

# A Landscape Analysis of the Ethnomedicinal, Pharmacological and Therapeutic Potential of *Kalanchoe pinnata* (Lam.) Pers

Mahender Singh<sup>1</sup>, Suresh Kumar<sup>2\*</sup>, Divya<sup>3</sup>, Mamta Verma<sup>4</sup>

<sup>1,2,3,4</sup> Department of Biosciences, Himachal Pradesh University, Shimla-171005, India

\*Corresponding author, Suresh Kumar, shahriask@gmail.com

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## ABSTRACT

According to World Health Organization (WHO), medicinal plants are a rich source of therapeutic drugs, which are relatively secure and economical as compared to synthetic drugs. *Kalanchoe pinnata* (family Crassulaceae) is a valuable medicinal plant, having significant therapeutic potential. It is extensively used in traditional and folk medicines throughout the world. The objective of the current review is to highlight the distribution, morphological characters, ethnomedicinal uses, pharmacological activities and therapeutic potential of *Kalanchoe pinnata*. The plant is used for the treatment of several diseases due to the presence of bioactive phytochemicals such as alkaloids, phenolic compounds, flavonoids, saponins, glycosides, etc. The plant possesses various pharmacological activities such as anti-inflammatory, analgesic, antidiabetic, hepatoprotective, gastroprotective, anti-ulcer, anti-urolithic, anti-microbial, anti-tumor, antileishmanial and wound healing. The plant has toxic effects on cattle, but no serious effects have been reported on other mammals. Although more toxicological research and investigations pertaining to the absolute mechanism of pharmacological activities are required on this plant.

**Keywords:** Ethnomedicinal, *Kalanchoe pinnata*, Pharmacological, Phytochemical, Therapeutic, Traditional medicines.

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## INTRODUCTION

Medicinal plants are a novel source of natural products for the treatment of several ailments due to their negligible side effects on human beings [1, 2]. They provide a rich source of plant-based medicines used by people for curing many dreadful diseases throughout the world. According to WHO, there is approximately 80% of the global population relying wholly and partially on drugs of plant origin [3, 4]. *Kalanchoe pinnata* is a succulent perennial herb that belongs to the family Crassulaceae and is commonly known as Miracle leaf, Air plant, Life plant, Mexican love plant, Zakhm-ehyat, Cathedral bells, Paranabija, etc. [5]. The plant has significant therapeutic activity and is comprehensively used for remedial cure due to the presence of phytochemicals such as alkaloids, phenolic compounds, flavonoids, tannins, saponins and glycosides [6]. It has been revealed by various researchers that the plant possesses various pharmacological activities such as anti-inflammatory, analgesic, antidiabetic, hepatoprotective, gastroprotective, anti-ulcer, anti-urolithic, anti-microbial, anti-tumor, antileishmanial and wound healing [7]. However, the plant has toxicity effects due to the glycoside content which causes cardiac poisoning in grazing animals [8]. In the traditional medicine system, the herb is used to cure the wounds, diabetes, diarrhea, vomiting, hypertension, epilepsy, renal stone, arthritis, upper respiratory infection and flu.

### Geographical Distribution:

*Kalanchoe pinnata* is an evergreen herb native to the Madagascar region of Africa and extensively distributed throughout the world (Fig.1). The plant is extensively growing and used as a traditional medicine in tropical America, tropical Africa, Australia, New Zealand, Asia, India, China, Philippines and the Pacific region of the world. It is considered to be an invasive plant species in Hawaii regions.



[Source: *Kalanchoe pinnata* (Lam.) Oken in GBIF Secretariat, 2021]

**Fig.1: Worldwide Distribution of *Kalanchoe pinnata*.**

The plant is distributed throughout India, both in temperate and tropical regions. It is also cultivated as a decorative plant in the garden. It grows wild in northwestern India, Deccan and Bengal [9].

