

## EXPLORING THE THERAPEUTIC POTENTIAL OF *KALANCHOE PINNATA*: A COMPREHENSIVE REVIEW

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### ABSTRACT

The plant *Kalanchoe pinnata*, also referred to as the "miracle leaf," belongs to the Crassulaceae family and is well-known for its wide range of therapeutic uses. The botanical profile, chemical constituents, and pharmacological properties of the plant such as its anti-inflammatory, wound-healing, antibacterial, and antidiabetic properties are highlighted in this review. In many parts of the world, *K. pinnata*, which is abundant in bioactive substances like flavonoids, alkaloids, and glycosides, has long been used to heal wounds, respiratory conditions, and urinary issues. Nanotechnology and sophisticated extraction techniques have significantly increased its therapeutic potential. Notwithstanding its advantages, the plant's safety profile needs to be carefully evaluated, especially in light of its toxicity and recommended dosages. In order to maximise its medicinal potential, this study emphasises the necessity of thorough research and sustainable cultivation.

**KEYWORDS:** *Kalanchoe pinnata*, Pharmacology, extraction, Geographical sources.

### INTRODUCTION

*Kalanchoe pinnata* also known as the "miracle leaf" or "Bryophyllum," is a plant that belongs to the Crassulaceae family. It is commonly found in tropical regions and is known for its medicinal properties.<sup>[1]</sup> Botanical Name: *Bryophyllum pinnatum*, Family: Crassulaceae, Sanskrit: Pashanabheda, Hindi: Patharchur, English: Air Plant, Miracle-Leaf, Bengali: Koppata, Gujarati: Ghaymaari, Malayalam: Ilayinmeltai, Ilamulachi, Synonym: *Bryophyllum calycinum*,

*Bryophyllum pinnatum*.<sup>[2]</sup> The plant grows 1-1.5 m in height, The stem of *Kalanchoe pinnata* is hollow four-angled and usually branched, It has thick, fleshy leaves that can store water. The leaves are often green with a reddish tint around the edges. The leaves are about 5–20 cm long and 2–10 cm wide. to this plant Flowers in November-March and fruits in April. It is astringent and sour in taste.<sup>[3]</sup> Taxonomy: Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Order: Saxifragales, Genus: *Kalanchoe*, Section: *Bryophyllum*, Species: *K. pinnata*.<sup>[4]</sup> Chemical constituents: The plant contains alkaloids flavonoids, and some phenolic compounds tannins, microelements like magnesium, calcium, potassium, phosphorus, sodium. *Kalanchoe pinnata* leaves contain astragalin, 3,8-dimethoxy-4,5,7-trihydroxyflavone, friedelin, epigallocatechin-3-o- striate, luteolin, rutin, kaempferol, quercetin, quercetin-3L-rhamnosido-L-arabino furanoside, quercetin-3-O- diabinoside and kaempferol-3-glucoside.<sup>[5]</sup> Uses: Wound healing: Its ethanolic extracts really help reduce the size of cuts and wounds. They also lessen swelling at the affected spots. Additionally, researchers have found that using extracts made with alcohol, petroleum ether, or even water can be helpful for wounds.<sup>[6]</sup> Location: The plant grows all over India in hot and moist areas.<sup>[7]</sup>



**Marketed formulation:** 1 Amadol – cream Upper respiratory disorders, sinusitis, bronchitis, allergic reactions, conditions related to blockages in nasal passage.

Ingredients: *Mentha viridist* extract (mint.), *Iresine difusa* (escanel) extract, *Lippia alba* extract (yantria), *Zingiber officinalis* extract (ginger), *Kalanchoe pinnata* extract (Pakipanga), *Mansia alliacea* extract (ajo de monte), mentol, alcanfor, water, cream base. External usage only

2 Parnabija svarasa -anti obesity (Quazi Majaz A, Tatiya AU, Khurshid M, Nazim S, Siraj S. The miracle plant.<sup>[8]</sup>

**Phytochemical investigation:** *Kalanchoe pinnata* is rich in alkaloids, triterpenes, glycosides, flavonoids, cardienolides, steroids, bufadienolides and lipids.<sup>[9]</sup>

Leaf of *Kalanchoe pinnata* contains amino acids i.e. thiamine, pyridoxine, ascorbic acid, glycine, cysteine, casein hydrlylsate, nicotinamide, Food content i.e. carbohydrate, protein, lipids, Minerals; sodium, calcium, potassium, phosphorus, magnesium, ferrous, copper, zinc, and sugars; raffinose, lactose, sucrose, glucose etc.<sup>[10]</sup>

