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Review Article

Exploring The Pharmacological Activities of Kalanchoe Pinnata: A Review

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ABSTRACT

Kalanchoe pinnata, a succulent plant widely recognized for its traditional medicinal uses, has garnered significant attention for its diverse pharmacological activities. This review explores the various therapeutic properties attributed to Kalanchoe pinnata, including its anti-inflammatory, antimicrobial, and antioxidant effects. Research has demonstrated its efficacy in promoting wound healing, alleviating respiratory ailments, and aiding digestive health. The plant's bioactive compounds, such as flavonoids, phenolic acids, and saponins, are believed to contribute to these beneficial effects. Despite its long-standing use in traditional medicine, scientific validation and mechanistic studies are still needed to fully understand its therapeutic potential. This paper emphasizes the importance of further research to explore the pharmacological properties of Kalanchoe pinnata, which could lead to the development of novel natural products for clinical applications.

INTRODUCTION

Since life began on Earth, diseases have evolved, presenting constant challenges to researchers who seek effective defense mechanisms. Plants have long been crucial therapeutic resources for humanity, extensively researched for their potential in combating various severe diseases. Medicinal plants, valued for their healing qualities, play a critical role in preventing and treating illnesses, often with minimal toxicity and few side effects. The Kalanchoe genus includes multiple

species with well-documented medicinal uses. One such species, Kalanchoe pinnata (also called Bryophyllum pinnatum), known as "Ranakalli," "Miracle Leaf," "Life Plant," and "Mother of Thousands," belongs to the Crassulaceae family. This plant is unique for developing small plantlets on its leaf edges that can detach and grow independently. A water-storing perennial, K. pinnata reaches heights of 1–1.5 meters, displaying fleshy green leaves with scalloped edges, hollow stems, and bell-shaped flowers.

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Thriving in tropical and temperate areas of Africa, Australia, and the Americas, it is a prominent feature in traditional Asian medicine. In African traditional medicine, *K. pinnata* has been used for childbirth, ulcer care, skincare, and rheumatism relief, valued for its wound-healing and gallstone-alleviating abilities. Therapeutically, it exhibits antioxidant, anticancer, antimicrobial, antiviral, anti-inflammatory, antidiabetic, and liver-protective properties. Its use in anthroposophic medicine, a system informed by Rudolf Steiner's principles, has spanned over 90 years, highlighting its effects on human metabolism. Laboratory studies emphasize its antihistamine properties, muscle-relaxing effects akin to beta-agonists, and sleep-enhancing benefits for pregnant women, all with minimal side effects. Additionally, *K. pinnata* extracts can regulate uterine contractions, while its sour leaves and bark provide carminative benefits and a bitter, astringent tonic that aids in acne care. Traditionally, fresh leaf juice is used to address ailments like gout, headaches, earaches, asthma,

diarrhea, jaundice, and fatigue, and it is specifically applied to treat jaundice in Bundelkhand, India. Research has also examined the plant's mutagenic and anti-mutagenic properties. With bioactive compounds including alkaloids, phenols, flavonoids, saponins, tannins, and glycosides, *K. pinnata* displays an extensive range of pharmacological effects. This review aims to highlight the medicinal and ethnomedicinal significance of *K. pinnata* (Linn.) Pers. [1-5]



Img: Kalanchoe Pinnata

Taxonomy Classification:

Kingdom:	Plantae (Plants)
Subkingdom:	Tracheobionta (Vascular plants)
Super division:	Spermatophyta (Seed plants)
Division:	Magnoliophyta (Flowering plant)
Class:	Magnoliopsida (Dicotyledonous)
Subclass:	Rosidae
Order:	Saxifragales
Family:	Crassulaceae Stonecrop family
Genus:	Kalanchoe
Species:	Kalanchoe pinnata (Lam.) Per

Chemical Constituents:

