Journal of Applied Pharmaceutical Science Vol. 6 (03), pp. 151-158, March, 2016
Available online at http://www.japsonline.com
DOI: 10.7324/JAPS.2016.60326
ISSN 2231-3354

The "Wonder Plant" *Kalanchoe pinnata* (Linn.) Pers.: A Review

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ARTICLE INFO

Article history:
Received on: 04/11/2015
Revised on: 05/01/2016
Accepted on: 21/01/2016
Available online: 30/03/2016

Key words:
Kalanchoe pinnata; plant extracts; pharmacological; ethnomedicine.

ABSTRACT

Kalanchoe pinnata (Linn.) Pers. is a plant found mostly in the temperate and tropical regions of the world. It is traditionally known to exhibit a wide range of pharmacological activities that involves treatment for the most serious disorders related to mankind. In this review, the therapeutic and medicinal values of the plant which includes its wound-healing, antioxidant, anticancerous, antiproliferative, antimicrobial, antiviral, antiprotozoal, antileishmanial, anthelmentic, insecticidal, anti-allergic, analgesic, antinociceptive, anti-oedematogenic, anti-inflammatory, muscle-relaxant, antipyretic, anticonvulsant, antidepressant, sedative, antilithiatic, hepatoprotective, gastroprotective, antidiabetic, nephroprotective, haemoprotective, antihistamine, antihypertensive and immunosuppressant activities have been comprehensively discussed. In ethnomedicine, it is known for its anthroposophical and tocolytic effects in pregnant women. Also, it is used to facilitate dropping of placenta during child birth. Scientists have explored the different parts of the plant and have established the clinical potentials of the plant as a whole and its parts successfully. Few scientific validations have even lead to the isolation and determination of the applications of the bioactive compounds from various solvent extracts of the plant. Further research and clinical trials have to be carried out in order to commercialise the potential pharmaceutical uses of the plant for which one should thoroughly know about the pharmacognostic properties of the plant.

INTRODUCTION

Diseases are on the rise since the advent of life on earth. Procuring a defensive mechanism is a challenge for researchers. Plants are a boon to mankind. They are explored, researched and exploited to combat various dreadful diseases. Plants that prove a cure to diseases are considered medicinal. Their therapeutic nature also prevents occurrences of certain conditions. Such plant-based compounds are less toxic and show minimal or nil side effects. *Kalanchoe* is a genus that has many species most of which are used as agents to treat various ailments. Plants belonging to this genus have been traditionally known for their pharmaceutical value and have been studied by scientists for a very long time. *Kalanchoe pinnata* (synonym: *Bryophyllum pinnatum*) (Figure 1) commonly known as "Ranakalli" "Miracle leaf", "Mexican Love plant", "Katakataka", "Cathedral Bells", "Air plant", "Life plant", "Goethe plant", "Wonder of the World" and so on belongs to the Crassulaceae family. It is also known as "Mother of thousand" as new plantlets arise from the leaf margins which can be cut off from the parent and cultivated separately on pots or barren lands (Kaur *et al.*, 2014). This plant is a water-storing perennial that grows about 1 to 1.5 m tall. The leaves are thick green, fleshy, distinctively scalloped. The stems are tall and hollow bearing pendulous bell-like flowers (Okwu and Nnamdi, 2011a). This plant is mostly found on plains, tropical and temperate regions of Africa, Australia and America. It is one of the ethnomedically used medicinal plants by the folklore of Asia (Afzal *et al.*, 2012b). Earlier in Africa, *K. pinnata* was used to facilitate childbirth, treat ulcers, skin diseases (Okwu and Nnamdi, 2011a) and rheumatism (Prasad *et al.*, 2012). It has high wound-healing properties (Khan *et al.*, 2004; Nayak *et al.*, 2010). It is used to treat stones in the gall bladder (Gahlaut *et al.*, 2012; Raj *et al.*, 2014). It possesses various pharmacological qualities like antioxidant (Asiedu-Gyekye *et al.*, 2012; Bhatti *et al.*, 2012), anticancerous (Devbhuti *et al.*, 2012; Mahata *et al.*, 2012), antiproliferative (Gupta *et al.*, 2010), antimicrobial (Akinpelu, 2000; Okwu and Nnamdi, 2011a, b), antiviral (Mahata *et al.*, 2012; Supratman *et al.*, 2001), antiprotozoal, antileishmanial (Muzitano *et al.*, 2006; Muzitano *et al.*, 2009), anthelmentic (Majaz *et al.*, 2011b), insecticidal (Supratman *et al.*, 2000), anti-allergic (Cruz *et al.*, 2008; Cruz *et al.*, 2012), analgesic (Afzal *et al.*, 2012a),

