MINI-REVIEW article

Phytochemistry and pharmacological insights into *Kalanchoe pinnata*: A brief review

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Abstract: Kalanchoe pinnata, commonly known as the "Wonder Plant," is a tropical succulent widely recognized for its broad spectrum of pharmacological activities and rich phytochemical profile. This review summarizes the phytochemical constituents and therapeutic potentials of K. pinnata as documented in various scientific studies. The plant demonstrates significant antimicrobial, anticancer, anti-inflammatory, antidiabetic, and wound-healing properties, largely attributed to its abundance of flavonoids, phenols, alkaloids, vitamins, and other bioactive compounds. These findings highlight its value in traditional medicine and support continued research into its pharmacological applications.

Introduction

Medicinal plants have gained widespread acceptance due to their significant role in traditional medicine, offering remedies for a variety of health concerns. One such medicinal plant is Kalanchoe pinnata. Kalanchoe pinnata, commonly known as the Wonder Plant, Resurrection Plant, Air Plant, or Africa Never Die, is a perennial shrub found in parts of Africa, the West Indies, Asia, Australia, Bermuda, the Mascarenes, the Galapagos Islands, New Zealand, Brazil, Suriname, Polynesia, and Hawaii. However, it is most commonly found in Madagascar and other regions of Africa [1]. The plant grows up to about 1 meter in height and has over 450 known species. It features cylindrically shaped leaves on a succulent stem. What makes K. pinnata unique is that all parts of the plant are medicinally useful. It is easily propagated through stem or leaf cuttings [2]. Originally introduced as an ornamental plant, it is now often found growing wild as a weed in plantation areas. In traditional medicine, Kalanchoe species have been used to treat infections, rheumatism, and inflammation, and are known for their immunosuppressive properties [1, 2]. In southeastern Nigeria, for instance, K. pinnata plays a role in childbirth practices, where it helps facilitate the detachment of a newborn's placenta. The leaves, when lightly roasted, are used externally to treat fungal skin infections. Leaf infusions are used internally to reduce fever [3]. Additionally, K. pinnata is used to manage pneumonia, intestinal

worms, asthma, and other respiratory tract infections, as well as various inflammatory conditions. It is believed to have antitussive, diuretic, and sedative effects. Other reported uses include the treatment of leg edema, stomach ulcers, and kidney [4]. In Ayurvedic medicine, the plant is valued as an astringent, analgesic, and carminative agent. It is also used to relieve nausea, vomiting, otitis (ear infections), convulsions, headaches, irritation, and general weakness. The leaves are particularly recognized in African traditional medicine for their antifungal properties [1, 3].

Figure 1: *Kalanchoe pinnata* plant displaying characteristic fleshy leaves with marginal plantlets [3].

Methods

This review was conducted using secondary data sourced from peer-reviewed articles accessed via databases such as ScienceDirect, ResearchGate, Google Scholar, Hinari, and Cochrane, as well as physical resources available at Novena University Library.

Phytochemical insights

Kalanchoe pinnata has been found to contain a broad range of phytochemicals including lipids, tannins, alkaloids, flavonoids, phenols, glycosides, vitamins, bufadienolides, cardenolides, minerals, and various organic acids [2]. Among the lipids present are triterpenes such as friedelin, α- and β-amyrins, glutinol, 18-α-oleanane, bryophollone, and tar axerol [5]. Sterols like stigmasterol, kaempferol, dimethoxy flavone-7O-β-D-glucopyranoside, and epigallocatechin-3-O-syringate, as well as fatty acids including stearic, palmitic, arachidic, and behenic acids, have also been identified [6]. The tannins and alkaloids include phenanthrenes, alkanes, alkanols, n-triacontane, and hentriacontane. Flavonoids, phenols, and glycosides such as phosphoenolpyruvate, p-coumaric acid, ferulic acid, protocatechuic acid, cinnamic acid, 4-hydroxybenzoic acid, caffeic acid, and syringic acid are also present [2]. Moreover, compounds like astragalin, 3,8-dimethoxy-4,5,7-trihydroxyflavone, luteolin, rutin, and O-diarabinoside have been identified. The cardenolides, including peposterol, campesterol, isofucosterol, β-sitosterol, clionasterol, 22-dihydrobrassicasterol, bryophyllins A and B, and bufadienolide (noted for its insecticidal properties), contribute to the plant's insecticidal effects [7]. Steroidal glycosides found in the plant include 25-methyl-5α-ergost-24-en-3-β-ol, ergosta-5,24-dien-3-β-ol, 25-methyl-ergosta-5,24-dien-3-β-ol, 5α-stigmast-24-en-3-β-ol, (24S)-stigmast-25-en-3-β-ol, (24R)-stigmast-25-en-3-β-ol, patuletin, 3-O-(4-O-acetyl-α-L-rhamnopyranosyl)-7O-(2-O-acetyl-α-L-rhamnopyranoside), and quercetin-3-O-α-L-arabinopyranosyl (1→2)-α-L-rhamnopyranoside-often used as a marker compound for the plant [7]. Beyond fatty acids, other organic acids such as oxalic acid, citric acid, isocitric acid, oxaloacetate, malic acid, and succinic acid have been detected [2]. The plant is also a source of vitamins including riboflavin, thiamine, niacin, pyridoxine, and amino acids such as glycine, cysteine, methionine, tyrosine, phenylalanine, glutamic acid, as well as protein hydrolysates and casein hydrolysates. Minerals identified include sodium, calcium, potassium, phosphorus, magnesium, manganese, iron, copper, and zinc. The abundance of these

