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REVIEW ON "UNRAVELLING THE TRADITIONAL WISDOM OF BRYOPHYLLUM PINNATUM: MODERN INSIGHTS AND THERAPEUTIC IMPLICATIONS

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ABSTRACT

Bryophyllum pinnatum, A member of the Crassulaceae family, is a widely distributed medicinal plant that has long been utilized in tropical countries for Ayurvedic, homeopathic, and folk medicine purposes. Often referred to as the "miracle plant," "air plant," or "life plant," it has unusually succulent leaves that may reproduce vegetatively by producing plantlets on the leaves. The plant's rich phytochemical composition and varied pharmacological profile have drawn a lot of scientific interest. Anti-inflammatory, analgesic, antibacterial, antioxidant, antidiabetic, antiurolithiatic, wound-healing, hepatoprotective, immunomodulatory, and anticancer properties have all been shown in B. pinnatum's leaves, roots, and stems. Its secondary metabolites, including as flavonoids, phenolic compounds, glycosides, tannins, triterpenoids, alkaloids, and steroids, are responsible for these biological characteristics. B. pinnatum is used in traditional medical systems to treat conditions like fever, asthma, hypertension, skin infections, kidney stones, ulcers, and gastrointestinal issues. Its potential for neuroprotection and reproductive health has also been highlighted by recent studies. Many ethnomedicinal claims

have been confirmed by preclinical research, but there are still few thorough clinical assessments available. To guarantee safety and therapeutic efficacy, extract standardization, toxicity profiling, dosage adjustment, and thorough mechanistic research are necessary. Furthermore, potential to improve the bioavailability and therapeutic uses of its bioactive ingredients are presented by developments in formulation science and biotechnology. This review covers Bryophyllum pinnatum's botany, phytochemistry, and pharmacological properties to help with future scientific research and drug development. Strengthening evidence-based research will facilitate its incorporation into modern healthcare as a promising natural medicine with extensive therapeutic potential.

KEYWORDS: Bryophyllum Pinnatum, Miracle Plant, Traditional medicine, Phytochemistry Anti-inflammatory, Analgesic, Antibacterial, Antiurolithiatic.

INTRODUCTION

Calcium oxalate crystals are the primary cause of kidney stones, which impact millions globally and lead to considerable health issues. Bryophyllum pinnatum has been traditionally used to treat urolithiasis, with modern studies confirming its effectiveness through compounds that prevent stone formation. Creating standardized tablet formulations from this plant may provide an affordable alternative to traditional treatments.[1,2]

Description of the Plant[3]

Scientific Name: Bryophyllum Pinnatum
Synonyms: bryophyllum calycinum.
Family: Crassulaceae
Sanskrit: Pashanabheda
Hindi: Patharchur

Also known as: Cathedral Bells, Air Plant (USA), Life Plant, Miracle Leaf, Goethe Plant, and Katakataka. Referred to as the "Wonder of The World" in english-speaking Caribbean regions. Oliwa ka kahaki (Hawaii), Mother of Thousands, Herbe Mal Tete (Dominica), Never Dead, Parvu, Air Plant Leaf (Bolivia).

Figure 1: Bryophyllum Pinnatum.

Taxonomical Study[3]

Kingdom : Plantae

Division : Magnoliophyta

Class : Magnoliopsida

Order : Saxifragales

Genus : Kalanchoe

Section : Bryophyllum

Species : K. pinnata

Phytochemical and Pharmacological Profile

Bryophyllum pinnatum offers a wide spectrum of phytochemicals and nutrients. It is abundant in alkaloids, glycosides, flavonoids (such as quercetin, rutin, kaempferol), saponins, anthocyanins, tannins, steroids, and phenolic compounds as well as specialized bufadienolides like bryotoxin A, B, and C. The plant features an array of organic and carboxylic acids, including citric, isocitric, oxaloacetic, gallic, caffeic, coumaric, syringic, ferulic, protocatechuic, and succinic acids.

Bryophyllum pinnatum is also a source of essential minerals such as calcium, magnesium, potassium, sodium, phosphorus, manganese, copper, iron, and zinc. It provides key vitamins—ascorbic acid (vitamin C), riboflavin, thiamine, pyridoxine, and niacin—alongside amino acids (like glycine, cysteine, tyrosine, methionine, glutamic acid, and phenylalanine). Fatty acids found in the plant include stearic and palmitic acids.