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antinociceptive, anti-oedematogenic, anti-inflammatory (Gupta *et al.,* 2010; Ojewole, 2005), muscle-relaxant (Ozolua *et al.,* 2010; Salahdeen and Yemitan, 2006), antipyretic (Biswas and Montal, 2015), anticonvulsant, antidepressant, sedative (Matthew *et al.,* 2013a; Salahdeen and Yemitan, 2006), antilithiatic (Gilhotra *et al.,* 2013; Shukla *et al.,* 2014), antidiabetic (Goyal *et al.,* 2013; Matthew *et al.,* 2013c), hepatoprotective (Afzal *et al.,* 2013; Yadav and Dixit, 2003), gastroprotective (Pal and Chaudhuri, 1991; Sharma *et al.,* 2014), nephroprotective (Harlalka *et al.,* 2007; Ramesh *et al.,* 2014), thrombolytic (Akanda *et al.,* 2014), haemoprotective (Sharker *et al.,* 2012), antihistamine (Nassis *et al.,* 1992; Cruz *et al.,* 2008), antihypertensive (Bopda *et al.,* 2014; Ghasi *et al.,* 2011; Ojewole, 2002), immunosuppressant (Cruz *et al.,* 2008; Rossi-Bergmann *et al.,* 1994), etc. This medicinal plant has been widely used in anthroposophic therapy for about 90 years, from Rudolf Steiner's indications and understanding of its action in human beings.

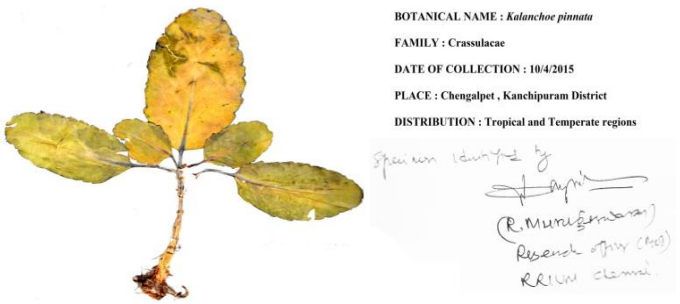

Fig. 1: Herbarium sheet of the plant *Kalanchoe pinnata* (Linn.) Pers.

The parts of the plant are supposed to be closely connected with characteristics of 'astrality' corresponding to the soul organisation in humans, controlling the hysteria (excess of activity) of the metabolic-limb system. *In vitro* experimental studies showed antihistaminic activity of this plant. Those studies also demonstrated improvement of sleep quality in pregnant women, and tocolytic effects similar to the beta-agonist but with fewer adverse effects (including for newborns) (Nascimento *et al.,* 2014). A study by Plangger *et al.,* (2006) suggested that the juice was better tolerated than beta-agonists. Gwehenberger *et al.,* (2004) researched on the *in vitro* relaxant effect in human myometrium. They reported that the plant extract effectively reduced the spontaneous contractions and oxytocin-induced contractions in humans, thus exhibiting change in uterine contractility pattern. The leaves and bark of the plant are sour to taste, carminative in nature and used as bitter tonic (Afzal *et al.,* 2012b). They act as astringent and used to treat acne (Kumar *et al.,* 2013). The juice from fresh leaves is used to treat vomiting, earache, smallpox, otitis, cough, asthma, bronchial disorders, diarrhoea, blood dysentery, jaundice, gout, headache, convulsion and general debility (Afzal *et al.,* 2012b). It is also used for the treatment of jaundice in folk medicines of Bundelkhand region of India (Yadav and Dixit, 2003). A study by Umbuzeiro-Valent *et al.,* (1999) was conducted to investigate the mutagenic as well as antimutagenic activity of the juice extract of the plant. Phytochemicals such as alkaloids, phenols, flavonoids, saponins, tannins, triterpenoids, glycosides, carbohydrates, sterols and amino acids are found to be present in this plant (Matthew *et al.,* 2013b). These chemical components are responsible for exhibiting the above mentioned pharmacological effects. In this review, an effort has been made to discuss the various fore-mentioned activities of *K. pinnata* (Linn.) Pers. so as to gain knowledge about its therapeutic and ethnomedical values.