**Taxonomical Classification:**

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Saxifragales
Family:	Crassulaceae
Genus:	<i>Kalanchoe</i>
Species:	<i>pinnata</i>

**Botanical Description:**

The plant is an erect herb about 1-1.5 m tall having an obtusely four-angled branched stem (Fig. 2). The leaves are thick, fleshy, elliptical, crenate and decussate (arranged in opposite directions). The upper leaves are compound, 3-7 foliate and have long petioles, whereas bottom leaves are simple. The inflorescence is a terminal panicle having pendent reddish-purple flowers. The calyx is tubular in shape, red-green at the base and pale green above with triangular lobes at the end. Corolla is reddish to purple in color. The stamens are eight in number inserted basally on the corolla and organized in two whorls. The ovary has four carpels, slightly fused at the central region with delicate styles and numerous ovules.



**Fig. 2: Whole plant of *Kalanchoe pinnata*.**

The fruit is a follicle with papery calyx and corolla surrounded it. The fruit pod contains four septa having numerous, small, ellipsoid, smooth striate seeds. The flowering occurs from November to March and the fruit sets in April. The vegetative propagation occurs through leaves by producing adventitious buds. The plant leaves are predominantly used for therapeutic purposes [10].

### Phytochemical Profile:

Phytochemicals are the chemical compounds present in plants that are liable for their biological activities and therapeutic potential. The phytochemical screening of *Kalanchoe pinnata* revealed the presence of various chemical compounds, i.e., alkaloids, terpenes, steroidal glycosides, cardenolides, steroids, bufadienolides, free amino acids, lipids, polyphenol, tannins, glycosaponins and organic acids [11]. The structures of major active phytochemical compounds have been depicted in Fig.3.

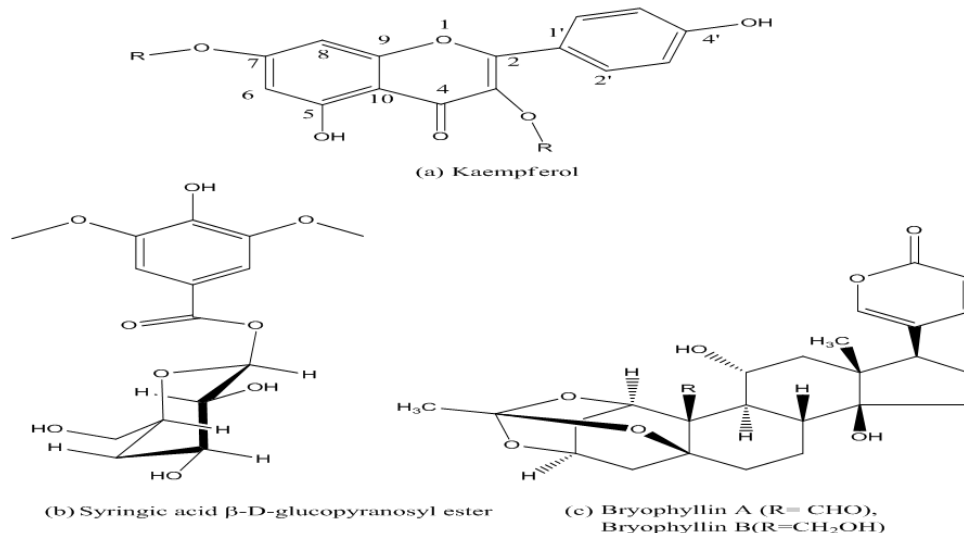


Fig. 3: Major Active Phytochemicals of *Kalanchoe pinnata*.

### Ethno medicinal Uses:

*Kalanchoe pinnata* is a medicinal plant that is widely used in traditional medicine all over the world. The plant is used in traditional medicines due to the significant therapeutic and pharmacological activities of its phytochemicals. Generally, the whole plant is utilized in the folklore system for the cure of various ailments. But the leaves have greater ethnobotanical significance than the other parts (Table 1).

