RESEARCH PAPER

"The Miracle Leaf: Succulent with Wealth of Multifaceted Promising Bioactive Compounds"

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ABSTRACT
There are nearly 350000 species of plants on the earth and each of them has a great medicinal and therapeutic activity. Among of them a plant named as *Kalanchoe Pinnata* also known as "air plant" that grows approximate 5 feet tall. Contained a wide range of active compounds. This review aims to provide an overview on the medicinal and therapeutic perspective of *Kalanchoe Pinnata.* Kalanchoe genus species have a long-term history with therapeutic use in Ethnomedicine relating with their remarkable healing properties. From different types of studies that we have conducted we are able to know presence of different types of compounds in it like Glycoside, Alkaloids, Phenolic compounds, Flavonoids etc and wide range of pharmacological character including antioxidant, antiseptic or anti-microbial anti-cancer, anti-allergic, wood healing activities and many more. The herb contains gallic acid caffeic acid, coumaric acid, quercetin, quercitrin, isorhamnetin, kaempferol, bersaldegenin bryophyllin a, bryophyllin c, bryophynol, bryophyllol and bryophollone, stigmasterol, campesterol, and other elements. Its phytochemicals participate in the regulation of proliferation, apoptosis, cell migration, angiogenesis, metastasis, oxidative stress, and autophagy.
Keywords: Kalanchoe pinnata, Air plant, Pharmacological character, Ethnomedicine, Bryophyllin, Stigmasterol, Healing properties.
How to cite this article: Thakur P, Kaur P, Kaur S, Khanna C, Chakraborty T, Singh MM., "The Miracle Leaf: Succulent with Wealth of Multifaceted Promising Bioactive Compounds". Int J Drug Deliv Technol. 2026;16(3s): 286-300; DOI: 10.25258/ijddt.16.3s.38
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

Kalanchoe Pinnata usually known as the "life plant" [1] "air plant "[2] and "cathedral bells" [3] or "miracle leaf" is a remarkable succulent species that belongs to the Crassulaceae family [4]. The thick, meaty, fleshy leaves of *Kalanchoe Pinnata*, which can reach a length of 10 to 20 cm [5] are one of its most notable features. Which possesses proliferation from leaf cuttings. The leaves are usually bright green, but they can turn red under specific conditions. They have a distinctive serrated or scalloped edge that enhances their aesthetic attractiveness [6]. The plant can reach heights of around 3 meters and frequently develops a bushy appearance, making it an appealing addition to gardens.[7] This plant is native to Madagascar and encompasses 145 species [8] or gained popularity in various tropical and subtropical regions around the world, including India, due to its striking appearance, resilience, and diversity. It is a house hold plant and the species is notable for the abundance of tiny plantlets that develop along the edges of its leaves, a characteristic it shares with certain other species of Bryophyllum (which is now classified under Kalanchoe [9]. (Where as in warmer months kalanchoe Pinnata yields clusters of tubular blooms in the warmer months which can range in colour from pink to red to yellow. Along the edges of its leaves the plant can create tiny planets that are readily detached and taken up by roots in the soil, allowing for much simpler proliferation by fostering the formation of new plant easily.) Because of its therapeutic qualities, this plant has long been used in many cultures. It has been shown to contain a variety of bioactive substances that support its medicinal properties, such as tannins, phenolic acids, and flavonoids.[2] The antioxidant, anti-inflammatory, antibacterial, and anti- diabetic properties of Kalanchoe pinnata have been investigated, making it a useful topic for pharmacological study [9].Temperate areas of Asia, including Australia, New Zealand, the West Indies, Mascarenes, Melanesia, and Hawaii, have seen the naturalization of Kalanchoe pinnata [10]. It is traditionally recognized to have a wide variety of pharmacological activities, including the treatment of the most serious illnesses known to mankind [11]. In this review, the therapeutic and medicinal values of the plant, which includes its wound-healing [12], antioxidant, antiproliferative [13] anti-cancerous [14], antiviral antimicrobial [15], antiparasitic [16] ,antileishmanial [17], anthelmintic [18], anti-allergic [19], ,insecticidal [20], analgesic-

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anticonvulsant [21], anti-inflammatory [22], antipyretic [23], antidepressant [24], sedative [25], antilithiatic or hepatoprotective [26], gastro-protective [27], antidiabetic [28], nephroprotective [29] , It is recognized in ethnomedicine for its anthroposophical and tocolytic properties in pregnant women[11].