bioactive constituents contributes to the plant's chemoprotective, anti-infective, anticancer, and insecticidal properties. The leaves and bark have also been traditionally used to treat diarrhea and nausea [8]. Molecular formula, Structure description, and functions of key phytochemicals present in Kalanchoe (**Tables 1** and **2**).

Table 1: Triterpenoids

Compound	Molecular Formula	Structure Description	Function
Friedelin	$C_{30}H_{50}O$	Pentacyclic triterpenoid with a ketone group	Exhibits anti-inflammatory and hepatoprotective properties [1]
α-Amyrin	$C_{30}H_{50}O$	Ursane-type pentacyclic triterpenoid with a hydroxyl group at C-3	The precursor to ursolic acid; possesses anti-inflammatory and analgesic effects [3]
β-Amyrin	$C_{30}H_{50}O$	Oleanane-type pentacyclic triterpenoid with a hydroxyl group at C-3	The precursor to oleanolic acid [9] known for anti-inflammatory and hepatoprotective activities [2]
Glutinol	$C_{30}H_{50}O$	Pentacyclic triterpenoid with a hydroxyl group	Demonstrates anti-inflammatory and antimicrobial properties [1]
18-α-Oleanane	$C_{30}H_{50}$	Oleanane-type pentacyclic triterpene hydrocarbon	Serves as a structural backbone for various bioactive triterpenoids [6]
Bryophollone	$C_{30}H_{48}O$	Triterpenoid ketone	Exhibits cytotoxic activity against certain cancer cell lines [10]
Taraxerol	$C_{30}H_{50}O$	Pentacyclic triterpenoid with a hydroxyl group	Known for anti-inflammatory and hepatoprotective effects [11]

Table 2: Sterols and flavonoids

Compound	Molecular Formula	Structure Description	Function
Stigmasterol	$C_{29}H_{48}O$	Plant sterol with a double bond in the side chain	Lowers cholesterol levels; anti-inflammatory and antioxidant properties [3]
Kaempferol	$C_{15}H_{10}O_6$	Flavonoid with hydroxyl groups at positions 3, 5, 7, and 4'	Antioxidant, anti-inflammatory, and anticancer activities [3, 5, 6, 9]
Dimethoxy flavone-7O-β-D-glucopyranoside	$C_{23}H_{24}O_{10}$	Flavone derivative with methoxy groups and a glucose moiety at position 7	Potential antioxidant and anti-inflammatory effects [1, 2]
Epigallocatechin-3-O-syringate	$C_{22}H_{24}O_{10}$	Catechin derivative esterified with syringic acid at the 3-O position	Exhibits strong antioxidant activity [9]

Pharmacological insights

Kalanchoe pinnata has demonstrated a broad spectrum of pharmacological activities supported by in vitro, in vivo, and some clinical studies. These findings provide a scientific basis for many of its traditional medicinal uses.

Anti-inflammatory and analgesic activity: The anti-inflammatory effects of K. pinnata have been attributed to the presence of flavonoids, triterpenoids, and other phenolic compounds [12-14]. These constituents inhibit key inflammatory mediators such as prostaglandins, leukotrienes, and cytokines. Animal models have shown significant reductions in inflammation and pain, confirming its analgesic potential [11].

Antimicrobial and antiviral activity: Extracts of K. pinnata have demonstrated antimicrobial activity against a variety of pathogens including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Candida albicans [15]. The antiviral properties have been particularly noted against herpes simplex virus and influenza strains. These effects are primarily attributed to the flavonoid and bufadienolide content, which disrupt microbial cell walls and inhibit viral replication [8].

Anticancer and cytotoxic effects: Several studies have reported that K. pinnata exhibits cytotoxic activity against various cancer cell lines such as HepG2 (liver), MCF-7 (breast), and HeLa (cervical) cells. Bufadienolides, a group of cardiac glycosides present in the plant, induce apoptosis through mitochondrial pathways, inhibit cell proliferation, and alter cellular redox status. These findings support its potential as a source of novel chemotherapeutic agents [10].

Antidiabetic and hypoglycemic activity: Administration of K. pinnata extracts in diabetic animal models has shown significant reductions in blood glucose levels. This activity is believed to involve the stimulation of insulin secretion and enhancement of glucose uptake by peripheral tissues, possibly due to the presence of flavonoids and saponins [16].