**Traditional uses:** In Himalaya Leaves of *Kalanchoe pinnata* are applied to a wound, bruises, swelling, and insect bite. extract of leaves is taken on an empty stomach is used in the treatment of urinary bladder stones in Arunachal Pradesh. In Maharashtra the leaves juice is used against cough, dysentery. In Karnataka Leaf juice is externally applied to scabies and leucoderma and a leaf decoction is applied over cuts to stop bleeding. And outside of India in Brazil *Kalanchoe pinnata* use for burns, calluses, conjunctivitis, corns, coughs, dermatitis, dermatosis, earaches, eczema, edema, erysipelas, fever, glaucoma, headache, infections, inflammation, insect stings, intestinal problems, itch, kidney stones, lymphatic disorders, mouth sores, nervousness, respiratory infections, rheumatism, scurvy, skin problems, toothache, tuberculosis, tumor, ulcers, urinary insufficiency, wart, whooping cough, wounds, and as a sedative.<sup>[11]</sup>

### **Cultivation, Preservation & Propagation**

#### **Cultivation**

**Climate and Soil Requirements:** Warm, tropical, and subtropical conditions are ideal for *Kalanchoe pinnata* growth. For best growth, it needs a moderate temperature of 20 to 30°C. Being a succulent that can withstand drought, it is perfect for water-wise gardening and xeriscaping. The plant likes soil that drains well and has a pH between 6.0 and 7.5. For field planting or container development, a blend of organic materials and cactus potting mix or sandy loam is advised. In thick, water-retaining soils, root rot is a typical problem that can be avoided by adding sand or perlite to the soil mix to further improve drainage.<sup>[12]</sup> **Light Requirements:** Full sun to partial shade is necessary for *Kalanchoe pinnata*. It needs at least four to six hours of direct sunshine per day to thrive well. However, leaf burn may result from prolonged exposure to the strong noon sun. The best location for container-grown plants is one that gets morning sunlight and afternoon shade.<sup>[13]</sup> **Watering and Fertilization:** *Kalanchoe pinnata* requires less water because it is a succulent. In the spring and summer, when growth is most active, watering once a week is adequate; in the autumn and winter, watering should be reduced to once every two to three weeks. Fungal infections and root rot can result from overwatering. Healthy growth and flowering are supported by applying a slow-release, balanced fertiliser twice a year, in the early spring and late summer. For a nutrient boost, a diluted liquid fertiliser can be applied every four to six weeks throughout the growing season.<sup>[14]</sup>

#### **Preservation**

**Harvesting and Drying:** When *Kalanchoe pinnata* reaches maturity (6–12 months old), the leaves are typically harvested for medicinal purposes. Carefully removing leaves will prevent harm to the plant. If the plant cannot be produced all year round, drying is a crucial preservation technique to preserve its therapeutic properties. Spreading the leaves in a single layer in a well-ventilated, shaded area will help them dry. An other method that successfully preserves the bioactive chemicals is to use a dehydrator set at a low temperature (40– 50°C).<sup>[15]</sup> **Storage:** To preserve their efficacy, the dried leaves should be kept in airtight containers in a dry, cool, and dark location. The phytochemicals that give the plant material its therapeutic properties can be weakened by storing it in places with high humidity or intense sunshine.<sup>[16]</sup>

#### **Propagation**

The distinctive ability of *Kalanchoe pinnata* to develop plantlets along the edges of its leaves—a feature common to the Bryophyllum genus—makes it exceptionally simple to propagate. Plantlets and leaf cuttings are the two primary means of propagation.

**Propagation by Plantlets:** The small plantlets that develop along the leaf margins are the most often used propagation strategy. When fully grown, these plantlets separate and are able to take root in the ground. Plantlets can be propagated by simply placing them on potting mix that drains well and watering them sparingly. In a few weeks, they will start to grow.<sup>[17]</sup> **Propagation by Leaf Cuttings:** Alternatively, leaf cuttings can be used to propagate *Kalanchoe pinnata*. Place a healthy leaf on top of a potting mix that is moist and drains properly. New shoots will appear a few days after the roots at the leaf's base. Young roots are especially vulnerable to rot, so it's important to avoid overwatering.<sup>[18]</sup>

### Geography and Collection

**Native Region:** Madagascar, an island renowned for its distinctive biodiversity and tropical environment, is the origin of *Kalanchoe pinnata*.