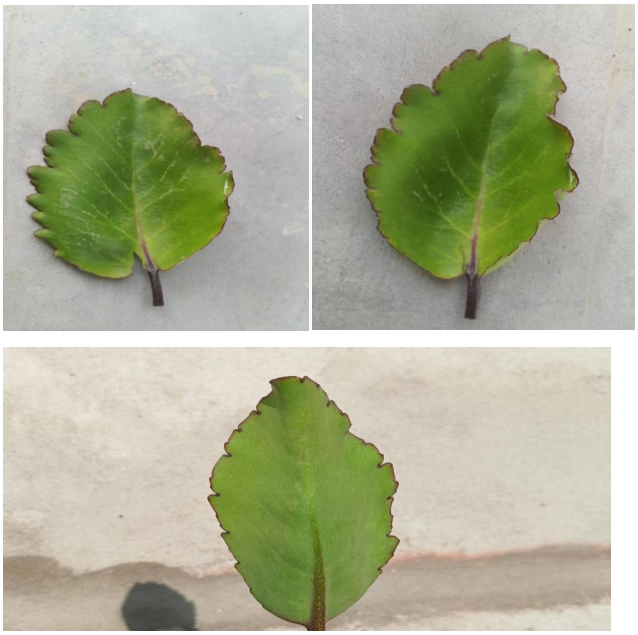


Figure 01: - leaves of kalanchoe pinnata

Literature Review Survey- Kaur et al. (2014) called Kalanchoe pinnata the "Mother of thousands" because of its distinctive capability to produce new plantlets along the leaf margins these plantlets can easily be separated from the parent and cultivated independently in pots or in wild areas. Okwu and Nnamdi (2011a) observed that traditionally in Africa, this plant was utilized to aid in childbirth and to address ulcers and different skin disorders, whereas Prasad et al. (2012) emphasized its application in controlling rheumatism. The medicinal significance is reinforced by Khan et al. (2004) and Nayak et al. (2010), who highlighted its potent wound-healing capabilities. As reported by Gahlaut et al. (2012) and Raj et al. (2014), K. pinnata has been used for the treatment of gall bladder stones. Asiedu-Gyekye et al. (2012) and Bhatti et al. (2012) revealed its antioxidant properties, while Nayak et al. (2010) further examined its role in controlling infections, inflammation, and rheumatism. Furthermore, McKenzie and Dunster (1986) noted that it has immunosuppressive properties. Phytochemical analysis, demonstrated by Majaz et al. (2011), indicated the existence of tannins that possess significant anthelmintic characteristics. A thorough analysis by Biswas (2011b) emphasized the extensive medicinal potential of K. pinnata, underscoring its historical significance as a healing herb. The genus was initially characterized by botanist Michel Adanson in 1763, and its classification has progressed over time. In the early 1800s, Christiaan Hendrik Persoon classified the species within Kalanchoe, while Richard Anthony Salisbury suggested the name Bryophyllum calycinum, leading to a continuing discussion about whether Bryophyllum ought to be regarded as a separate genus or a subset of Kalanchoe. are well-recorded Nguelefack et al. (2006) indicated its ethnomedicinal applications use in traditional African medicine for addressing otitis, headaches, inflammation, seizures, and overall weakness. The antifungal properties were previously observed by Misra and Dixit (1979).