Additionally, Bryophyllum pinnatum contains sugars (including glucose, fructose, galactose, lactose, raffinose, and sucrose), proteins, carbohydrates, lipids, and a range of secondary compounds such as quercitrin, phenanthrene derivatives, alkanols, and hentriacontane.[2,6]

Pharmacological investigations have shown the plant

- Bryophyllum pinnatum prevents the formation, growth, and clumping together of calcium oxalate crystals. It effectively stops initial crystal nucleation, slows down their enlargement, and inhibits the aggregation of these crystals, which are common causes of kidney stone development. This activity helps in reducing crystal buildup and protects against kidney stone formation by maintaining the crystals in a dispersed state, thereby preventing their deposition on kidney tissues.Possesses diuretic, nephroprotective, and antispasmodic activity.[1,2,7]
- **Extraction and Standardization:** The leaves are first washed thoroughly and then allowed to dry. After drying, they are ground into a powder. This powdered material is then subjected to extraction processes using solvents such as water or ethanol to obtain the active compounds from the leaves.[6]
- **Tablet Manufacturing:** The tablets are produced using either wet granulation or direct compression techniques. To enhance the tablets 'quality and ensure their stability, various excipients are incorporated, including binders like PVP K90, disintegrants such as starch, fillers like lactose, and lubricants including magnesium stearate and talc.
- **Processing:** The mixture undergoes granulation followed by a drying step, after which it is compressed into tablets. Key processing factors such as the force applied during compression and the size of the granules are carefully adjusted to ensure the tablets are consistent in size, shape, and quality.[4,5,6]

PHARMACOLOGICAL ACTIVITY

Herbal tonic

The plant is rich in niacin, riboflavin, thiamine, and ascorbic acids. The body's normal production of intercellular substances, such as collagen, bone matrix, and tooth dentine, depends on natural ascorbic acid. Ascorbic acid and appropriate connective tissue metabolism can therefore be linked to the clinical signs of scurvy, which include bleeding from the mouth, gastrointestinal system, anemia, and joint discomfort. Ascorbic acid's typical ability to heal wounds is explained by this function. Consequently, the plant is utilized in herbal therapy to treat a variety of illnesses, including prostate cancer and the common cold. A study indicates that a herbal composition containing extracts from various plants, including B. pinnatum, functions as a tonic to enhance respiration, facilitate toxin clearance, and augment general vitality.[7,8,9]

Antileishmanial Activity

Leishmaniasis, caused by protozoa of the genus Leishmania, remains a significant global health challenge, particularly in developing nations where it is highly endemic. Its incidence has risen notably with the spread of AIDS. According to L.G. Rocha et al., in a review of plant extracts, naturally derived compounds such as coumarin and quercetin have demonstrated antileishmanial potential. The flavonoid quercitrin is identified as the key component responsible for the antileishmanial activity of Bryophyllum pinnatum. Structural features, including the quercetin aglycone core and a rhamnosyl group attached at the C-3 position, appear to play a critical role in this activity.[10,11]

Anti-ulcer Activity

Adesanwo et al. demonstrated in their study that the incidence of ulceration and both basal and histamine-stimulated gastric acid secretion were significantly reduced in a dose-dependent manner, supporting the traditional use of the substance as an anti-ulcer remedy.[12]

Anti-Diabetic Activity

Because plants contain zinc, they may play an important role in controlling diabetes. Zinc is known to influence insulin production and secretion, and since diabetes results from the body's inability to synthesise or use insulin effectively, plants rich in zinc could potentially help in regulating blood glucose levels and improving overall metabolic balance.[9,13]

Uterine Contractility

B. Gwehenberger et al. explore the phytotherapeutic tocolytic properties of B. Pinnatum in vitro, comparing it to the conventional betamimetic fenoterol in human myometrium. They measured contractility in strips of term myometrium obtained during caesarean sections from 14 women, exposed to escalating concentrations of B. Pinnatum along with +/- oxytocin 1 U/I. The findings indicate that the inhibition of spontaneous contractions was dependent on the concentration. B. Pinnatum raised contraction frequency by 91% at a constant amplitude and reduced oxytocin-induced contractions by 20% while maintaining constant amplitude, though with a slight reduction in frequency. In contrast, fenoterol led to a 50% decrease in contraction along with a significant reduction in frequency.[14]

