Chapter Title

PHARMACOGNOSTICAL AND PHYTOCHEMICAL POTENTIAL OF KALANCHOE PINNATA.

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ABSTRACT

Kalanchoe is a succulent perennial plant that grows 3-5 feet in length. This chapter presents a detailed survey of the literature on pharmacogenetic and phytochemical studies of this plant. The phytochemicals reported from the plant belong to different classes such as alkaloids, diterpenoid lactones, glycosides, steroids, phenolics, aliphatic compounds, etc. The notable pharmacological properties include anti-diabetic, anti-neoplastic, antioxidant, immunomodulation, anti-lipidemic, anti-allergic, and many more activities which are yet to be explored. Now it has become an endangered plant that needs to be conserved as well as explored for its significant green chemistry.

KEYWORD: *Kalanchoe pinnata*, Pharmacognostical analysis, Phytochemical studies, Pharmacological effects of the plant, Ethanomedical uses.

INTRODUCTION

India, often regarded as the global herbal garden, has served as a rich repository of plants and their derivatives since ancient times. Humans have employed these resources in diverse ways, adapting them to various needs, notably as sustenance and medicine. Within the vast array of flora present, a staggering 35,000 to 70,000 species have found application for medicinal purposes [1]. Comprising over 100 succulent plants, the *Kalanchoe* genus typically flourishes in tropical climates. Michel Adanson, a French botanist, was the first to document this genus in the mid-1700s.

HABITAT

The Kalanchoe genus is hypothesized to have originated in Madagascar, where the largest number of identified species within the genus has been discovered. Additionally, it is suggested that species of this genus are native to various regions in Asia, including Southeast Asia and China, as well as southern and eastern Africa and the Americas. [1,2]

DESCRIPTION

- A synonymous term for this genus is Bryophyllum.
- *Kalanchoe pinnata*, a member of the *Crassulaceae* family.
- It is a perennial shrub that can grow up to 1.5 meters in height (Fig-1).
- This succulent plant, is native to hot and humid regions of India, particularly Bengal.
- It has hollow, four-angled stems with branching.
- It reproduces both vegetatively from leaf buds and through seeds.[3]
- The succulent leaves are arranged oppositely, decussate, and range from 10 to 20 cm in length. The upper leaves, numbered 3–7, have long petioles and a foliate structure, while the lower leaves are plain, displaying prominent red-trimmed scallops and a robust dark green texture (Fig-1). [4]
- The taxonomic classification of the genus is provided below for easy identification (Integrated Taxonomic Information System, n.d.).[5]

Scientific Classification of *Kalanchoe pinnata*

Kingdom	Plantae	**Class**	Magnoliopsida
Sub-kingdom	Viridiplantae	**Order**	Saxifragales
Super-division	Embryophyta	**Family**	Crassulaceae
Division	Tracheophyta	**Genus**	Kalanchoe

(Fig.1)




COMMON NAME

- In English, it is commonly referred to as "floppers," "air plants," "best of luck leaves," "Hawaiian air plants," "life plants," and "American life plants."
- In India, particularly in Hindi, it goes by the names "Patharchattam," "Patharchur," "Pather Talk," and "Paan-futti."
- In Bengali, it is mentioned as "Koppat," "Patharkuchi," "Gatrapuri," "Kaphpat," and "Pathorkuchi."
- In the Unani tradition, it is known as "Zakhm-eHayaat," "Pattharchoor," and "Pattharchat".[2]

Regional Names of Kalanchoe pinnata [6]

Hindi	Zakhm-hayat	**Tamil**	Ranakalli
Arabic	Kushnulhayat	**Kannad**	Ganduklinga
Bengal	Koppata	**Malayalam**	Elamurunga
Sanskrit	Asthi-bhaksha	**Persian & Urdu**	Chubehayat
Telgue	Simajamudu		

PHARMACOGNOSTICAL ANALYSIS

Numerous investigations were carried out to identify and examine *Kalanchoe pinnata*'s macroscopic and microscopic features.

MORPHOLOGICAL CHARACTERISTICS

The average height of a *Kalanchoe pinnata* is 0.3 to 1.2 meters, however, there are instances when it can reach 2 meters.

Stem - The age of the stem affects the color it takes on. While younger stems are often reddish-pink with white specks, older stems are distinguished by their lighter tone. Additionally, the smooth, branching branches are often long and hollow.