Synonyms

Bryophyllum calycinum Kalanchoe pinnata
Bryophyllum pinnatum Kalanchoe pinnata
Cotyledon pinnata
Crassula pinnata
Sedum madagascaricum

Table 1: Vernacular Names Kalanchoe Pinnata

English	Air plant, Life plant, Love bush.
Hindi	Bhasampathri, Paashaanbhed
Malayalam	Ilamulachi
Kannada	Kadu Basale
Sanskrit	Parnabija
Tamil	Ranakalli
Telugu	Pashanbethi
Gujarati	Pathar Chatta
Bengali	Patharkuchi, Himasagara,

Table 2: Botanical Classification of Kalanchoe Pinnata

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.)

HISTORY- It is native to Madagascar, but many varieties of Kalanchoe pinnata, which are found throughout tropical regions, have distinct chemical compositions, structural and botanical variances, and ate therefore appealing for usage as potential therapeutic remedies in the Ayurvedic medical system [33]. It has now expanded to many tropical and subtropical areas across the world, including islands in the Pacific, sections of Africa, India, and the Caribbean. Its attractiveness as an ornamental plant and its ease of reproduction through leaf cuttings are two factors contributing to its proliferation [34]. Numerous conditions, such as infections, wounds, and respiratory problems, have been treated with it. Its leaves are frequently employed in infusions or poultices [35,36], demonstrating the plant's lengthy history of use in conventional medical procedures. 1786 Pierre Sonnerat was the first person to record the plant

in Mauritius. Jean-Baptiste Lamarck then called it Cotyledon pinnata [37]. In modern classifications, Bryophyllum is frequently included as a part within Kalanchoe [38]. We discovered several chemicals in Kalanchoe pinnata, including bufadienolides, that may contribute to its therapeutic qualities [39].

Geographical Source - Kalanchoe pinnata is native to Madagascar [44] but is found in tropical and subtropical regions worldwide [45], including parts of India. Or globally includes areas in Africa, the Caribbean, Southeast Asia, and parts of India, including Himachal Pradesh, where it can thrive in warm climates and well-drained soils [46]

PLANT BIOLOGY

Herb-Kalanchoe pinnata is a perennial succulent plant that typically grows as a shrub [47]. It can reach heights of about 1 to 2 meters [48]. Kalanchoe pinnata is known for its unique reproductive habit [49].

Leaf-The plant has fleshy, thick leaves that are often oval or lance-shaped, with a distinctive serrated edge [50,51]. The leaves can be green or have a bluish tint [52], and they are known for their ability to store water, which helps the plant survive in dry conditions [53].

Leaf Structure-The leaves are thick and succulent, enabling the plant to store water efficiently, making it drought-resistant [54]. They are green with smooth margins and may exhibit a waxy coating that further reduces water loss [55].

Propagation- It is well known that Kalanchoe pinnata reproduces vegetatively [56]. Along the edges of its leaves, the plant may generate tiny plantlets that [57], when they come into touch with soil, may fall off and take root. Its broad prevalence in a variety of settings is a result of its ease of propagation [58].

Flowers and Inflorescence-The inflorescence and flowers of Kalanchoe pinnata are tiny, tubular, and usually pink to reddish in colour [59]. Pollinators like bees and butterflies are drawn to the flowers, which are carried in clusters on erect stalks. Typically, certain environmental factors, like as light and temperature, trigger flowering [60].

Habitat Preference: This plant is typically found in sandy or rocky locations, frequently in disturbed habitats, and it grows best in well-drained soils. It can withstand both full sun and moderate shade and is tolerant of several soil types [61],[62].

PLANT CHARACTERISTICS

Morphological character -Generally growing to a height of 0.9 to 1.8m (about 3 to 6feet) [63], Kalanchoe Pinnata has a number of intriguing morphological traits, ranging from colour, which is youthful and reddish with a hint of radish, to its aesthetic appeal. This plant's fleshy, cylindrical stems define it as a herbaceous succulent shrub. Thes leaves have a brownish crenate (scalloped) edge and are smooth, glossy, and meaty [64].