**Global Distribution:** Parts of Africa, Asia, the Americas, and Australia are among the tropical and subtropical regions where this plant is extensively found. Although it can survive in a variety of conditions, it favours warm, humid settings.<sup>[19]</sup>

**Growth Conditions:** **Temperature:** Temperatures between 20°C and 30°C are ideal for *kalanchoe pinnata* growth. **Soil:** It favours sandy or loamy soils that drain well and are high in organic matter. **sunshine:** Full to partial sunshine is ideal for the plant's growth.

**Ecological Adaptations:** Because of its succulent leaves, which retain water, the plant can withstand drought. It is extremely adaptable to a variety of environments due to its capacity for vegetative reproduction from leaf edges.<sup>[20]</sup>

**Collection Time:** To ensure the highest phytochemical content, *Kalanchoe pinnata* should be harvested as soon as it begins to flower.

**Procedure for Collection:** **Identification:** To prevent misunderstanding with other species, make sure the plant is correctly identified.

**Parts gathered:** While the stem and roots may potentially be used medicinally, leaves are the most frequently gathered part.

**Method:** To avoid harming the plant, the leaves are often hand-picked. It is advised to wear gloves to prevent skin irritation.<sup>[21]</sup>

**Post-Harvest Handling:** To maintain the bioactive chemicals, the leaves should be cleaned to get rid of dirt and then dried in the shade. Their effectiveness for extended usage is ensured by proper storage in sealed containers.

**Sustainability:** The native populations of the plant may be threatened by overharvesting. Conservation depends on sustainable gathering methods, such as letting plants regrow.<sup>[22]</sup>

### Extraction Techniques

**Decoction Method:** Decoction is a method of extraction by boiling herbal or plant material (which may include stems, roots, bark and rhizomes) to dissolve the chemicals of the material.

In one of the study, researcher did decoction extraction by using water as solvent. In that study, researcher had taken fresh leaves of *kalanchoe pinnata* and were chopped and boiled in water afterward the extraction was filterout by

whatman filter paper. Additionally, they investigate in-vitro Antiurolithiatic activity of kalanchoe pinnata. Extract they got significance and useful result.<sup>[23]</sup>

**Maceration Method:** Maceration is one of the simplest extraction techniques in which coarse and powdered plant material is soaked in solvents such as methanol, ethanol, ethyl acetate, acetone, hexane etc. It is one of the popular and inexpensive techniques used for the extraction of different bioactive compounds from plant material.

In one of the study, observer did Maceration extraction by using ethanol as solvent. In that study, Observer had taken (400g) leaves of kalanchoe pinnata were washed and dried in direct sunlight. Then fine powdered was prepared by grinding the dry leaves in blender.

Afterwards (300g) fine powder of Kalanchoe pinnata was dissolved in (600ml) ethanol and kept for 24 hrs at room temperature. Then the Ethanolic extract was filtered and kept for drying in a water bath at temperature 40° C. Then they were obtained 15g of clear Ethanolic extract of kalanchoe pinnata. Additionally, they investigate Wound healing potential of ethanolic extract of Kalanchoe pinnata. They got significance and useful result.<sup>[24]</sup>

In another study, Observer did Maceration extraction by using menthol as solvent. In that study observer had taken fresh leaves of kalanchoe pinnata were chopped into small pieces by hand and put into a conical flask. Volume of menthol to water was in ratio of 80ml: 80ml was added in conical flask and covered with cotton plug on mouth of flask. then it was kept in Maceration for 15 days at 4°c in order to maximize the extraction. After 15 days it was filtrated through whatman filter paper and transfer sutaible container. Additionally, they investigate total antioxidant capacity of kalanchoe pinnata extract. They got significance and useful result.<sup>[25]</sup>

**Soxhlet Extraction method:** The Soxhlet extraction method is a widely used technique for extracting bioactive compounds or specific constituents from plant or other solid materials.