PHARMACOLOGICAL EFFECTS OF THE PLANT

Wound-healing activity

The ethanolic extract of *K. pinnata* showed significant wound-healing activity by decreasing the size of the affected area as well as oedema at the wounded site. Nayak *et al.,* (2010) reported that this may be due to the presence of steroidal glycosides and phenolic antioxidants. A study carried out by Khan *et al.,* (2004) proved that water, petroleum ether and alcoholic extracts of the plant have the potential to heal wounds. The study also demonstrated that water extract showed more activity than the other two extracts.

Antioxidant activity

Antioxidative agents protect cells against the damaging effects of reactive oxygen species, such as singlet oxygen, superoxide, peroxyl radicals, hydroxyl radicals and peroxynitrite. Antioxidants possess reducing properties generally associated with the presence of reductones, which have shown to exert antioxidant action by breaking the free radical chain either by donating a hydrogen atom or an electron. Reductones are also reported to react with certain precursors of peroxide, thus preventing peroxide formation. Potential antioxidant activity has good correlations in the treatment of cardiovascular disorders. Bhatti *et al.,* (2012) found that scavenging capacity increased with increase in concentration. The leaves were reported to show maximum scavenging effects than stems and the ethanolic extract showed more total phenolic and flavonoidal content than other extracts. The high amount of phenols and flavonoids in the extracts may be the reason for their high antioxidative activity (Bhatti *et al.,* 2012). The phenolic constituents have the ability to interact with the transition metals even in lipid phase and chelate them by filling their aqua-coordination sites and generating metal-coordinated insoluble complexes. Inhibition of lipid auto-oxidation could be attributed to the ability of phenolics to stabilise the radicals through generation of stabilised phenoxyl radicals by directly scavenging peroxyl radicals. Jaiswal *et al.,* (2014) reported that ethanolic extract of *K. pinnata* has strong protective potential than standard antioxidants against oxidative stress in both aqueous and lipid phases. The metal-chelating ability (aqueous phase) of the extract was found to be dependent on its ability to reduce metal-induced peroxidative stress (lipid phase). Tatsimo *et al.,* (2012) studied the antimicrobial and antioxidant activities of ethyl acetate and methanolic extracts of the plant. They isolated seven

kaempferol rhamnosides derivatives from ethyl acetate extract and tested for their antioxidant ability. It was reported that methanolic extract and compound 7 showed highest activity by scavenging of free radicals along with inhibition of microorganisms. Sindhu and Manorama (2013) experimented on hexane, chloroform, ethyl acetate, acetone and ethanol extracts of the plant. They demonstrated that various solvent extracts from leaves showed varying degrees of antioxidant activity in different test systems in a dose-dependent manner. Majaz *et al.,* (2011a) experimented on the roots of the plant by preparing various solvent extracts. Among them, methanolic extract of the roots was proved to show best activity.