Organoleptic character -The organoleptic features of Kalanchoe pinnata are particularly remarkable. The leaves are typically oblong or elliptic in form, with crenate or serrated edges. They have an asymmetric base and show reticulate venation [65]. The leaves are smooth, glossy, and meaty, with a brownish hue to the margins. Lower leaves are normally simple, but upper leaves can be compound, with 3 to 7 leaflets [66]. The powdered leaves are characterized as odorless and bitter. The leaves are normally bright green with a slight reddish hue [67]. However, Kalanchoe pinnata leaves have a mild, almost unnoticeable odour when fresh or when dried or crushed, they emit a moderate, slightly bitter aroma [68]. Some describe it as herbaceous or earthy [69].

Microscopical character- A single layer of epidermal cells covers means it is hairless and smooth. Palisade and spongy layers are the distinct forms of mesophyll tissue [70]. The palisade layer, which maximizes photosynthesis, is made up of long cells that are abundant in chloroplasts and situated just beneath the upper epidermis. Gas exchange is facilitated by the loosely packed cells with air gaps seen in the spongy layer Xylem and Phloem [71],[72],[73],[74]. In Kalanchoe pinnata, vascular bundles are usually grouped in a closed configuration, with xylem and phloem situated next to one another [75]. The xylem is in charge of carrying water. Whereas nutrients are transported by the phloem or Water and nutrients are supported and transported by vascular bundles that are dispersed throughout the leaf [76]. On the other hand, the lower epidermis has stomata, which aid in gas exchange. Typically, they are submerged, which minimizes water loss and the existence of on the leaf surface, glandular or non-glandular trichomes structures that resemble hair can be seen. Reduced water loss, herbivore deterrence [77], and environmental stress prevention are just a few of the potential uses for these structures. Thin-walled parenchyma cells that store nutrients and water make up Kalanchoe pinnata's root system. Water absorption is facilitated by the root hairs' increased surface area for absorption. The arrangement of the petals, sepals, and stamens can be seen when the floral which add to their colour and texture. The petiole (leaf stalk) is long and similar in structure to the leaf, with a separate lower epidermis and vascular tissues [78].

Macroscopic Character - Kalanchoe pinnatas succulent, meaty leaves, which are grouped in a rosette arrangement as an asymmetric base and have reticulate venation, are one of its most noticeable macroscopic characteristics [79]. The succulent, cylindrical stem can reach a height of several centimetres. Usually bell-shaped, the blooms have four or five petals and come in a variety of colours, such as white, yellow, orange, pink, or red, along with unique scents [80].

CULTIVATION-For cultivation Kalanchoe Pinnata favours sandy, loamy, or well-drained soil for Kalanchoe growing. Although it can withstand poor soil conditions, it prefers pH ranges of 6.0 to 7.0, which are slightly acidic to neutral. Full light is preferred by the plant over partial shade. It can withstand moderate shade, but for best growth and blooming, it needs ample sunlight. Succulents can withstand drought [81],[82]. It needs to be watered sparingly so that the soil dries out fully in between applications. Root rot can result from overwatering [83], Warm temperatures

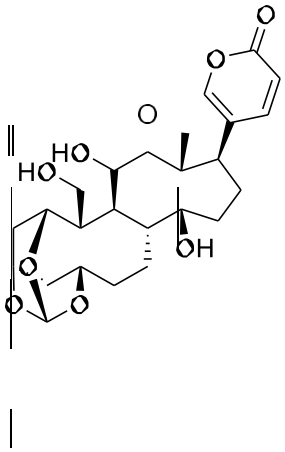
are ideal for this plant's growth, ideally between 20°C and 30°C (68°F and 86°F) [84],[85]. It is easily propagated by leaf cuttings or offsets (plantlets) that grow along the leaf margins, and it can withstand slightly lower temperatures

but needs to be protected from frost. These can be sown straight into the ground to take root [80],[86].