The *Kalanchoe pinnata* plant, notable for its subtle sweetness and mildly tangy fragrance, is widely esteemed for its therapeutic applications. Various species within the *Kalanchoe pinnata* family are classified based on unique flavor characteristics. This plant generally reaches a height of 1 to 1.5 meters. Despite its moniker, "Sweet *Kalanchoe pinnata*" exhibits a green hue with a tangy flavor. The signature scent of different *Kalanchoe pinnata*

species and varieties is due to the essential oils present in the leaves and other parts. This species is abundant in compounds such as lipids, alkaloids, triterpenes, bufadienolides, steroids, glycosides, cardenolides, and flavonoids. The leaves contain bufadienolides like bryotoxin-C, bryotoxin-B, bryotoxin-A, digitoxin, and digoxin, recognized for their chemopreventive, anti-tumor, antibacterial, and insect-repellent effects. Traditionally, the plant's bitter leaves and bark

have been employed for their carminative, pain-relieving, and astringent properties to manage symptoms of diarrhea and vomiting. Key anti-ulcer agents in this plant include arachidic acid, astragalol, behenic acid, β -amyrin, benzenoids, β -sitosterol, bryophollone, bryophollone, bryophyllin, bryophyllin-AC, bryophyllol, bryophynol, bryotoxin-C, bufadienolides, caffeic acid, campesterol, cardenolides, cinnamic acid, clerosterol, clionasterol, codisterol, coumaric acid, epigallocatechin, ferulic acid, flavonoids, friedelin, glutinol, hentriacontane, isofucosterol, kaempferol, oxalic acid, oxaloacetate, palmitic acid, patuletin, peposterol, phosphoenolpyruvate, protocatechuic acid, pseudotaraxasterol, pyruvate, quercetin, steroids, stigmasterol, succinic acid, syringic acid, taraxerol, and triacontane. It also contains essential fatty acids like behenic, arachidic, stearic, and palmitic acids, along with HCN, succinic acid, oxalic acid, malic acid, citric acid, oxaloacetate, and isocitric acid. Nutrient-rich, the plant provides methionine, casein hydrolysate, glutamic acid, ascorbic acid, cysteine, riboflavin, glycine, thiamine, pyridoxine, niacin, and protein hydrolysate. Significant levels of calcium, potassium, zinc, iron, sodium, magnesium, phosphorus, riboflavin, thiamine, and niacin enhance its nutritional value. Noteworthy phytochemicals include flavonoids, alkaloids, tannins, phenolics, and minerals such as zinc, iron, sodium, phosphorus, potassium, calcium, and magnesium. Additional constituents comprise vitamins and derivatives like phosphoenolpyruvate, protocatechuic acid, ferulic acid, p-coumaric acid, p-hydroxycinnamic acid, 4-hydroxybenzoic acid, and u-hydroxy-3-methoxycinnamic acid, with astragalol, rutin, 3,8-dimethoxy-4,5,7-trihydroxyflavone, friedelin, kaempferol-3-glucoside, quercetin-3-O-diarabinoside, quercetin-3-L-rhamnosido-L-arabino-furanoside, and epigallocatechin-3-osyryglate also noted in the leaves. [6-8]

Traditional Uses:

Kalanchoe pinnata, commonly referred to as the "mother of thousands" or the "leaf of life," holds a vital place in traditional medicine across different cultures. Its leaves are often applied topically to support wound recovery and reduce inflammation, while infusions made from the plant are ingested to help with infections, digestive issues, and respiratory ailments. Known for its antibacterial and anti-inflammatory qualities, *Kalanchoe pinnata* is widely used in folk remedies. Recent research has started to highlight its significance in natural healing practices and examine its therapeutic possibilities. In several African countries, *Kalanchoe* juice is traditionally used to address ailments such as cholera, ear infections, abscesses, whitlow, tissue damage, joint discomfort, stomach ulcers, and children's split lips. In Southeastern regions, it assists in the expulsion of the placenta following childbirth. Fresh leaves are either rubbed on or fastened to the forehead to relieve headaches. Across Africa, this herb is also employed for treating conditions such as rheumatoid arthritis, pneumonia, immune system disorders, and gastric ulcers. In Indonesia, it is utilized to manage a range of health issues. [9-11]

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Pharmacological Activities:

- 1. Wound Healing Activity:** The ethanolic extract of *Kalanchoe pinnata* has been shown to significantly reduce the size of wounds, cuts, and swelling at affected sites, highlighting its wound-healing capabilities. Recent studies suggest that phenolic antioxidants and steroidal glycosides may contribute to these healing effects. Additionally, research indicates that extracts prepared with water, petroleum ether, and alcohol may aid in wound recovery, with aqueous extracts proving more effective than etheric and alcoholic forms. [13]
- 2. Antioxidant Activity:** Reactive oxygen species (ROS), including singlet oxygen, superoxide, peroxy radicals, hydroxyl radicals, and peroxy nitrite, are known to cause cellular injury. Antioxidants are essential in protecting cells from such oxidative damage. Generally, antioxidants act as reducing agents, often due to compounds known as reductones. These reductones contribute to antioxidant action by donating electrons or hydrogen atoms, which interrupts the propagation of free radical chains. Additionally, they can react with peroxide precursors to block their formation. In the context of cardiovascular health, antioxidant properties have demonstrated beneficial

correlations. Studies suggest that scavenging capacity is dose-dependent, with leaves typically showing greater scavenging ability than stems. Enhanced antioxidant effects seen in ethanolic extracts may be due to their high phenolic and flavonoid concentrations. Phenolic compounds are particularly effective in lipid phases, where they can stabilize radicals by forming phenoxyl radicals and directly quench peroxy radicals, thereby preventing lipid oxidation. Research indicates that ethanolic extracts from *K. pinnata* provide superior oxidative protection compared to conventional antioxidants in both lipid and aqueous systems. Their metal-binding properties in aqueous solutions may help reduce metal-driven oxidative stress in lipid environments. Other studies reveal that certain components and methanolic extracts exhibit strong antibacterial and antioxidant effects, with methanolic root extracts being the most potent, although other leaf extracts also displayed antioxidant activities across multiple assays. [14,15]

- 3. Antitumour Activity:** Research on mice with experimentally induced peritoneal tumors indicates that methanolic and aqueous extracts of *Kalanchoe pinnata*, administered at specific dosages, lowered ascitic fluid levels and inhibited tumor development, suggesting potential antitumor activity. Further investigations using the plant's chloroform extract identified specific phytochemicals that induced apoptosis and inhibited growth in cervical cancer cell lines. Additionally, the antiviral properties of *K. pinnata* have been highlighted in related studies. Another study on rats with liver cancer induced by N-diethylnitrosamine (DEN) found that treatment with the aqueous extract reduced liver damage. This protective effect is likely due to its



antiperoxidative and antioxidant properties, as well as its ability to normalize lipid metabolism by enhancing the function of lipid-metabolizing enzymes. DENA, a significant environmental hepatocarcinogen, is known to generate liver free radicals, impair antioxidant defenses, and encourage oxidative stress and carcinogenesis. The aqueous extract acted by scavenging free radicals, reducing necrotic damage, and protecting hepatocytes from DENA's carcinogenic impact, although histopathological analysis of liver sections from DENA-treated rats showed severe centrilobular necrosis and vacuolization. [16,17]

- 4. Anti-Inflammatory Activity:** The plant's leaves were used to produce extracts with petroleum ether, methanol, acetone, chloroform, and formaldehyde for experiments aimed at evaluating their effects on edema. Of these, the methanolic extract showed the highest efficacy in reducing paw edema. The study also investigated the involvement of bradykinin, prostaglandins, serotonin, and histamine in inflammation caused by formaldehyde, which can stimulate the formation of endogenous mediators. Results suggested that bufadienolides and other compounds in the water-soluble extract played a crucial role in inhibiting formalin-induced edema in rats. [18]
- 5. Antiviral Activity:** Cervical cancer is largely attributed to the human papillomavirus (HPV), posing a significant health risk. Studies have examined the anti-cancer and anti-HPV properties of chloroform extracts from this plant, with findings indicating that the fractions derived from these extracts inhibit viral growth and tumor formation by suppressing viral protein production. Additionally, research on bufadienolides,

isolated from the plant's methanolic extract, showed their potential to obstruct viral activation and tumor progression linked to the Epstein-Barr virus. This herpes virus is known for targeting human B-lymphocytes and promoting tumor growth. [19]

- 6. Immunomodulatory Activity:** The aqueous extract derived from the leaves of *Kalanchoe pinnata* significantly inhibited both humoral and cell-mediated immune responses in mice, as demonstrated in a model where spleen cells were pre-treated with the extract. Various administration routes—including intravenous, topical, intraperitoneal, and oral—induced a delayed-type hypersensitivity reaction to ovalbumin. This indicates the immunosuppressive properties of the *K. pinnata* extract. Furthermore, cases of fatal anaphylactic shock exhibited Th2-type T-cell-mediated immunopathology alongside the protective effects associated with *K. pinnata* leaves. The in vivo oral protection was correlated with reduced eosinophil counts, diminished IgE antibody levels, and lower secretion of interleukin-5, interleukin-10, and tumor necrosis factor cytokines. Additionally, in vitro studies showed that *K. pinnata* inhibited mast cell degranulation triggered by antigens.[20]
- 7. Nephroprotective and Antioxidant Activity:** The nephroprotective properties of the aqueous extract of *Kalanchoe pinnata* were assessed in rats subjected to Gentamycin-induced toxicity. Results demonstrated that the *K. pinnata* leaf extract significantly safeguarded rat kidney tissues from histological damage caused by Gentamycin. In the group receiving both Gentamycin and the *K. pinnata* extract, there was a marked decrease in glomerular contraction, vascular constriction within the peritubular area, tissue inflammation, and