Flower - The delicate, tubular blossoms of Kalanchoe pinnata are recognized by their pinkish-red hue. These are suspended on opposite sturdy stems in huge panicles. Additionally, the corolla often has an octagonal base shape and is bloated. The flower's calyx, which can grow

anywhere between 3.5 and 4 cm long, is reported to be tubular and brownish or purple. Typically, the flower's base has triangular teeth and a pale green tint [7].

Leaves - leaves have a serrated or crenate edge and an oblong or elliptical form. In addition, the leaves have a long petiole, an asymmetric base, and glabrous leaf surfaces. Furthermore, the color of the leaves is dependent on which side of the epidermis is exposed; that is, the lower epidermis typically has a lighter hue and the top epidermis typically has a darker green color. Additionally, the leaves are distinguished by a strong smell and a harsh flavor [8].

Fruit - The papery-textured calyx and corolla of the Kalanchoe pinnata plant often envelop the fruit. Additionally, the species is identified by its smooth, oblong-shaped seeds [9].

MICROSCOPIC CHARACTERISTICS

The layer of the epidermis, hypodermis, palisade cells, and meri stele that makes up the lamina of the *Kalanchoe pinnata* leaf is exposed together with the vascular bundle, both sides of the epidermis, and the collenchymatous tissues when it passes through the midrib. It is said that this area is even and level. Both the adaxial and abaxial surfaces of the leaf lack trichomes. Additionally, it is noted that the leaves are convex on the abaxial side and shallow on the adaxial side [10].

The midrib's homogenous ground tissue is made up of parenchyma cells. The parenchymatous cells have a round shape and are compact. The vascular strand, on the other hand, is hemispherical and is made up of broad phloem bands and horizontal xylem bands. The vascular bundles, which can have a horizontal plane width of at least 170 μm, are made up of the vascular strands. In addition, the leaf petiole contains calcium oxalate crystals found in parenchymatous cells, with spiral vessels being observed in the area. Further, the stomata of the leaf of *Kalanchoe pinnata* are also observed. It was discussed that there are many stomata present in the leaf at approximately 18 to 20 mm in length. The stomata of the leaf is described as anisocytic, or structures that are uneven in size [11].

Regarding the stem, it is noted that the outer layer of the thick-walled epidermis is covered in a cuticle. Sclerenchymatous cells make up the hypodermis, which lies underneath this outermost layer. Furthermore, the parenchymatous cells that make up the cortex of the stem are organized loosely and are distinguished by their thin walls and starch granules. The stem's

xylem resembles that of herbaceous dicots, typically taking the shape of tracheids with a few parenchymal fibbers. In the meantime, the species' pith, which is made up of parenchymatous cells, is distinguished by the deposition of starch grains and crystals formed from calcium oxalate (CaC_2O_4). The color of the plant's flower is determined by the pigments and spongy cells that make up the epidermis on both sides of the *Kalanchoe pinnate*'s blooms [12].

PHYTOCHEMICAL STUDIES

PHYTO - CHEMICAL CONSTITUENTS

The plant is rich in various phytochemical constituents, including alkaloids, flavonoids, phenolic compounds, and tannins. It also contains essential macro elements such as magnesium, calcium, potassium, phosphorus, and sodium, as well as microelements like iron and zinc. The presence of vitamins, including ascorbic acid, riboflavin, thiamine, and niacin, has been identified [6]. Specifically, B. Pinnatum is noted for its abundance of alkaloids, triterpenes, glycosides, flavonoids, cardenolides, steroids, bufadienolides, and lipids [13]. The leaves of the plant contain amino acids like thiamine, pyridoxine, ascorbic acid, glycine, cysteine, and nicotinamide. In terms of food content, it includes carbohydrates, proteins, lipids, and various minerals such as sodium, calcium, potassium, phosphorus, magnesium, ferrous, copper, and zinc. Additionally, sugars like raffinose, lactose, sucrose, and glucose are present [14]. The flavonoids identified in the leaves encompass astragalin, 3, 8-dimethoxy-4, 5, 7-trihydroxyflavone, friedelin, epigallocatechin-3-o-syringate, luteolin, rutin, kaempferol, quercetin, quercetin-3-O-diarabinoside, and kaempferol-3-glucoside [15].

Roots

The roots exhibit the highest concentration of elements, including potassium, iron, calcium, phosphorus, sodium, copper, and zinc [16].

Leaves

The leaves of Bryophyllum pinnatum contain various compounds such as Butyrolactose, 3,4-Epoxy tetrahydrothiophene-1,1-dioxide, 3,5-Dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one (DDMP), Benzaldehyde, 2-methyl, alpha-D Glucopyranoside, n-hexadecanoic acid. These

components are utilized in the treatment of rheumatism and inflammation. Additionally, oleic acid found in the leaves contributes to reducing the risk of breast cancer and lowering blood pressure. Octadecanoic acid is also present in the leaves [16,17].