In one of the study, Analyst did soxhlet extraction by using hydro-alcohol as a solvent analyst had taken 50g of coarse powder of the leaves of kalanchoe pinnata and place it in 250ml of hydro-alcohol for 24 hrs. The concentrated extract was then evaporated to dryness using an electronic water bath at 60°C. The dried extract was then stored in a refrigerator at 4°C. Later, when the extract was tested on mice, they found significant analgesic, anti- allergic, anti-anaphylactic, anti-inflammatory, anti-leishmanial, anti-tumorous, anti-ulcerous, antibacterial, activity of kalanchoe pinnata extract. They got useful results without any side effects.<sup>[26]</sup>

In another study analyst did soxhlet extraction by using petroleum ether as solvent. In that study, Analyst had taken 78g of kalanchoe pinnata leaves and extracted with 700ml of 80% menthoal using soxhlet apparatus. Then the extraction was carried out for 8 hrs and extract was thereafter concentrated by evaporation in roto-vaccum. They investigate Antioxidant activity of kalanchoe pinnata extract. They got significance and useful result.<sup>[27]</sup>

In another study, analyst did soxhlet extraction by using dried stem of kalanchoe pinnata. The dried stem of kalanchoe pinnata was extracted with solvent of increasing polarity by soxhlet apparatus whereas aqueous was obtained by cold maceration. They got percentage yield of plant extract is Petroleum ether - 3.63 %, Ethanol - 5.03 %, Aqueous - 4.30 %. The percentage yield of ethanolic extract of stem of kalanchoe pinnata was found to be greater (5.03%) than other extract.<sup>[28]</sup>

**Nanotechnology applications for expanding utilization of kalanchoe pinnata**

- 1. Nanoformulations for Drug Delivery:** Drug distribution that is both targeted and maintained is ensured by encapsulating *Kalanchoe pinnata*'s bioactive components in nanoparticles (such as liposomes or polymeric nanoparticles). This minimises adverse effects and lowers the necessary dosage. For instance, to improve bioavailability, quercetin and flavonoids from *Kalanchoe pinnata* can be combined to create nanoparticles.
- 2. Enhanced Antioxidant and Anti-inflammatory Effects:** *Kalanchoe pinnata* extract-based nanoemulsions increase the stability and absorption of antioxidants, boosting their medicinal effectiveness.[29]
- 3. Wound Healing:** Because of their antibacterial action, silver nanoparticles made from *Kalanchoe pinnata* extract have shown remarkable wound-healing capabilities.
- 4. Cancer Therapy:** When loaded onto nanocarriers, phytochemicals from *Kalanchoe pinnata* can enhance their cytotoxic effects on cancer cells while preserving healthy tissues.[30]
- 5. Cosmetic Applications:** Nanogels or nanocrems based on *kalanchoe pinnata* extract are used to cure eczema, reduce inflammation, and rejuvenate the skin.
- 6. Green Synthesis of Nanoparticles:** In the environmentally friendly synthesis of metallic nanoparticles (such as gold and silver) for use in antimicrobial coatings, medication delivery, and diagnostics, the plant extract acts as a reducing agent.<sup>[31]</sup>

**Bioactive components**

- 1. Flavonoids:** Eg. Quercetin, Kaempferol, Luteolin.

Properties: Antioxidant, Anti-inflammatory, Antimicrobial, Hepatoprotective.

Mechanism: scavenges free radicals, prevents oxidative stress on biological components, and suppresses pro-inflammatory mediators (such as COX-2).

- 2. Alkaloids:** Eg. Bryophyllin A and B Properties: Antitumor, Insecticidal.

Mechanism: block specific enzyme systems and impede cellular development.<sup>[32]</sup>

- 3. Triterpenoids:** Eg. Bryophyllin C

Properties: Antitumor, Antiviral, Anti-inflammatory

Mechanism: changes inflammatory pathways by blocking MAPK and NF- $\kappa$ B signalling.

- 4. Steroids:** Eg.  $\beta$ -sitosterol, Stigmasterol

Properties: Anti-inflammatory, Immunomodulatory, Anticancer.

Mechanism: interacts with immune cell signalling to reduce inflammation.<sup>[33]</sup>

- 5. Phenolic Compounds:** Eg. Gallic acid, Caffeic acid.

Properties: Antioxidant, Antimicrobial, Anti-diabetic.

Mechanism: Protects against oxidative damage and inhibits microbial growth.

- 6. Glycosides:** Eg. Bufadienolides (e.g., bersaldegenin-1-acetate).

Properties: Cardiotonic, Antitumor, Antibacterial.