Antitumour activity

Devbhuti *et al.,* (2012) experimented on mice by inducing tumour formation in the peritoneal region of the body. Methanolic and aqueous extracts of the plant were administered as drugs in specific dosages. These extracts decreased the ascitic fluid volume and arrested the tumour growth, acting as a tumour-suppressing agent. Thus, the extracts were reported to possess antitumour activity. Mahata *et al.,* (2012) researched on anticancer activity of the chloroform extract of the plant. The extract exhibited apoptosis-inducing property, growth-inhibitory activity, on cervical cancer cells due to the presence of certain phytocompounds. The study also discussed on the antiviral properties of the plant. The antineoplastic activity of the plant was studied by Afzal *et al.,* (2013). In the study, the intake of the aqueous extract for N-diethylnitrosamine (DENA)-induced hepatocarcinogenesis in rats decreased the hepatic damage. The protective effect may be due to the antioxidant and antiperoxidative effects coupled with an ability to correct the abnormalities in lipid and lipoprotein metabolism through an increase in the activities of few lipid metabolising enzymes. DENA has the tendency to generate free radicals as its metabolism takes place in the liver, disturbing the antioxidant status, ultimately leading to oxidative stress and carcinogenesis, and that is the reason it is considered as a major environmental hepatocarcinogen. Histopathological examination of the liver section of DENA-treated rats showed intense centrilobular necrosis and vacuolisation. The aqueous extract scavenged the free radicals, reduced necrotic damage and protected the hepatocytes from the carcinogenic effects of DENA.

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. A study by Mahata *et al.,* (2012) examined the anticancer and anti-HPV activities of chloroform extract of the plant. The extract fractions when subjected to cancer cell lines, suppressed the expression of viral proteins thus inhibiting viral as well as tumour growth. Epstein-Barr virus is a herpes virus that affects the B-lymphocytes of humans, leading to the formation of tumours. Supratman *et al.,* (2001) studied the activity of compounds (bufadienolides) isolated from methanolic extract of the plant. The researchers reported that the bioactive compound inhibited the activation of the virus and suppressed tumour promotion.

Antimicrobial activity

Okwu and Nnamdi (2011a, b) isolated two flavonoids and an alkaloid from the ethanolic leaf extract of *K. pinnata* and proved the antimicrobial activity of the plant. These phytocompounds inhibited growth of some commonly found gram-negative and positive bacteria and fungi. Ogochukwu (2011) demonstrated the antimicrobial ability of aqueous and methanolic extracts of the plant stem. Pattewar *et al.,* (2013) studied the antimicrobial potential of *K. pinnata* and stated that methanolic extract showed better inhibition rate. Bacteria that are found on the skin can cause skin infections and when they enter the body, they cause respiratory diseases, food poisoning, wound infections, abscesses, osteomyelitis, endocarditis, pneumonia and other complications. So, the prepared extract can act against such diseases, and save the lives of infected ones. The reported data can be used to prepare antibacterial and antifungal cream for commercial use (Pattewar *et al.,* 2013). Mudi and Ibrahim (2008) isolated three bioactive compounds from leaf extract and tested their activity against respiratory infection-causing pathogenic bacteria. The research confirmed the traditional use of the plant for curing respiratory tract infections including pneumonia. Chowdhury *et al.,* (2011) worked on petroleum ether and aqueous extracts of *K. pinnata* to study the antifungal and cytotoxic activities of the extracts. It was reported that both the extracts showed almost same effect as that of the antifungal agent used as a standard.

Antileishmanial activity

The protozoans of the genus *Leishmania* cause the disease Leishmaniasis. The aqueous extract of *K. pinnata* was given orally to mice infected with *Leishmania amazonensis*. After the trial, few observations were made such as the decrease in size of the lesions and the parasitical load at the infected area. Continuous treatment with the extract not only controlled the growth but also prevented from further occurrence of the infections. It was suggested that this method could be applied for visceral leishmaniasis also (Muzitano *et al.,* 2009). The antileishmanial activity may be attributed to the presence of flavonoid glycosides in the extract of the plant (Muzitano *et al.,* 2006).

Anthelmentic activity

Majaz *et al.,* (2011b) did a comparative study on the activity of different solvents against the commonly found earthworms and roundworms. The results of their study revealed that chloroform, methanolic and aqueous extract of roots of *K. pinnata* possess anthelmentic activity, while petroleum ether extract did not show any activity against the worms. The methanolic extract was found to be most effective when compared

with others. The root extract of the plant not only demonstrated paralysis, but also caused death of worms especially at higher concentration in shorter time span. The reason may be attributed to the presence of tannins, as they can bind to free proteins in the gastrointestinal tract of host animal or glycoprotein on the cuticle of the parasite and cause death.