Table 1: Ethnomedicinal Uses of *Kalanchoe pinnata*

Plant Part	Ethnobotanical Uses	Reference
Leaves	Leaves juice and decoction used for constipation and fever.	[12]
Leaves	Fresh leaf juice is taken orally to cure dysentery. The paste of leaves is used externally to cure cuts and wounds and also applied on forehead to mitigate headache.	[13]
Leaves	A single raw leaf is eaten for seven days to cure cough. It is also used to cure respiratory tract infections i.e. pneumonia, bronchitis and flu.	[14]
Leaves	Leaves are applied to treat wounds and boils, leaves are considered antilithic.	[15]
Leaves	Decoction of leaves is considered useful for kidney stone. Poultice of leaves is applied for piles. Slightly warmed leaf is practiced to cure furuncles.	[16]
Leaves	Leaves paste used against scorpion and snake bites.	[11]
Leaves	The steamed leaf juice is used in cough along with ghee/ garlic. The leaves are treated with palm oil & used externally in sore	[17]

	eyes.	
Leaves	Leaf juice is used to cure urinary stones, bleeding disorders, ulcers and diarrhea.	[18]
Roots	Decoction of roots used to cure cholera, diarrhea, dysentery, ulcer and gastrointestinal disorders.	[19]
Seeds	Juice obtained from crushed seeds is applied to eye for curing Styte disease.	[11]
WholePlant	Fresh juice of whole plant is used to cure diabetes.	[11]

**Pharmacological Activity and Therapeutic Potential of *Kalanchoe pinnata*:**

*Kalanchoe pinnata* has significant therapeutic potential for the treatment of various ailments. The therapeutic potential of the plant is mainly due to various pharmacological activities of its phytochemicals. It has been reported by various researchers that the plant possesses various pharmacological activities such as anti-inflammatory, analgesic, antidiabetic, hepatoprotective, gastroprotective, anti-ulcer, anti-urolithic, anti-microbial, anti-tumor, antileishmanial and wound healing (Fig. 4; Table 2). These pharmacological activities of *Kalanchoe pinnata* have revealed that the plant has promised potential for treatment of various disease and disorders.

**Table 2: Biological activity of different parts of *K. pinnata* for curing various disease**

<b>Plant Part</b>	<b>Pharmacological Activity</b>	<b>Reference/s</b>
Leaves	Antiulcer and gastroprotective activity	[20]
Leaves	Antimicrobial activity against pathogenic bacteria and fungi	[21, 22]
Leaves	Antileishmanial activity	[23]
Leaves	Hepatoprotective activity against liver disorders	[24]
Leaves	Anti-inflammatory and Analgesic effect against inflammation	[25]
Leaves	Antitumor and anti-cancerous activity	[26]
Leaves	Antidiabetic activity	[27]
Leaves	Antimicrobial activity against pathogenic bacteria	[28]
Leaves	Antioxidative activity against oxidative stress	[29]
Leaves	Antilithiatic activity against kidney and urinary bladder stones	[30]
Leaves	Wound healing activity against cuts and wound	[31]
Leaves	Neuroprotective effect	[32]
Roots	Anti-inflammatory activity against gout and inflamed joints	[33]
Whole Plant	Gastroprotective effect	[34]

Although different parts of the plant are valued for therapeutic use but most of the earlier works with respect to pharmacological activity of *Kalanchoe pinnata* pertain to the leaf.

**Anti-inflammatory and Analgesic Effect**

Generally, leaf and root extracts of *Kalanchoe pinnata* are used as anti-inflammatory and analgesic agents due to the presence of flavonoids and steroid derivatives. The flavonoids can inhibit the activities of the cyclooxygenase enzyme which declines the activity of alpha-tissue necrosis factor and also inhibits the synthesis of inflammatory cytokines and mediators including prostaglandins, histamine, polypeptide kinin [35]. It has been experimentally reported that the steroid compound in the aqueous extract of plant leaves inhibited the carrageenan-induced rat paw edema. The steroidal compound is to be functional in decreasing inflammation when measured with the diclofenac. Moreover, the steroid compound in the aqueous extract of plant leaves acts as an analgesic agent and shows 75.72 % protection in analgesic activity in acetic acid-induced writhing in mice when measured with standard drugs [25]. The analgesic values of the aqueous extract of plant leaves were also proved by using an animal model [36]. Therefore, the plant has considerable potentials for anti-inflammatory and analgesic activity.