Stem

Phytochemical screening of the *K. pinnatum* stem has revealed the presence of various compounds, including flavonoids, alkaloids, tannin, saponins, phenol, phytate, and hydrogen cyanide (HCN). Elemental analysis indicates that the stem of *K. pinnatum* contains noticeable amounts of calcium, magnesium, phosphorus, sodium, and potassium [16].

PHARMACOLOGICAL EFFECTS OF THE PLANT

WOUND-HEALING ACTIVITY

The significant wound-healing activity was demonstrated by the ethanolic extract of *K. pinnata*, which reduced edema at the location of the wound and the size of the affected region. The wound-healing activity exhibited by the extract may be due to the presence of steroid glycosides [18]. Petroleum ether and alcoholic extracts of the plant have the potential to heal wounds. Additionally, the study indicated that compared to the other two extracts, the water extract exhibited greater activity [19].

ANTIOXIDANT ACTIVITY

The harmful effects of reactive oxygen species, such as singlet oxygen, superoxide, peroxyl radicals, hydroxyl radicals, and peroxy-nitrite, are prevented by antioxidant compounds. Reducing characteristics are often linked to the existence of reductones, which have been demonstrated to break the chain of free radicals by either donating an electron or a hydrogen atom this process is how antioxidants work. It has also been observed that reductones inhibit the generation of peroxide by reacting with certain peroxide precursors. Potential antioxidant activity has good correlations in the treatment of cardiovascular disorders [20].

The discovery of quercetin and kaemferol in K. pinnata leaves suggests that quercetin has a notable protective effect against cadmium-induced nephrotoxicity, which is caused by an

increase in the expression of eNOS (endothelial nitric oxide synthase), a small cysteine-rich protein, and COX-2 (cyclooxygenase-2), as well as an inhibition of iNOS (inducible nitric oxide synthase) and Metallothionein. The ethanolic extract had a higher total phenolic and flavonoid content than other extracts, and it was claimed that leaves exhibited greater scavenging effects than stems. The extracts' strong antioxidative action might be attributed to their high concentration of phenols and flavonoids [21].

Even in the lipid phase, the phenolic components can interact with the transition metals and chelate them by occupying their aqua-coordination sites and producing insoluble complexes with metal coordination. The capacity of phenolics to stabilize radicals by directly scavenging peroxyl radicals and producing stabilized phenoxy radicals may be the cause of the inhibition of lipid auto-oxidation. The extract's capacity to lessen metal-induced peroxidative stress (lipid phase) was revealed to be a prerequisite for its metal-chelating activity (aqueous phase). In a study using several solvent extracts to examine the plant's roots. The root methanolic extract was shown to have the highest level of activity among them [22].

ANTITUMOR ACTIVITY

The inhibitory effects of five bufadienolides (1–5) extracted from K. pinnata leaves on Raji cells' activation of the Epstein-Barr virus early antigen (EBV-EA) caused by the tumor promoter 12-O-tetradecanoylphorbol-13-acetate were investigated. Among the substances studied, bryophyllin A (1) had the most significant inhibition (IC50 = 0.4 microM) among all bufadienolides that showed inhibitory action. Less active compounds were bryophyllin C (2), a reduction counterpart of 1, and bersaldegenin-3-acetate (3), which lacked the orthoacetate moiety. These findings imply that bufadienolides have the potential to be used as cancer chemopreventive drugs.

DENA is regarded as a significant environmental hepatocarcinogen because of its propensity to produce free radicals during its metabolism in the liver, upsetting the antioxidant state and eventually resulting in oxidative stress and carcinogenesis. The aqueous extract scavenged the free radicals, reduced necrotic damage, and protected the hepatocytes from the carcinogenic effects of DENA [23].

ANTIVIRAL ACTIVITY

Human papillomavirus (HPV) is one of the sexually transmitted viruses, acting as a major threat to humans. Cervical cancer which is on the rise is caused by HPV. When the extract fractions were added to cancer cell lines, they inhibited both the development of the tumors and the production of viral proteins. Epstein Barr virus is a herpes virus that affects the B-lymphocytes of humans, leading to the formation of tumors [24].