Mechanism: has cytotoxic effects on cancer cells and increases heart contractility.<sup>[34]</sup>

**7. Organic Acids:** Eg. Malic acid, Citric acid Properties: Antimicrobial, Detoxifying  
Mechanism: breaks down the cell walls of bacteria and promotes detoxification.

### 8. Other Bioactive Compounds

Polysaccharides: Immunostimulatory and anti-inflammatory properties.

Saponins: lower cholesterol and have antibacterial and anti-inflammatory properties.

Vitamins and Minerals: contribute to the antioxidant and nutritional characteristics of the plant.<sup>[35]</sup>

### Pharmacological Activity

**Anti-Inflammatory Activity:** The various extracts/fractions of leaves of *Bryophyllum pinnatum* were investigated in chemically-induced inflammation rodent model. Indomethacin showed more or less uniform inhibition of edema in early intermediate and later phases.

Methanolic fraction showed also more or less significant inhibition of formaldehyde induced edema in early phases while significant inhibition at later phases.<sup>[36]</sup>

**Wound Healing Activity:** Ethanolic extract due to treated animal showed comparatively high wound healing potency with standard drug mupirocin. There was also a marked reduction in swelling in the area of the wound 3days of extract treatment. The Statistics of Hydroxyproline Content of Granulation Tissue Was animals of the starfs logan significantly higher control group.<sup>[37]</sup>

**Herbal Tonic:** This plant is a good source of ascorbic acid, riboflavin, thiamine and niacin. Natural ascorbic acid is essential for the body's functioning; for example, the production of intercellular substances in the body, including collagen, bone matrix and dental dentin. Therefore, clinical symptoms of scurvy, such as oral mucosal bleeding, gastrointestinal bleeding, anemia and joint pain, may be related to ascorbic acid and normal connective tissue. The activity of ascorbic acid explains its natural benefits. For this reason, the plant is used in herbal medicine to treat colds and other conditions such as prostate cancer. In one study, an herbal extract made from several plants, including lupine, was given as a supplement to improve breathing, help flush toxins and increase energy levels.<sup>[38]</sup>

**Antihypertensive Activity:** This study investigated the effects of *K. pinnata* leaf aqueous extract on blood pressure in the liver and kidney during anesthesia in rabbits. The results showed that the extract slightly reduced blood pressure during anesthesia and also reduced the effects of epinephrine-induced increases in blood pressure. It was concluded that this study provides a pharmacological basis for the use of *K. pinnata* in lowering blood pressure among the Igbo people of Nigeria. However, its actual blood pressure lowering effect is low and *K. pinnata* leaf extract has the potential to be toxic to the body, so it cannot be used to monitor one's blood pressure.<sup>[39]</sup>

**Uterine Contractility:** B. Gwehenberger et al. first described the in vitro phytotherapeutic tocolytic effects of *B. Pinnatum* and the beta-mimetic fenoterol on human myometrium.

Measurement of adherence was performed during myometrial strip biopsy during caesarean section in 14 women exposed to the introduction of *B. Pinnatum* with +/- oxytocin 1 U/l. The results show that inhibition of spontaneous contractions is concentration dependent. *B. Pinnatum* increases contraction frequency by 91% of the steady amplitude and inhibits oxytocin-stimulated contractions by 20% of the steady amplitude, but with less frequency.

Fenoterol reduces contractions by 50% Especially less frequent.<sup>[40]</sup>

**Anthelmintic Activity:** *K. pinnata* roots were extracted using petroleum ether, chloroform, methanol, and aqueous solvent, respectively, and their anthelmintic activity against *Ascaridia galli* (nematode) and *Pheretima posthuma* (Annelida) was assessed in vitro. The findings indicate that *K. pinnata* extracts in aqueous, methanolic, and chloroform form exhibit strong anthelmintic activity, whereas petroleum ether has no helminth-fighting properties. Out of all the anthelmintic agents, methanolic extract of *K. pinnata* root was shown to be the most efficacious. In comparison to the reference medication, the *K. pinnata* root extract not only showed paralysis but also killed worms, particularly at higher doses of 100 mg/ml, in a shorter amount of time.<sup>[41]</sup>

**CNS depressant activities:** Significant behavioural pattern changes were elicited by methanolic fractions of *Bryophyllum pinnatum* leaves, including dose-dependent potentiation of pentobarbitone sleeping time and notable impacts on analgesic activity. Conversely, there was a noticeable decline in exploratory performance and a loss of lingering curiosity.<sup>[42]</sup>