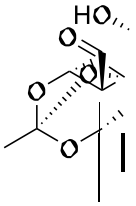
COLLECTION -The leaves of Kalanchoe Pinnata are typically harvested for their therapeutic properties. Although you can do this at any time during the growing season, the morning is the best time to apply it due to the higher moisture content [87]. The leaves are usually collected by hand, preferably in the morning when there is more moisture, which can help extract beneficial ingredients [88],[89]. After gathering, the leaves should be thoroughly cleaned and left to dry in a shaded, well-ventilated area to avoid the spread of molding [90]. After drying, they can be stored in sealed containers away from direct sunlight to maintain their medicinal efficacy. One way to process the leaves is to triturate them without adding water or heat to extract the juice [91].

CHEMICAL CONSTITUENTS -Kalanchoe pinnata is an aromatic plant that is used as a herb with a sweet and sour scent. A large number of species of Kalanchoe pinnata have been described in terms of flavour. The plant's height ranges from 1-1.5 meters [92]. Sweet Kalanchoe pinnata has a sour taste and a green tint [93]. The presence of essential oil in the leaves and other parts of the plant gives many Kalanchoe pinnata species/cultivars [94] their characteristic fragrance and aroma. This plant contains an abundance of lipids, alkaloids, bufadienolides, triterpenes, steroids, glycosides, cardenolides, and flavonoids [95]. Its leaves are high in "bufadienolides," which include bryotoxin-C, bryotoxin-B, bryotoxin-A, and digoxin, all of which have strong chemo preventive, antitumor, and antibacterial properties as well as insecticidal potential [96]. The bitter leaves and bark of this plant are used to treat vomiting and diarrhoea because of its carminative and analgesic properties, as well as its astringent effect on the bowels [97]. Several key anti-ulcer chemical components in Various components of this plant include arachidic acid [98], astragalus, and behenic. acid, β-amyrin, benzenoids, β-sitosterol, bryophyllinone, bryophyllin, bryophyllin-A and C, bryophyllol [99], bryophynol, bryotoxin-C, bufadienolides, , campesterol , cardenolides, cinnamic acid, clerosterol, clionasterol, codisterol, coumaric acid [100], epigallocatechin, ferulic acid, flavonoids, friedelin, glutinol, hentriacontan, isofucosterol, kaempferol, oxalic acid, oxaloacetate, palmitic acid, patuletin, and peposterol phosphoenolpyruvate, protocatechuic acid, pseudotaraxasterol, pyruvate, quercetin, steroids, stigmasterol, succinic acid, syringic acid, taraxerol, and triacontane [101]. Some essential fatty acids of this plant include behenic acid, arachidic acid, stearic acid, and palmitic acid. addition to that, this plant also contains HCN, succinic acid, oxalic acid, malic acid, citric acid, and oxaloacetate [102]