CYTOTOXICITY AND ANTIMICROBIAL ACTIVITY

Two flavonoids and an alkaloid from the ethanolic leaf extract of *K. pinnata* proved the antimicrobial activity of the plant. These phytocompounds inhibited the growth of some commonly found gram-negative and positive bacteria and fungi. Antimicrobial potential of K. pinnata and stated that methanolic extract showed a better inhibition rate. In addition to causing skin infections, bacteria on the skin may also cause food poisoning, respiratory illnesses, wound infections, abscesses, osteomyelitis, endocarditis, pneumonia, and other issues when they enter the body. So, the prepared extract can act against such diseases, and save the lives of infected ones. The research confirmed the traditional use of the plant for curing respiratory tract infections including pneumonia [25].

ANTILEISHMANIAL ACTIVITY

Leishmaniasis is a disease caused by protozoans belonging to the genus Leishmania. Oral administration of *K. pinnata* aqueous extract was administered to mice harboring Leishmania amazonensis infection. A few findings were recorded following the study, including the lesions' reduced size and the parasite load at the affected location. Ongoing administration of the extract not only regulated the growth but also stopped new infections from occurring. The plant extract's flavonoid glycoside content may be the cause of the antileishmanial action [26].

ANTHELMINTIC ACTIVITY

The *K. pinnata roots* aqueous, methanolic, and chloroform extracts are anthelmintic, while the petroleum ether extract was ineffective against the worms**.** The methanolic extract was found to be most effective when compared with others. In addition to causing paralysis, the plant's root extract killed worms, especially when it was applied at greater concentrations for shorter periods. Tannins may be the culprit, since they can attach to free proteins in the host animal's digestive system or to glycoprotein on the parasite's cuticle, ultimately resulting in death [27].

INSECTICIDAL ACTIVITY

Isolated compounds were reported to exhibit strong insecticidal activity against third instar larvae of the silkworm and the reason was associated with the presence of 1, 3, 5-orthoacetate moiety of the bufadienolides [28].

ANTI-ALLERGIC ACTIVITY

Aqueous extract of *K. pinnata* was evaluated for its protective effect in fatal anaphylactic shock, likewise a The-driven immunopathology and the identification of its active component. In vitro, *K. pinnata* prevented antigen-induced mast cell degranulation and histamine release. Oral treatment with the quercitrin flavonoid isolated from the plant prevented fatal anaphylaxis in 75% of the animals. These findings indicate that oral treatment with *K. pinnata* effectively down-modulates pro-anaphylactic inducing immune responses. Protection achieved with quercitrin, although not maximal, suggests that this flavonoid is a critical component of *K. pinnata* extract against this extreme allergic reaction [29].

ANTINOCICEPTIVE ACTIVITY

The methanolic extract of K. pinnata showed a significant effect on mice when compared with the standard drug aspirin. It reduced the number of acetic acid-induced writhings in a dose-dependent manner. The aqueous extract may probably have exerted its antinociceptive effects by inhibiting the release, synthesis, and/or production of inflammatory cytokines and mediators, including prostaglandins, histamine, polypeptide kinins, and so on [30].

ANTI-INFLAMMATORY ACTIVITY

The different *Kalanchoe pinnatum* leaf extracts/fractions were studied in a rat model of chemically induced inflammation. Indomethacin inhibited edema in early, middle, and later phases in a rather homogeneous manner. Early stages of formaldehyde-induced edema were likewise somewhat inhibited by the methanolic fraction; however, later stages demonstrated considerable suppression. The methanol fraction from *K. pinnatum* leaves was more important than the other fractions in terms of % prevention of paw edema among the pet-ether, chloroform, acetone, and Methanol fractions [31].

Formaldehyde induces inflammation from cell damage, which initiates the production of endogenous mediators such as histamine, serotonin, prostaglandins, and bradykinin. It is also known that inhibition of edema induced by formalin in rats is one of the most suitable test

procedures to screen anti-arthritic and anti-inflammatory agents as it closely resembles human arthritis. The anti-inflammatory activity could be associated with the action of the flower extract of the plant on the edema induced by croton oil, indicating the anti-oedematogenic ability of the plant [32].

ANTIPYRETIC ACTIVITY

The impact of plant extract on experimental animals hyperthermic conditions. Brewer's yeast injections were used to cause pyrexia in rats. The laboratory specimens' body temperatures were lowered by the hydroalcoholic extract of *K. pinnata*, demonstrating its antipyretic action. This action could be caused by the flavonoids that are present in the extract [33].