Insecticidal activity

Supratman *et al.,* (2000) isolated two bufadienolides from the methanolic extract of *K. pinnata*. 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.

Anti-allergic activity

Cruz *et al.,* (2012) studied the effect of *K. pinnata* on mast cells. Mast cells play a pivotal role for the development of allergic asthma. The study showed that aqueous extract of the plant effectively inhibited mast cell degranulation, thus preventing the development of allergic airway diseases. The data reported suggest that the extract can also act as an immunosuppressive agent. Allergic anaphylaxis is another life-threatening immune reaction that causes death under extreme situations. Continuous administration of aqueous extract of *K. pinnata* prevented acute events related to allergen-induced anaphylaxis. The potential anti-allergic activity may be due to the presence of flavonoids (Cruz *et al.*, 2008).

Antinociceptive activity

Morshed *et al.,* (2010) worked on two medicinal plants to determine the antinociceptive activity of them. It was determined that methanolic extract of *K. pinnata* showed significant effect on mice when compared with standard drug aspirin. It reduced the number of acetic acid-induced writhings in a dose-dependent manner. Ojewole (2005) reported that the aqueous extract showed antinociceptive effects against thermally and chemically induced pain in mice. The aqueous extract relieved pain and protected the mice. 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.

Anti-inflammatory activity

An experiment to determine the anti-inflammatory activity of the plant was performed by Gupta *et al.,* (2010). Petroleum ether, chloroform, acetone and methanol fractions from leaves were administered to experimental models with formaldehyde-induced oedema. Out of which, methanolic fraction exhibited more significant inhibition of paw oedema than other extracts. 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 oedema 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. Arthritis induced by formalin is a model used for the evaluation of an agent with probable antiproliferative activity. As some of the above fractions significantly inhibited inflammation, they can be considered to possess antiproliferative and anti-arthritic activities as well, which is quite similar to the standard drugs available at the market (Gupta *et al.,* 2010). Anti-inflammatory activity could be associated with the action of the flower extract of the plant on the oedema induced by croton oil, indicating the anti-oedematogenic ability of the plant.

The compounds isolated from the aqueous extract reduced inflammation against carrageenan-induced rat paw oedema and showed analgesic effect in acetic acid-induced writhings in mice (Ferreira *et al.,* 2014). Afzal *et al.,* (2012a) state that the analgesic activity may be due to suppression of cyclooxygenase enzymes by the steroidal compounds.

Muscle-relaxant activity

Salahdeen and Yemitan (2006) tried evaluating the muscle-relaxant activity of the aqueous extract and observed reduction in the muscle tone of the laboratory animals. Spasmolytic activity was studied by Ozolua *et al.,* (2010) which presented the antispasmodic effect of aqueous leaf extract on tracheal smooth muscle cells and that the extract could be used for the prophylaxis of asthma. Nwose (2013) determined the effect of ethanolic extract on serum creatine kinase. An increase in the values of creatine kinase activity in the albino rats treated with the ethanolic extract of the plant was observed. This increase in activity could encourage the supply of energy (ATP) needed for muscular contraction and relaxation, which in the case of asthma can bring about dilatation of constructed smooth muscles of the bronchi.

Antipyretic activity

Biswas and Montal (2015) demonstrated the effect of plant extract on hyperthermic condition in laboratory animals. Pyrexia was induced in rats by injecting Brewer's yeast. When hydroalcoholic extract of *K. pinnata* was administered to the laboratory specimens, it reduced the body temperature thus exhibiting its antipyretic effect. The presence of flavonoids in the extract may be the reason for this activity.

Neuropharmacological activity

Matthew *et al.,* (2013a) reported that ethanolic extract of the plant showed CNS-depressant activity in mice. The rate of activity was found to be nearly same as the commercially used antidepressant drugs. Another study was made by Salahdeen and Yemitan (2006) to demonstrate the sedative effect and anticonvulsant activity of the aqueous extract. Picrotoxin-induced seizures were delayed and the mortality of the mice was prevented. Behavioural changes were observed in mice that were administered aqueous extract. The CNS-depressant activity of the

extract could be due to the presence of bufadienolides and other water-soluble constituents in the extract.