Antiparasitic and antileishmanial potentials: Leishmania amazonensis amastigotes are the causative agents of leishmaniasis, a parasitic disease also known as uta, chiclero ulcer, or pian bois. This condition is characterized by ulcerative lesions on exposed areas of the skin [17]. Several flavonoids present in Kalanchoe pinnata, including coumarin and quercetin, have been identified as key contributors to its antileishmanial activity. Specifically, the flavonoids quercitrin, quercetin, and afzelin have demonstrated inhibitory effects against L. amazonensis amastigotes in murine models [18].

Antioxidant activity: K. pinnata is rich in antioxidant compounds such as quercetin, kaempferol, caffeic acid, and ferulic acid [1]. These compounds scavenge reactive oxygen species (ROS), reduce oxidative stress, and protect biomolecules from oxidative damage [19]. This antioxidant potential contributes to many of the plant's therapeutic effects, including neuroprotection, hepatoprotection, and cardio-protection [3].

Proton pump inhibitory potential: Substances that inhibit gastric acid secretion by targeting the H^+/K^+-ATPase enzyme system in the stomach lining are known as proton pump inhibitors, and are effective in the management of peptic ulcers. In traditional medicine, Kalanchoe pinnata has long been employed for its anti-ulcer properties. Comparative studies using omeprazole a well-established proton pump inhibitor as a reference drug have demonstrated that K. pinnata extracts exhibit significant ulcer-suppressive activity. The leaf and root extracts showed strong anti-inflammatory and anti-ulcer effects in rat models, while the stem extract exhibited comparatively weaker anti-inflammatory activity [19]. The anti-ulcer activity of K. pinnata is believed to be mediated through multiple biochemical pathways. Its flavonoid content, particularly quercetin and kaempferol, may inhibit gastric proton pumps (H^+/K^+-ATPase), reduce oxidative stress, and promote mucosal defense by enhancing prostaglandin synthesis [3]. Additionally, the antioxidant and free radical-scavenging properties of its phytochemicals help stabilize gastric mucosa, reduce lipid peroxidation, and suppress pro-inflammatory cytokines such as TNF-α and IL-1β, contributing further to its gastroprotective effects [10].

Wound healing and skin regeneration: Topical application of K. pinnata extracts has been shown to accelerate wound healing by promoting collagen synthesis, angiogenesis, and epithelialization. These effects are largely attributed to its anti-inflammatory, antimicrobial, and antioxidant properties [20].

Diuretic and antiurolithiatic effects: Experimental studies have demonstrated increased urinary output and a reduction in kidney stone formation following treatment with K. pinnata extracts [4, 16]. The mechanism is believed to involve increased renal clearance and reduced crystallization of oxalate and phosphate [8].

Hepatoprotective activity: K. pinnata has shown significant hepatoprotective effects in animal models exposed to hepatotoxins such as carbon tetrachloride and paracetamol. The protective action is thought to be due to its antioxidant and membrane-stabilizing properties [10].

Immunomodulatory effects: Polysaccharides and flavonoids present in the plant have been reported to enhance immune responses by stimulating lymphocyte proliferation, increasing cytokine production, and enhancing macrophage activity [21].

Neuropharmacological effects: Preliminary studies suggest anxiolytic, sedative, and anticonvulsant effects, which may be mediated by modulation of the GABAergic system. This indicates potential applications in anxiety, epilepsy, and related neurological disorders [1].

Antifertility and contraceptive activity: Some studies have indicated antifertility effects, especially in male rats, where extracts reduced sperm count and motility. These effects are considered reversible and are thought to be due to steroidal compounds interfering with reproductive hormones [3].

Pesticidal potential: Kalanchoe pinnata exhibits notable pesticidal activity when applied in agricultural settings, demonstrating significant efficacy in pest elimination. However, studies have shown that the plant is toxic to cattle when ingested [22]. This toxicity is primarily attributed to the presence of bryotoxins and bufadienolides, which are known to induce cardiac glycoside poisoning in animals [23]. This review has synthesized and evaluated the phytochemical and pharmacological properties of K. pinnata as reported in

recent and historical scientific literature. Nonetheless, the current body of knowledge should serve as a foundation rather than a culmination. Continued and rigorous scientific investigation into K. pinnata, as well as other medicinal plants employed in traditional medicine, is essential. Moreover, research rooted in traditional practices must be systematically documented and supported, as such efforts are pivotal to the advancement of novel drug discovery and development [4].

Conclusion: The significance of Kalanchoe pinnata in traditional medicine is profound and well-recognized. Its wide-ranging therapeutic applications-including the management of systemic diseases, and dermatological conditions, and its roles as an antioxidant and hematinic agent highlight its distinguished status among medicinal plants globally. it is, therefore, fitting that it is locally referred to as the wonder plant.

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