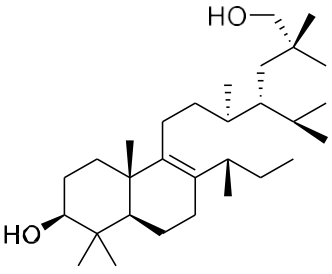
Bryotoxin B



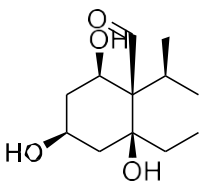
Bryophyllin



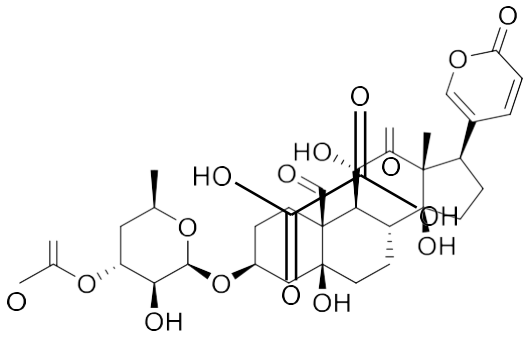
Bryonolol



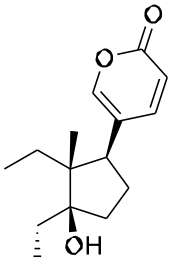
Bersaldegenin



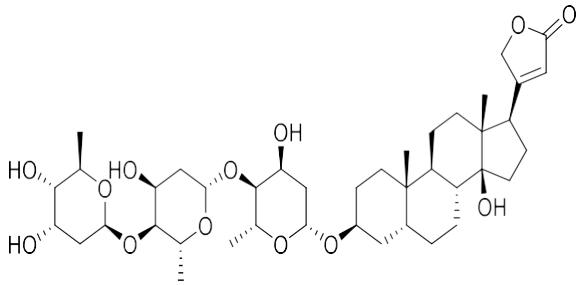
Bryotoxin A



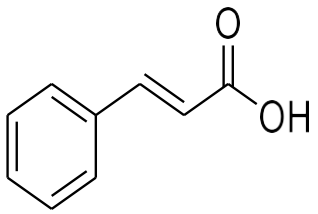
Oxalic acid



Digitoxin



Cinnamic acid



PHARMACOLOGICAL CHARACTERS

According to our review it is claims that the genus Kalanchoe has several pharmacological characteristics, including antiviral, sedative, antiulcer, immunomodulatory [103], anti-leishmanial, CNS depressant, anti-inflammatory, thyroid peroxidase inhibitor, cytotoxic, hepatoprotective, antioxidant, analgesic, anticonvulsant, antimicrobial [104], B cell growth inhibitor, cardiovascular activity, Larvicidal, insecticidal, and antihyperglycemic action and etc [105],[106].

Natural Tonic -The plant serves as a rich source of ascorbic acid, riboflavin, thiamine, and niacin [107]. Its leaves have substantial levels of ascorbic acid, essential for numerous physiological processes, such as collagen production, immune system support, and antioxidant protection [108],[109]. Natural ascorbic acid is essential for the body's function, such as the normal creation of intercellular materials throughout the body, including collagen, bone matrix, and dental dentine [110]. Therefore, the clinical manifestations of scurvy that are haemorrhaging from the mucous membrane of the mouth, gastrointestinal tract, anaemia, pain in the joints can be related to the association of ascorbic acid and normal connective tissue metabolism [111]. This function of ascorbic acid accounts for its normal wound healing property [112]. As a result, the plant is used in herbal medicine for the treatment of common cold and other diseases like prostate cancer [113]. In a study, an herbal composition comprises extracts of a number of herbs including B. Pinnatum act as a tonic to improve respiration, aid in the elimination of toxins and improve overall vitality [114]. Whereas as a result the presence of vitamin C makes the plant a valuable resource for enhancing overall health [115].

Anti-inflammatory Activity - While studying the different chemical constituents we have founded that characteristic of different flavonoid glycosides have been examined to determine and define their possible use as therapeutic agents in treating inflammatory diseases [116]. The anti-inflammatory impact of Quercetin Flavonoid in the acetic acid triggered vascular permeability and the percentage reduction of inflammation [117],[118]. Our findings showed that the quercetin flavonoid exhibited strong anti-inflammatory effects during the acute phase of inflammation [119] [120].

Antibacterial Activity-The existence of phenolic compounds suggests that the plant has anti- microbial properties. From the water extracts of K. Pinnata leaves, the flavonoids quercetin and rutin are obtained. Phytochemical analyses were conducted and assessed [121],[122]. The antibacterial effectiveness was assessed using the macro dilution technique. Quercetin has the ability to impede the growth of all examined bacterial strains [123]. The findings suggest the possible application of the species for treating bacterial infections. The assessment of the antimicrobial properties of the aqueous extract and flavonoids has been conducted using the agar dilution method (microdilution) [124], [125]. The water extract from the leaves demonstrated a decrease in four of the assessed strains.