Antilithiatic activity

The reduced oxalate excretion in urine causes the formation of calcium oxalate stones. Fresh juice extracted from the leaves of *K. pinnata* was administered to patients having stones in their body based on medical prophylaxis. Regular intake of the juice effectively dissolved the stones regardless of its position, nature and previous treatments. There was an increase in the quantity of urine excreted, thus showing the diuretic nature of the juice. It also facilitated the decrease in oxalate excretion, while increasing citrate excretion. This study suggests that the juice may have antilithiatic properties (Gahlaut *et al.,* 2012). Shukla *et al.,* (2014) evaluated the anti-urolithiatic effect of aqueous extract on ethylene glycol-induced renal calculi in rats. Histopathological examination of the kidneys showed reduced renal damage, less degeneration of epithelial lining and tubular dilatation in all the extract-treated rats. Gilhotra *et al.,* (2013) formulated tablets of *K. pinnata* extracts and reported that the drug is effective in controlling the accumulation of calcium oxalate crystals and preventing stone formation in the kidneys.

Hepatoprotective activity

Yadav and Dixit (2003) tested the activity of ethanolic extract and juice obtained from fresh leaves of *K. pinnata* in rats which were subject to chloroform-induced hepatotoxicity. They reported that the juice was found more effective than ethanolic extract after conducting *in vitro*, *in vivo* and histopathological studies. Afzal *et al.,* (2013) observed decreased lipid peroxidation in the liver of treated animals after administering the aqueous extract of the plant for DENA-induced hepatotoxicity. The extract may have exhibited antioxidant activity through scavenging of free radicals in the liver of rats. The treatment also showed signs of protection against the toxicants to a considerable extent, which was confirmed by the formation of normal hepatic cells and absence of necrosis and vacuoles. The hepatoprotective activity may be due to its antioxidant effect which would have reduced the accumulation of toxic DENA-derived metabolites.

Gastroprotective activity

Pal and Chaudhuri (1991) investigated that the methanol-soluble fraction of the plant extract inhibited the development of a variety of acute ulcers induced chemically in the stomach and duodenum of rats and guinea pigs. They also reported that the extract protected the gastric mucosa from ulcer formation. The extract was observed to significantly enhance the healing rate of chemically induced gastric ulcers in rats. The ulcer-healing effect of the extract could possibly be attributed to local antisecretory and/or antipeptic activity. Another study was performed by Sharma *et al.,* (2014) to determine the gastroprotective activity of the plant. It was found that the aqueous extract of the plant showed significant gastroprotective effect on mice by decreasing the ulcer index. The mucilage of the plant was isolated and tested on the ulcers induced by ethanol. The mucilage was also reported to have potential antiulcer activity. From the study, it was concluded that both aqueous and mucilage extracts could be used for gastric ulcers.

Antidiabetic activity

Diabetes is a major risk for cardiovascular diseases such as stroke, heart attack which affects majority of the global population. Goyal *et al.,* (2013) reported that the ethanolic extract of *K. pinnata* decreased the blood glucose level of rats affected by diabetes. Thus, decreasing the serum glucose level and increasing glucose tolerance. The plant extract also increased the pancreatic secretion of insulin. Matthew *et al.,* (2013c) investigated the antidiabetic activity of ethanolic and aqueous extracts of the dried stem of *K. pinnata* against alloxan-induced diabetes in rats. They reported that both the extracts exhibited hypoglycemic activity, that is, significant antihyperglycemic activity. The activities of both the extracts were compared and it was observed that the ethanolic extract showed more inhibitory activity of α- amylase enzyme than the aqueous extract, while the aqueous extract showed more hypoglycemic activity than the ethanolic extract. Ojewole (2005) determined the hypoglycaemic activity of aqueous extract of the plant by inducing diabetes in rats through streptozotocin treatment. Once the aqueous extract was orally administered, the reduction in blood glucose level was observed. And, after 24-hour continuous observation, the glucose levels subsided to normal baseline levels indicating the antidiabetic potential of the plant.