**Antidiabetic Activity**

Diabetes is the most prevalent and rapidly growing metabolic disease in the world. The phytochemicals mainly secondary metabolites have an effective role in the medication of diabetes mellitus. The antidiabetic activity of

*Kalanchoe pinnata* is predominantly due to the presence of flavonoids, polyphenols, triterpenoids, phytosterols, etc. It has been revealed that the ethanol extract of the plant leaves has antidiabetic effects on alloxan-induced hyperglycemic Wistar albino rats[37]. Further, the steam distillate of leaves was subjected to fractionation and antidiabetic activity was detected in dichloromethane (DCM) fraction. The DCM fraction has glucose-independent insulin secretagogue actions due to the presence of bioactive molecule phenyl alkyl ether which inhibits the streptozotocin-induced diabetes mellitus in rats[38]. The plant leaves extract has a hypoglycemic effect in the acute phase in rats and also inhibits the activity of the alpha-amylase enzyme of the intestine which revealed that it has a valuable role in the treatment of diabetes[39].

#### **Hepatoprotective Activity**

Liver diseases affect millions of people worldwide. *Kalanchoe pinnata* has hepatoprotective properties. The juice of fresh leaves is used in traditional medicine for the treatment of jaundice in the Bundelkhand region of Madhya Pradesh state of India. It has been investigated that the fresh leaf juice of the plant is greater effective than ethanolic extract of leaves in the reduction of the level of serum liver enzyme, serum bilirubin, serum cholesterol, and serum protein in the carbon tetrachloride activated hepatotoxicity in albino rats[40]. The ethanolic extract of leaves also shows hepatoprotective effects by decline in the level of serum liver enzyme in paracetamol-induced hepatotoxicity in albino rats. The antioxidative features of the plant also provide the hepatoprotective values[41]. Moreover, the histopathological study reveals that the plant has hepatoprotective effects with significant potential in the medication of hepatic disorders.

#### **Antiulcer and Gastroprotective Activity**

The cases of gastrointestinal diseases have been reported to be increased in the last decades specifically gastritis and ulcers. *Kalanchoe pinnata* has gastroprotective and antiulcer properties because of the presence of phenols and flavonoids compounds. The gastroprotective effects have been reported in plant hydroethanolic extract (HE) and ethyl acetate fraction (EAF) from plant leaves against ethanol/HCL-induced ulcer model in rats. The HE declined the gastric lesions approximately 47%, while the EAF reduced the gastric lesions by 50% in rats which is mainly due to the abundance of flavonoids and phenolic compounds in the fraction. Further, the aqueous and mucilage extract of plant leaves have significantly protected gastric mucosa from ethanol-induced gastric damage in rats. Such activity is also observed by the decrease of ulcer area in gastric walls as well as inhibition of edema and leucocyte infiltration of the submucosal layer which is analyzed by NMR spectroscopy [34].

#### **Anti-urolithic Activity**

It has been estimated that kidney stones occur in approximately 12% of the total population of world and the greater number of the renal stones (about 80%) are commonly composed of insoluble calcium oxalate[42]. *Kalanchoe pinnata* is widely used in the traditional medicine system as a medicinal herb for the treatment of renal stones. It has been discerned that the ethanolic concentrates of the whole plant have antilithiatic actions against ethylglycerol-induced lithiasis in rodents[43]. The experimental evidence revealed that the plant extract decreased the level of calcium in the renal tubule and its calcium chelating ability inhibits aggregation of calcium oxalate which eventually inhibits stone formation. Further *in vitro* studies revealed that the plant extract increased the dissolution and considerably decreased the weight of extracted calcium oxalate kidney stones [44]. Thus, the evidence implicated that the plant has significant potential in the treatment of urolithiasis.