Anticancer Activity -Studies indicate that the extract from the k. pinnata plant contains a substance that has a cytotoxic impact on cancer cells [126]. These compounds, which include flavonoids, phenols, and alkaloids, demonstrate diverse mechanisms of action, like triggering apoptosis in cancer cells, hindering tumour growth, and blocking angiogenesis [127]. Extracts of Kalanchoe pinnata have demonstrated potential in improving the effectiveness of traditional cancer therapies such as chemotherapy and radiotherapy, while simultaneously lessening their side effects. Bufadienolides isolated from Kalanchoe pinnata were assessed for their inhibitory effects on the activation of Epstein Barr virus early antigen in Raji cells triggered by the tumour promoter all bufadienolides displays good activity, while Bryophyllin [129]. A demonstrates the most significant activity, or Bersaldegenin-1, 3, 5-orthoacetate suppressed cancer cell proliferation across various cancer lines [130].

Antihypertensive Activity - The antihypertensive effects of Kalanchoe pinnata are linked to its abundant phytochemical composition, which contains flavonoids, tannins, saponins, and various other bioactive substances [131]. These substances influence their effects through different mechanisms, mainly focusing on the cardiovascular system [132]. Flavonoids serve as strong vasodilators, relaxing smooth muscle cells within blood vessel walls, which results in expanded blood vessels and decreased peripheral resistance. This reduction in resistance enables blood to move more freely, decreasing blood pressure [133]. While tannins are recognized for their astringent qualities, some research indicates that they might also aid in vasodilation by blocking the function of specific enzymes tied to vasoconstriction [134]. Saponins found in Kalanchoe pinnata have been demonstrated to block angiotensin-converting enzyme (ACE). ACE is an essential enzyme that plays a role in the renin-angiotensin-aldosterone system (RAAS), which controls blood pressure [135]. By blocking ACE, these saponins decrease the synthesis of angiotensin II, a strong vasoconstrictor, which results in lowered blood pressure [136]. Several studies indicate that certain components in Kalanchoe pinnata might exhibit a diuretic effect, enhancing urine production and diminishing blood volume [137].

Antidiabetic Activity -Numerous studies indicate that extracts from the plant K. pinnata contain bioactive compounds like flavonoids and alkaloids, which have shown diverse mechanisms of action related to diabetes including [138]. The extraction from this plant has been shown to reduce blood glucose [139] levels by boosting insulin release from pancreatic beta cells, improving glucose absorption by peripheral tissues, and suppressing glucose production in the liver. The presence of zinc in these plants suggests they may have important roles in diabetes management, which arises from insulin dysfunction [140].

Anti-Allergic Activity -Recent scientific studies have shown that oral administration of quercitrin extracted from plants can prevent fatal anaphylaxis in animals by up to 75 percent [141]. These findings indicate that the oral intake of different types of Kalanchoe pinnata is effective in inhibiting the modules of pro-anaphylactic induced immune reactions. The protection provided by quercetin indicates that this flavonoid is the key element in Kalanchoe pinnata that proves effective against severe allergic responses [142]. The anti-allergic properties of Kalanchoe pinnata could be associated with its capacity to block the release of histamine and additional inflammatory mediators from mast cells [143]. By decreasing the release of histamine, the plant can assist in easing symptoms linked to allergic reactions, such as itching, swelling, and redness [145]. Historically, Kalanchoe pinnata has been employed in different cultures to address ailments linked to allergies, such as respiratory problems like asthma and allergic rhinitis [146]. Its use in traditional medicine indicates its effectiveness in controlling allergic symptoms [147].

Antioxidant Activity -The aqueous extract of Kalanchoe pinnata was assessed for its possible protective effects against gentamicin-induced nephrotoxicity in rats [148]. In-vitro studies have shown that the leaf extract of Kalanchoe pinnata has significant antioxidant properties and oxidative radical scavenging effects [149]. The antioxidant effect of Kalanchoe pinnata largely
results from bioactive compounds that can provide electrons to free radicals, thus neutralizing them and avoiding cellular damage [150]. This protective role is crucial in reducing oxidative stress, which is associated with aging and several diseases, including cancer and cardiovascular issues. Flavonoids like quercetin and kaempferol serve as powerful scavengers of free radicals. They give away electrons to neutralize free radicals, stopping them from harming cellular components [151]. While certain compounds in Kalanchoe pinnata obstruct enzymes that play a role in the formation of reactive oxygen species (ROS), known as damaging free radicals [152]. Some compounds can bind to metal ions, like iron and copper, which may promote the creation of free radicals [153]. By binding to these metals, Kalanchoe pinnata diminishes their capacity to produce ROS. Oxidative stress plays a role in the progression of atherosclerosis, a condition that stiffens arteries and elevates the risk of heart disease [154]. The antioxidants found in Kalanchoe pinnata might assist in safeguarding blood vessels and lowering the likelihood of cardiovascular disease. Oxidative stress is also associated with inflammation. The antioxidant qualities of Kalanchoe