renal cell apoptosis. Conversely, rats treated solely with Gentamycin showed elevated blood urea, blood urea nitrogen, urine creatinine levels, and kidney weight. Meanwhile, those given the *K. pinnata* aqueous extract demonstrated resilience to these adverse effects and produced greater urine volumes. Histopathological examination revealed that Gentamycin led to inflammation, glomerular shrinkage, and reduced peritubular capillary and vascular size. However, co-administration of the *K. pinnata* extract significantly alleviated these Gentamycin-induced changes, while the control group showed normal renal histology. In vitro studies indicated that the leaf extract of *K. pinnata* had robust antioxidant capabilities and effectively scavenged free radicals. Furthermore, compounds such as kaempferol and quercetin found in *K. pinnata* leaves provided protective effects against cadmium-induced nephrotoxicity, potentially through increased metallothionein production, enhanced endothelial nitric oxide synthase (eNOS) activity, and the suppression of COX-2 and inducible nitric oxide synthase (iNOS) expression [21,22].

8. Antimicrobial Activity: The ethanol-based extract of *Kalanchoe pinnata* leaves yielded an alkaloid and two flavonoids, which showed notable antibacterial effects. These phytochemicals effectively inhibited a range of gram-positive and gram-negative bacterial strains, as well as certain fungi. The assessment of antibacterial efficacy was conducted with both aqueous and methanolic extracts from the plant's stem, with the methanolic extract displaying a stronger inhibition effect. In addition to skin infections, bacterial pathogens are known to cause numerous health problems, including respiratory infections, foodborne illnesses,

wound infections, abscesses, osteomyelitis, endocarditis, and pneumonia, all of which can lead to serious complications upon entering the body. Consequently, the extracts may play a vital role in addressing these conditions. The study's findings highlight the potential to develop antibacterial and antifungal creams for commercial distribution. Furthermore, investigations into the bioactive elements in the leaf extract, particularly against bacteria responsible for respiratory infections, reinforce the plant's traditional use in treating respiratory conditions such as pneumonia. In addition, both petroleum ether and aqueous extracts of *K. pinnata* exhibited antifungal and cytotoxic properties comparable to common antifungal treatments [23–24].

9. Antileishmanial Activity: Mice that were infected with *Leishmania amanuensis* received an oral administration of the aqueous extract from *K. pinnata* as a treatment for leishmaniasis, an illness caused by protozoans belonging to the *Leishmania* genus. The findings indicated a reduction in both the size of lesions in the affected regions and the overall parasite load. Continued application of the extract not only inhibited the progression of the infection but also controlled its proliferation. This approach shows potential for treating visceral leishmaniasis. The antileishmanial effects of the plant extract may be attributed to flavonoid glycosides [25, 26].

10. Antidiabetic Activity: The ethanol-based extract of *Kalanchoe pinnata* leaves yielded an alkaloid and two flavonoids, which showed notable antibacterial effects. These phytochemicals effectively inhibited a range of gram-positive and gram-negative bacterial strains, as well as certain fungi. The assessment of antibacterial efficacy was conducted with both aqueous and methanolic

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11. Antifungal Activity: A previous investigation assessed the antifungal properties of both petroleum spirits and liquid extracts derived from *Kalanchoe pinnata*, revealing that their effects were comparable to the well-known antifungal agent Griseofulvin [27]. Another study indicated that the methanolic extract of *K. pinnata* effectively inhibited the growth of *Aspergillus niger* and *Aspergillus flavus*, achieving reductions of 76% and 51%, respectively. Additionally, through genetic modification, *K. pinnata* has been engineered to express Cecropin P1 (CecP1) antimicrobial peptides, significantly enhancing its antifungal performance. This CecP1-enriched extract demonstrated superior effectiveness over commercial fungicides in eliminating *Candida albicans* from infected wounds [28].