Immunosuppressive effect

The immunosuppressive action of B.pinnatum in vivo may be caused, at least in part, by the fatty acids it contains. According to Rossi-Bergmann et al., mice's humoral and cell-mediated

immune responses are significantly suppressed by leaf aqueous extract. In vitro, the spleen cells of mice that had received plant extract beforehand shown a reduced capacity to proliferate in response to both mitogen and antigen. Mice who received extract treatment were also less able to develop a delayed-type hypersensitivity reaction (DTH) to ovalbumin. The DTH reaction was virtually eliminated by the topical and invitro delivery methods, which proved to be the most successful. Compared to controls, the intraperitoneal and oral methods decreased the reactivity by 73% and 47%, respectively. Treatment also dramatically decreased the specific ovalbumin antibody responses. Therefore, the leaf aqueous extract has immunosuppressive properties. In a study, Almeida et al. also discovered that leaf extracts exhibited in vivo immunosuppressive activity and suppressed the growth of lymphocytes in vitro. an effort to determine which immunosuppressive compounds are present in B. pinnatum using lymphoproliferative assays as a guide. A purified fraction (KP12SA) of the ethanolic extract was discovered to be twenty times more effective than the crude extract at preventing the proliferation of murine lymphocytes. This shows that the herb's saturated fatty acids have a significant impact on lymphocyte proliferation, which explains why it has an immunosuppressive effect in vivo.[15]

TABLET MANUFACTURING PROCESS

Wet Granulation Method

1. The powdered extract is thoroughly mixed with various excipients to assist in tablet formation. These excipients include starch, which acts as a binder and helps in forming granules; magnesium stearate, used as a lubricant to prevent sticking during tablet compression; and lactose, which serves as a filler or diluent to add bulk to the tablet.
2. A moist mass is prepared and then passed through a sieve. It is subsequently dried at 60°C and sifted again through finer sieves numbered 22 and 44 to produce granules that are consistent in size and uniform in texture.
3. The granules are coated with a lubricant and then compressed into tablet shapes using rotary tablet pressing machines. These machines apply controlled pressure through rotating punches and dies to form tablets of the desired size and shape continuously and efficiently.[4,6]

Direct Compression

1. The granules are first coated with a lubricant and then shaped into tablets using rotary tablet presses. These machines feature a rotating turret with multiple punches and dies that

apply precise, controlled pressure. As the turret spins, the granules are fed into the die cavities, compressed simultaneously by upper and lower punches, and then ejected as finished tablets continuously and efficiently, maintaining the desired tablet size, shape, and uniformity throughout the production process.[4,6]

Polyherbal Combinations

1. Frequently combined with other plants like Moringa oleifera and ginger, it delivers enhanced benefits through synergistic effects, providing combined antiurolithiatic, diuretic, and antioxidant properties that work together to improve efficacy.
2. Tablets are prepared by mixing powdered extracts in carefully determined proportions, based on experimental data, to achieve the highest therapeutic effectiveness.[3,6]

EVALUATION OF TABLET

Standard pharmacopeial methods are essential to ensure quality, dosing accuracy, and efficacy.

1. **Weight variation:** No more than two tablets in a batch deviate by more than the prescribed limit (±5% for >324 mg tablets).
2. **Hardness:** Tested using Monsanto hardness tester; contributes to handling and transport stability.
3. **Friability:** Roche friabilator is used to assure the tablet resists crumbling; below 1% loss acceptable.
4. **Thickness:** Evaluated with vernier calipers for physical uniformity.
5. **Disintegration time:** Measured using disintegration apparatus at 37±2°C; tablets must disintegrate within 15 minutes for immediate release forms (5 min reported for Bryophyllum polyherbal tablets).
6. **Content uniformity and assay:** Ensure that each tablet contains the labeled amount of key bioactives, typically determined via spectrophotometric or chromatographic methods.
7. **Stability studies:** Testing at ambient and accelerated conditions confirms retention of physical and biochemical integrity over at least 3 months.[4,5]

CONCLUSION

Bryophyllum pinnatum has been widely recognized in traditional medicinal systems for its diverse therapeutic benefits, and recent scientific studies increasingly support these historical applications. The plant is enriched with valuable bioactive compounds such as flavonoids, bufadienolides, phenolics, and glycosides, which are responsible for its extensive medicinal

actions. These include anti-inflammatory, antioxidant, antimicrobial, antidiabetic, antiurolithiatic, hepatoprotective, and anticancer properties. Additionally, its exceptional ability to regenerate from leaf fragments enhances its usefulness in promoting wound repair and tissue regeneration. Although numerous laboratory and animal studies have demonstrated its therapeutic potential, clinical utilization is still limited. This gap exists due to a shortage of well-designed human trials, lack of standardized extract preparations, and incomplete evaluation of toxicity and safe dosage ranges. Therefore, more rigorous scientific investigations focusing on pharmacological mechanisms, safety profiles, and formulation development are necessary to support its evidence-based application in modern healthcare. Moreover, advanced technologies in herbal drug development and targeted delivery systems may help maximize its medicinal value. In essence, Bryophyllum pinnatum serves as a vital link between traditional herbal knowledge and modern scientific discovery. With continuous interdisciplinary research and validation, it holds great promise as a reliable, safe, and innovative natural therapeutic agent for future medical advancements.

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