#### **Antimicrobial Activity**

The remarkable increase of antibiotic-related resistance in recent years among pathogenic bacteria has become a global challenge in the medication of diseases caused by bacteria. *Kalanchoe pinnata* leaves and stem extract has antimicrobial activity due to the presence of phytochemicals which effectively inhibits bacterial and fungal growth by virtue of secondary metabolites such as phenolic compounds, alkaloids, glycosides, steroids, terpenoids, flavonoids, saponins, bryophyllin, etc.[45]. It has been observed that the plant methanol and aqueous extract significantly inhibit the growth of bacteria especially *Bacillus subtilis*, *Escherichia coli*, *Klebsiella aerogenes*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Salmonella typhi*[46]. The stem extract has significant antifungal activity against *Candida albicans* and *Aspergillus niger* [28]. The presence of antimicrobial activity in the plant has been considerably utilized in the Unani medical system for the treatment of several diseases caused by microorganisms.

#### **Antitumor and Anti-cancerous Activity**

Cancer is very severe and the second major cause of the death of human population in the world. It has been observed that *Kalanchoe pinnata* has anti-cancerous values chiefly the presence of bioactive molecules i.e., steroid glycoside (bufadienolides) and alkaloids. *In vitro* studies revealed that the plant leaves extract has active compounds (steroid glycoside and alkaloids) which have anti-human papillomavirus and apoptosis-inducing potential thus practiced in the treatment of HPV infections and cervical cancer. It has been revealed that the five different kinds of bufadienolides isolated from plant extract were analyzed for the inhibitory effect on EBV-EA (Epstein Barr Virus Early Antigen)

activation in Raji cells that were induced by tumor promoter 12-O'tetradecanoylphorbol-13-acetate[26]. Thus, the bufadienolides have anti-cancer activity and have significant potential in cancer treatment. The current studies implicated that plant-based phytochemicals with anti-cancerous values become an important alternative as compared to synthetic drugs in the medication of cancer with lesser side effects [47].

### Antioxidative Activity

The free radicals can be generated during normal body metabolism and also acquired from the external environment which causes oxidative stress as well as cells degeneration and damages which leads to various serious diseases such as cancer, diabetes, cardiovascular abnormality, etc. To prevent the body from oxidative damage, medicinal plants act as the major sources of natural antioxidants. It has been experimentally observed that *Kalanchoe pinnata* has significant antioxidative activity mainly in the presence of phenolic and flavonoid compounds. The ethanol extract of leaves has a strong antioxidative activity which is measured by using DPPH and total antioxidant assays [48]. It has been recorded in the mice model that the methanol extract of plant leaves acts as an antioxidant and prevents the gastric mucosa from reactive oxygen species produced by *Helicobacter pylori* infections [49]. These studies revealed that *Kalanchoe pinnata* has bioactive molecules which have a strong ability to scavenge free radicals and have a promising potential in the treatment of diseases induced by oxidative stress and cell degeneration.

### Wound Healing Activity

*Kalanchoe pinnata* has been extensively used as a wound-healing herb in folk medicinal practices since ancient period. The plant extract has shown significant wound healing activity predominantly due to the presence of phytochemicals such as steroid glycoside, quercetin and bioflavonoids. The wound healing potential of the plant has been evaluated by using a wound excision model in albino rats [50]. It has been investigated that the animals treated with ethanol extract of leaves have a greater reduction of wound area as compared to petroleum jelly treated control and mupirocin treated standard. The hydroxyproline amount is also greater in animal tissues treated with leaf extract as compared to standard and control as hydroxyproline plays a significant role in wound healing [51].

