL EFFECTS

Anti-inflammatory and Analgesic activity: Customarily, *Bryophyllum pinnatum* leaves and its flowers are used for the anti-inflammatory and analgesic effects. It contains flavonoids which have ability to inhibit the cyclooxygenase enzyme and minimize the activity of α- tissue necrosis factor (Ferreira *et al.,* 2014). From leaves, a novel steroidal derivative has been separated and now its structure is also elucidated. In aqueous extract this new steroidal compound was found to be active in reducing inflammation when tested by carrageenan induced rat paw edema and compared with diclofenac. Furthermore, it has revealed 75.72% protection in analgesic activity when tested by mice acetic acid induced writhing test (Afzal *et al*., 2012) hence it has proven that aqueous extract of the plant has potent analgesic activity (Igwe and Akunyili, 2005). Leaves ethanolic extract was proved to be effective against the topical acute and chronic inflammation which is due to cramming of the arachidonic acid pathway (Chibli *et al.,* 2014).

Anti-allergy activity: An *in vitro* study has shown that the plant is helpful in reducing allergy. Its anti-allergic effect is due to the halting of antigen induced mast cell degranulation and also by minimizing the secretion of histamine (Cruz *et al.,* 2008).

Anti-cancer activity: The plant chloroform extract and its fractions have exhibited a concentration dependent inhibition of human cervical cancer cell growth. The fraction was more potent than the extract and strong activity was observed against human papillomavirus (HPV) which performs a vital job in the growth of cervical cancer (Mahata *et al.,* 2012). In leaves, five bufadienolides have been separated and investigated for their inhibitory effects on Epstein-Barr virus early antigen. From all the bufadienolides, an obvious inhibition was exhibited by bryophyllin A. Study outcomes have strongly recommended that the *Bryophyllum pinnatum* bufadienolides could be the potential chemotherapeutic candidates to treat the cancer (Afzal *et al.,* 2012).

Anti-diabetic activity: For many years, the plant has been utilized for its anti-hyperglycemic effects. The aqueous extract of leaves, after postprandial and streptozotocin induced diabetes in rats has exhibited striking hypoglycemic effects. Moreover, an advance investigation has confirmed its effectiveness in heart diseases and in diabetes (Ojewole, 2005).

Antihypertensive activity: Medicinal herb is used to treat various cardiovascular related disorders in folklore therapeutics (Tedge *et al.,* 2005). Now it is confirmed that aqueous extract of the leaves has an antihypertensive effect on rats which justify its use in folk medicines. It has been demonstrated that the extract has potent anti-oxidant effect on aorta thus plays a significant role in the lessening of blood pressure (Bopda *et al.,* 2014).

Anti leishmanial activity: Flavonoids present in the herb are responsible for its anti leishmanial effects. In the aqueous extract of leaves, it has been proven by testing three flavonoids separately against the *Leishmania amazonenis* amastigotes in comparison with quercitrin, quercetin and afzelin. The quercetin aglycone type structure and a rhamnosyl unit linked at C-3 were found to be essential for anti leishmanial activity (Muzitano *et al.,* 2006).

Antimicrobial and Antifungal activity: The plant different crude extracts were analyzed for their anti-microbial effect and it was determined that the extracts have broad spectrum anti-bacterial activity (Aqil and Ahmad, 2003). Considerable antibacterial activity was confirmed against gram positive and gram negative bacteria by the ethanolic extract of the plant (Biswas *et al.,* 2011). A methanolic extract of the roots was found to be effective against *S. aureus, P.* aeruginosa and *E. coli* but not effective against *C. albicans* (Majaz *et al.,* 2011).

Urolithic activity: The medicinal herb is used for the treatment of renal stones in traditional medicines (Tedge *et al.,* 2005). Leaves aqueous extract markedly decreases the level of urine oxalate and consequently it can be helpful in the cure of urolithiasis (Shukla *et al.,* 2014). In Pakistan, this medicinal herb is being used for the cure of kidney stones in customary treatment. *Bryophyllum pinnatum* has been proven beneficial in the reduction of renal stones because it enhances the excretion of oxalate crystals by reducing the size of crystals and by converting them from dehydrate crystals to calcium oxalate monohydrate form (Yasir and Waqar, 2011). Investigations have confirmed that the plant extracts protect the kidney cell from calcium oxalate crystals, oxidative stress and also lessened the formation of renal stones by increasing the solubility and excretion of these stones through the urine (Tiwari *et al.,* 2012).