**Antimicrobial activity:** *K. pinnata* roots were extracted using petroleum ether, chloroform, methanol, and aqueous solvent, respectively, and their antibacterial efficacy against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans* was assessed in vitro. According to a study, 60% methanolic leaf extract inhibits the growth of five out of eight bacteria used at a concentration of 25 mg/ml. Methanolic extract of *K. pinnata* roots was found to be the most effective antibacterial when compared to other extracts, but none of the extracts demonstrated activity against *Candida albicans*. While *Klebsiella pneumoniae*, *P. aeruginosa*, and *Candida albicans* were shown to withstand the extract's activity, *Bacillus subtilis*, *E. coli*, *Proteus vulgaris*, *Shigella dysenteriae*, and *S. aureus* were found to be inhibited.<sup>[43]</sup>

**Antidiabetic Activity:** The zinc content of the plants may indicate that they can be useful in the treatment of diabetes, which is caused by insulin failure. Using the 'hot-plate' and 'acetic acid' test models of pain in mice, Ojewole assessed the herb's aqueous leaf extract's antinociceptive properties. Rats with streptozotocin-induced diabetes mellitus and fresh egg albumin-induced pedal oedema were used to test the plant extract's anti-inflammatory and antidiabetic properties. Mice exposed to chemically and thermally generated nociceptive pain stimuli showed considerable ( $P < 0.05-0.001$ ) antinociceptive responses to the aqueous leaf extract. Additionally, the plant extract considerably ( $P < 0.05-0.001$ ) reduced acute inflammation brought on by fresh egg albumin and caused rats to experience marked hypoglycemia. The herb's many flavonoids, polyphenols, triterpenoids, and phytosterols are thought to be responsible for the plant's noted antidiabetic, anti-inflammatory, and antinociceptive effects. It likely works by preventing the release, synthesis, and/or production of inflammatory cytokines and mediators, including as prostaglandins, histamine, polypeptide kinins, and others, to provide antinociceptive and anti-inflammatory effects.<sup>[44]</sup>

**Neuroprotective activity:** In mice, *Bryophyllum pinnatum* leaf extract in water has neuropharmacological effects. Additionally, the *Bryophyllum pinnatum* extract demonstrated a strong sedative effect, as demonstrated by a notable decrease in gross behaviour and an increase in pentobarbitone-induced sleep duration.<sup>[45]</sup>

### Safety and toxicity issues of *Kalanchoe pinnata*

**1. Toxic Components:** Bufadienolides: *Kalanchoe pinnata* contains cardiac glycosides, which are known to have



potentially harmful effects on the heart. Symptoms of overconsumption include nausea, vomiting, and, in extreme situations, heart arrhythmias.

**2. Animal Studies:** Toxicity in Livestock: Large-scale animal consumption of *Kalanchoe pinnata* has been linked to cases of cattle poisoning. Lethargy, drooling, diarrhoea, and heart problems are some of the symptoms.[46]

**3. Cytotoxicity:** According to studies, some cancer cell lines may be cytotoxically affected by plant extracts, however large dosages may also endanger healthy cells.

**4. Hepatotoxicity:** Although few, several research suggest that excessive dosages or extended use of *Kalanchoe pinnata* may be harmful to the liver.<sup>[47]</sup>

**5. Carcinogenic or Mutagenic Risks:** No strong evidence exists of *Kalanchoe pinnata* being carcinogenic or mutagenic. However, further studies are necessary to confirm its long-term safety.

**6. Pregnancy and Breastfeeding:** The safety of *Kalanchoe pinnata* during pregnancy and lactation is not well documented. Bufadienolides may be harmful to nursing babies or foetal development.<sup>[48]</sup>

## CONCLUSION

*Kalanchoe pinnata*'s phytochemical diversity and wide range of therapeutic uses provide it great potential as a medicinal plant. Its availability is guaranteed by its tolerance to many climates and growing methods, and the effectiveness of its bioactive chemicals is enhanced by contemporary extraction procedures. Nonetheless, the plant's possible toxicity and scant clinical evidence emphasise the need for more research, especially in human subjects. To protect this priceless natural resource, sustainable farming and harvesting methods are essential. In order to successfully incorporate *K. pinnata* into conventional healthcare, future studies should concentrate on creating standardised formulations and clinical validations.

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