NEUROPHARMACOLOGICAL ACTIVITY

The Ethanolic extract of the plant showed CNS-depressant activity in mice. The rate of activity was found to be nearly the same as the commercially used antidepressant drugs. Picrotoxin-induced seizures were delayed and the mortality of the mice was prevented. The CNS-depressant activity of the extract could be due to the presence of bufadienolides and other water-soluble constituents in the extract [34].

ANTILITHIATIC ACTIVITY

Calcium oxalate stones develop because of decreased oxalate excretion in urine. Patients with stones in their bodies were given fresh juice made from *K. pinnata* leaves as part of a medical prophylactic regimen. Regardless of the location, kind, or history of treatments, the stones were successfully eliminated with consistent juice consumption. The amount of urine expelled increased, indicating that the juice had a diuretic effect. Additionally, it promoted the increase in citrate excretion and the decrease in oxalate excretion. All the rats treated with extract had less renal injury, less epithelial lining deterioration, and less tubular dilatation when the kidneys were examined histopathologically. Prepared tablets using extracts from *K. pinnata* and stated that the medication is useful in reducing the buildup of calcium oxalate crystals and avoiding kidney stone development [35,36].

ANTIHYPERTENSIVE ACTIVITY

The aqueous extract of *K. pinnata* prevented the rise in rats' systolic and diastolic arterial pressures, hence inhibiting salt-induced hypertension. It was suggested that the plant extract's overall antihypertensive action may be due to its antioxidant and vasculature-modifying

properties. Using both invasive and non-invasive methods, the effects of the plant's aqueous and methanolic leaf extracts were investigated on the arterial blood pressures and heart rates of normal (normotensive) and spontaneously hypertensive rats. The anesthetized rats' arterial blood pressure and heart rates were significantly reduced by both extracts in a dose-related manner. The guinea pig's isolated atria's contraction force and rate were likewise reduced by the leaf extracts [37].

As the extract dosage increased, the blood pressure dropped. However, this study also revealed the existence of bioactive substances that have harmful effects on both people and animals. Therefore, even though the plant is known to have a wide range of therapeutic benefits, the study concluded that, when testing on lab specimens, the dosage of plant extracts should be confirmed to prevent unfavorable responses [38].

USES

Various species within the Kalanchoe genus have been utilized in folkloric medicine across different regions of the world. Traditional medicinal practices have employed Kalanchoe species for alleviating infections, fever, and inflammation [5,8], as well as addressing conditions like kidney stones, gastric ulcers, lung infections, and rheumatoid arthritis. Additionally, these plants have been utilized as remedies for respiratory and digestive illnesses, allergies [29], and nausea [39]. Furthermore, certain species of *Kalanchoe* have exhibited antimicrobial [39], wound healing [42], and anti-aging properties [22].

ETHNOMEDICAL USES

The leaf extract, taken on an empty stomach, is employed in treating urinary bladder stones and fever in children. It is also used as a remedy for diarrhea. The juice extracted from the leaves is utilized to address coughs and dysentery. Externally, the leaf juice is applied to treat conditions like scabies and leucoderma, while a leaf decoction is applied to cuts to stop bleeding. Additionally, the plant is used for various purposes, including treating eye infections, headaches, inflammation, menstrual disorders, pimples, wounds, aches, burns, childbirth-related issues, colds, coughs, fever, pain, respiratory infections, earaches, eczema, and pimples. Furthermore, it finds application in addressing bacterial infections, boils, broken bones, bronchitis, cancer (lymphoma), conjunctivitis, epilepsy, erysipelas, gas, heartburn, intestinal problems, migraines, nausea, skin problems, sores, ulcers, and urethritis [7].

UNANI AND AYURVEDA

In Ayurveda, the leaves are considered bitter and possess insecticidal properties. On the other hand, in Unani medicine, the bark is characterized as bitter and poisonous. It is recognized for its tonic, alexipharmic, astringent effects on the bowels, analgesic properties, and carminative qualities. The bark is deemed useful in treating conditions such as diarrhea, vomiting, and inflammations, as well as for managing snake bites and scorpion stings [7].

CONCLUSION

It is concluded that detailed information as presented in this chapter is on its pharmacognostic studies, phytochemical constituents, various biological properties, and the use of the plant in medicine. Some small companies in India and Amazon are using *K. Pinnata* as raw materials for phytochemicals. The pharmacological studies so far have mostly been performed in vitro and in vivo with animals. In future studies, the isolated principles and *K. Pinnata* need to be evaluated in a scientific manner using specific animal models, and clinical studies The present literature shows the pharmacological potentials of *K. pinnata* which is very helpful to researchers to explore more about this medicinal plant.

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