Gastroprotective/ Anti-ulcer activity: *Bryophyllum pinnatum* possess gastroprotective effects and it has been verified by its striking dose dependent defensive effect on ethanol induced gastric injury. However, further studies should be carried out to validate its use in gastric ulcers (Sharma *et al.,* 2014).

Effect on hematological parameters: *Bryophyllum pinnatum* methanolic extract of the leaves has exhibited a marked effect on various hematological parameters i.e. it improves the hemoglobin level, packed cell volume and total white blood cell count (Aprioku and Igbe, 2017).

Hepatoprotective activity: The plant has been monitored for its hepatoprotective activity. In rats, carbon tetrachloride stimulated hepatic injury was induced and found that the ethanolic extract of the leaves reduces the levels of liver enzymes, serum bilirubin, serum cholesterol and serum total protein. Results have illustrated that the herb has an obvious hepatoprotective activity. Increased regeneration of hepatocytes and microsomal enzymes inhibition also defend the liver from damage (Yadav and Dixit, 2003).

Anti-oxidant activity: The medicinal plant is tested for its anti-oxidant activity by metal chelating assay, 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay and 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay. Study outcomes have indicated that the ethanolic extract has marked anti-oxidant activity (Sindhu and Manorama, 2015). Roots extracts have also exhibited the anti-oxidant effects when analyzed by DPPH assay (Gupta and Banerjee, 2011).

Nephroprotective effects: *Bryophyllum pinnatum* is widely used for its nephroprotective activity in folklore and the rationale behind its use has been proven by the studies. Results of an investigation have shown that this effect is dose dependent. The nephroprotective activity against the genatmicin induced nephrotoxicity on the Wistar rat kidney was tested and it is anticipated that this effect is due to the plant anti-oxidant and radical scavenging properties (Harlalka *et al.,* 2007). It is

suggested that the juice of leaves is more effective in the cure of hyperactive bladder and has fewer side effects than anti-cholinergic drugs (Schuler *et al.,* 2012).

Wound healing activity: The plant is used topically for the healing of wounds in traditional therapeutics. It is proposed that the plant has saponins in huge amounts which promote wound healing by aggregating the erythrocytes. Moreover, tannins present in the plant also enhance the process of wound healing because of their astringent effect (Pattewar, 2012).

Neurosedative and muscle relaxant activity: *Bryophyllum pinnatum* has marked effect on the CNS and it has been proven that the methanolic extract produced a significant change in behavior pattern. A study results have demonstrated that the herb caused the CNS depression and dose-dependent stimulation of pentobarbitone sleeping time (Ojewole, 2005). Another study has also suggested that it is useful in treating the sleep troubles during pregnancy (Afzal *et al.,* 2013). The medicinal plant is helpful for the treatment and management of seizures and that was confirmed by testing on mice. It showed a dose dependent increase onset and duration of pentobarbitone-induced sleep and decline of exploratory activities in the head-dip and evasion tests. A dose-dependent muscle incoordination has been verified in the inclined screen, traction and climbing tests. In both strychnine and picrotoxin induced seizures it caused a late onset of convulsions (Yemitan and Salahdeen, 2005).

Figure 1. The plant of *Bryophyllum pinnatum*

Uterine relaxant activity: In traditional therapeutics, the plant is used for tocolysis and the rationale behind its use has proven by *in vitro* studies and further research is still required (Gwehenberger *et al.,* 2004). The effect of leaf press juice and its chemical fractions were studied on human myometrial strips and were found to be useful in relaxing the myometrial strips (Wächter *et al.,* 2011).

Warning: *Bryophyllum pinnatum* contains the cardiac bufadienolide glycosides which may cause cardiac poisoning, especially in grazing animals. So, it should be used with the caution in impaired digestive system and also avoid for long period as it subsides the immune system (Pattewar, 2012).

Products available in market: *Bryophyllum pinnatum* present in the Amantol cream as an active ingredient which is used to treat upper respiratory disorders (Quazi *et al.,* 2011).

Conclusion: The current study focuses on the latest evidence base information regarding pharmacognostical, phytochemical and pharmacological profile of the *Bryophyllum pinnatum*. It is concluded that the divine herb contains many valuable active pharmacological constituents that are responsible for plant various therapeutic effects. Different studies have explained and verified the wisdom behind its use in traditional medicines. More exploratory studies are still required to confirm and justify use of the herb in folk medicine and also to prove its safety and efficacy.

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