pinnata may aid in decreasing inflammation and its related health issues [155].

Wound Healing Activity -Kalanchoe pinnata is well-known for its exceptional wound healing abilities, attributed to its various phytochemical and pharmacological effects [156]. The influence of k. pinnata leaf extract on wound healing, both incision and dead space wounds in albino rats, has been examined [157]. The three excerpts demonstrate a rise in the tensile strength of the incision wound. This encouraged the growth and movement of different cells participating in the wound healing process, such as fibroblasts, keratinocytes, and endothelial cells [158]. This speeds up the development of granulation tissue and re-epithelialization, resulting in quicker wound closure. The wound healing properties of Kalanchoe pinnata are demonstrated by the ethanolic extracts, as they notably decrease the size of cuts and sores as well as swelling at the impacted areas [159]. Nonetheless, recent studies indicate that this capability for wound healing might stem from the existence of phenolic antioxidants and steroidal glycosides [160]. Recent research indicates that extracts made with alcohol, petroleum ether, and water may possess wound healing properties [161]. These experimental studies showed that the aqueous extracts are more effective than the alcoholic and etheric extracts [162].

Anti-insecticidal Activity- Methanolic extracts of Kalanchoe Pinnata with bufadienolides exhibit potent insecticidal effects [163]. These individual compounds were noted to be potent insecticidal substances against the three distinct silkworm larvae, primarily due to the presence of the 1,3,5-orthoacetate group compared to the other compounds [164].

Immunosuppressive activity -The water extract from Kalanchoe pinnata leaves has been demonstrated to notably suppress both cell-mediated and humoral immune responses in mice [165]. Additionally, studies reveal that extracts from Kalanchoe pinnata leaves can reduce lymphocyte proliferation in vitro, highlighting its immunosuppressive effects [166]. The extract significantly diminishes delayed hypersensitivity reactions, further substantiating its function as an immunosuppressive agent [167]. Spleen cells from animals treated with K. pinnata exhibited a reduced capacity to proliferate when exposed to both mitogen and antigen in vitro [168]. K. pinnata treatment also hindered the mice's capability to initiate a delayed-type hypersensitivity reaction (DTH) to ovalbumin. The intravenous and topical methods of administration were the most successful in nearly entirely eliminating the DTH reaction [169]. Collectively, these findings suggest that the water extract of K. pinnata exhibits immunosuppressive properties [170].

CONCLUSION:

Kalanchoe pinnata is an exceptional succulent species that has been widely use or researched because of its healing properties and its medicinal uses. Our review demonstrates the plant's abundant phytochemical content with possible medicinal value. The presence of multiple bioactive compounds like flavonoids, alkaloids, and phenolic acids contributes to its antioxidant, anti- inflammatory, antimicrobial, and anticancer activities. Kalanchoe pinnata has been used traditionally to manage various health problems including wounds, infections, and respiratory ailments. Moreover, its wound-healing ability, owing to its phytochemical and pharmacological constituents, makes it a key component of herbal medicine. The antioxidant and anti-inflammatory actions of the plant suggest its efficacy in chronic diseases. In addition, its immunosuppressive. Anti-allergenic properties also make it suitable for treating autoimmune diseases and allergic reactions. All in all, the diverse pharmacological effects and historical uses of Kalanchoe pinnata underline its role in herbal medicine. More research is needed to assess its potential therapeutic applications and develop new drugs from it. Its ease of cultivation and propagation makes it useful for sustainable development..

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