12. Anthelmintic Activity: A comparative analysis was performed to evaluate the anthelmintic effectiveness of different solvent extracts on roundworms and earthworms. The petroleum ether extract showed no effect on the worms. In contrast, the aqueous, methanolic, and chloroform extracts from the roots of *K. pinnata* displayed significant anthelmintic activity. Notably, the methanolic extract was the most potent, particularly at elevated concentrations and shorter exposure durations, causing paralysis and mortality in the worms. This action is likely due to the presence of tannins, which may interact with glycoproteins on the parasites' surface or with free proteins in the host's gastrointestinal tract, ultimately leading to the death of the parasites. [29]

13. Hepatoprotective Activity: Rats with liver damage caused by chloroform exposure were used to evaluate the hepatoprotective effects of ethanolic extracts and fresh leaf juice from **Kalanchoe pinnata**. Research involving in vitro and in vivo studies, as well as histopathological assessments, demonstrated that fresh leaf juice was more effective than the ethanolic extract. Additionally, another investigation revealed that administering the plant's aqueous extract to rats suffering from DENA-induced liver toxicity led to a decrease in lipid peroxidation levels. Observations of intact liver cells and the absence of necrosis and vacuoles indicated that the antioxidant properties of the extract, which counteracted free radicals, played a crucial role in safeguarding against toxic agents. This protective effect on the liver may be linked to a decrease in the formation of harmful metabolites resulting from DENA.[4]

14. Haemoprotective Activity: The methanolic extract of *K. pinnata* was found to provide significant protection to human erythrocyte

membranes against lysis (hemolysis) induced by heat and hypotonic solutions. The bioactive compounds present in this plant serve as effective thrombolytic agents for managing conditions such as myocardial infarction, thromboembolic strokes, deep vein thrombosis, and pulmonary embolism, as they have the ability to dissolve blood clots within blood vessels. Additionally, the ethanol extract of *K. pinnata* demonstrated strong thrombolytic and antioxidant activities without exhibiting cytotoxic effects [30].

15. Gastroprotective Activity: The study revealed that the methanol-soluble fraction of *K. pinnata* extract effectively prevented the development of acute gastric and duodenal ulcers in rats and guinea pigs caused by different chemicals. Additionally, this extract notably accelerated the healing of these ulcers and offered protection to the gastric lining. The gastroprotective effects may result from the extract's local antisecretory and/or antipeptic actions. Another study found that the aqueous extract of the plant significantly reduced the ulcer index in mice and demonstrated gastroprotective effects. Both aqueous and mucilage extracts appear to be valuable in treating stomach ulcers, with the isolated mucilage from the plant also displaying promising antiulcer properties.[31]

16. Antihypertensive Activity: Research indicates that the aqueous extract of *K. pinnata* effectively inhibited increases in both systolic and diastolic blood pressure in rats, thereby counteracting salt-induced hypertension. This antihypertensive effect is believed to stem from the plant's antioxidant properties and its ability to modulate blood vessel function. Both aqueous and methanolic leaf extracts significantly lowered heart rates and arterial blood pressure in both normotensive and hypertensive rats.

Furthermore, these extracts diminished the contraction force and rate of isolated guinea pig atria. Notably, the cardiovascular effects of the extracts were not influenced by typical doses of common antagonist medications, suggesting a link between the observed cardio depression and vasodilation with the antihypertensive action. However, it was noted that administering higher doses of the extract to experimental animals led to toxic effects, including lethargy, reduced appetite, and, in some cases, mortality. Thus, it is crucial to validate dosages to avoid adverse effects, despite the plant's therapeutic potential [32–34].

CONCLUSION:

Kalanchoe pinnata, with its rich history in traditional medicine, demonstrates a diverse range of pharmacological activities that warrant further scientific investigation. Studies have highlighted its potential anti-inflammatory, antimicrobial, and wound-healing properties, along with its ability to support respiratory and digestive health. These findings suggest that *Kalanchoe pinnata* could play a significant role in developing natural therapeutic agents. As interest in herbal medicine continues to grow, understanding the active compounds and mechanisms behind these pharmacological effects will be essential for harnessing the full potential of this remarkable plant. Continued research may not only validate its traditional uses but also contribute to modern pharmacology and herbal therapies

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