### Antileishmanial Activity

Leishmaniasis are the infections caused by the various species of parasite protozoans. *Leishmaniasis* is a major public health-related problem mainly in developing countries. It has been recorded that *Kalanchoe pinnata* has significant potential in the medication of infections caused by *Leishmania*. The antileishmanial values of the plant is predominantly due to the presence of flavonoids especially coumarin and quercetin. It has been reported that the quercetin controls the growth of lesion caused by the *Leishmania* species and significantly decrease the parasite load [7]. The plant extract containing quercetin oral administration in mice shows the antileishmanial activity to a greater extent.

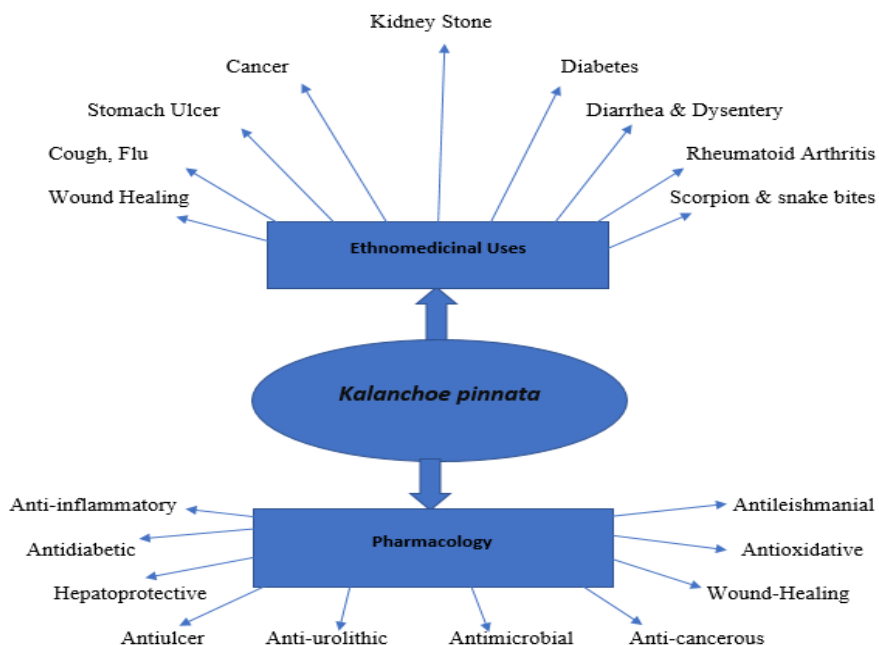


Fig.4 Ethnomedicinal and pharmacological benefits of *Kalanchoe pinnata*.

### Toxicological investigation of *Kalanchoe pinnata*

The toxicity effects of *Kalanchoe pinnata* caused by bufadienolides were observed in cattle grazing on the plant [52]. The clinical studies of several years reveal that *Kalanchoe pinnata* based drug consumption is well tolerated and there are no serious side effects on patients [53]. However, from the drug safety perspective, the amount of bufadienolides should be controlled in the preparation of drugs. Therefore, further studies should be conducted for the conscious use of *Kalanchoe pinnata* for medicinal purposes.

### CONCLUSION

*Kalanchoe pinnata* is a divine herb with significant medicinal values, widely practiced in the traditional medicinal system by various ancient human civilizations. The present review exercises documentation of ethno medicinal uses, phytochemicals, pharmacological activity and therapeutic potential of the plant for treatment of various ailments. It has been inferred that the plant has significant therapeutic potential with considerable anti-inflammatory and analgesic, antidiabetic, hepatoprotective, gastroprotective, anti-ulcer, anti-urolithic, anti-bacterial, anti-tumor, antileishmanial and wound healing properties. Moreover, the plant shows some toxic effects on the grazing animals, but no serious effects have been reported on other mammals. Although, more toxicity-related research is needed on this plant. Thus, more advanced studies are required to identify, isolate and investigate the absolute mechanism of action of phytochemicals present in the plant.

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