Nephroprotective activity

Aqueous extracts of *K. pinnata* exhibited nephro-protective effect when administered for mice affected by gentamycin-induced nephrotoxicity. Gentamicin induced glomerular congestion, peritubular and blood vessel congestion, epithelial desquamation, accumulation of inflammatory cells and necrosis of the kidney cells which were found to be reduced after receiving the extract. The extract also normalised the gentamicin-induced increases in urine and plasma creatinine, blood urea and blood urea nitrogen levels. This study states that the protective effect may be due to the presence of certain bioactive compounds acting as oxidative radical scavenging agents and antioxidants (Harlalka *et al.,* 2007). Ramesh *et al.,* (2014) chemically (ethylene glycol) induced urolithiasis in mice to study the nephroprotective effect of *K. pinnata*. The chemical inhibited protein synthesis, causing tissue damage and increased excretion of protein in urine. This process may cause severe necrosis of the proximal tubules throughout cortex and the outer strip of the medulla. Ethylene glycol also damaged the renal tubule and suppressed the excretion of urea in the renal tubule leading to elevated levels of urea in serum. Its disproportionate accumulation in kidney fissure contributed to formation of stones which varied the different biochemical parameters related with renal functions like urea, creatinine, uric acid, total protein, etc. The urea level was decreased and brought back to normalcy, and there was efficient

reduction in the calcium oxalate levels which inhibited stone formation after administration of ethanolic extract of *K. pinnata*.

Haemoprotective activity

The crude methanolic extract of *K. pinnata* significantly protected the human erythrocyte membrane from lysis (haemolysis of RBCs) induced by hypotonic solution and heat. This study was carried out by Sharker *et al.,* (2012). Certain bioactive compounds present in the plant can even dissolve blood clots in the blood vessels. These thrombolytic agents are useful in treating myocardial infarction, thrombo-embolic strokes, deep-vein thrombosis and pulmonary embolism to clear a blocked artery and avoid permanent damage to the perfused tissues. The experiment conducted by Akanda *et al.,* (2014) showed that the ethanol extract of *K. pinnata* has strong antioxidant and thrombolytic activities with minimal cytotoxicity.

Antihistamine activity

Cruz *et al.,* (2008) found that histamine released by immunologically challenged mast cells was significantly inhibited, and the decrease in levels of secreted histamine in mice cells was due to pre-treatment with aqueous extract of *K. pinnata*. It was also reported that the blockade of histamine release may ultimately contribute to the anti-anaphylactic effect. Nassis *et al.,* (1992) reported that a flavonoid fraction obtained by partitioning the juice of the plant between n-butanol and water contained the substance responsible for the antihistamine activity. When assayed on the isolated guinea pig ileum, the antagonism was specific for histamine. The juice protected guinea pigs from death by asphyxia induced by histamine and the protection lasted for at least an hour. Vascular permeability responses of rats to histamine were decreased by about 20%-25% in animals pre-treated with the juice.

Immunomodulatory activity

Rossi-Bergmann *et al.,* (1994) administered the aqueous extract of *K. pinnata* to mice having ovalbumin-induced allergy. The aqueous extract significantly depressed the delayed-hypersensitivity reactions thus proving to be an immunosuppressive agent. Cruz *et al.,* (2008) performed *in vitro* studies in mouse models to prove the anti-anaphylactic activity of *K. pinnata*. The aqueous extract prevented antigen-induced mast cell degranulation and histamine release, due to the presence of quercitrin, a flavonoid, which prevented fatal anaphylaxis through down-modulation of pro-anaphylactic-induced immune responses and modulation of acute events related to shock which leads to death (extreme allergic reaction). This immune response caused is highly critical for the resistance phenotype prophylactic therapy for hypersensitive people under the risk of anaphylactic shock.

Antihypertensive activity

The work by Bopda *et al.,* (2014) demonstrated that concomitant administration of the aqueous extract of *K. pinnata* inhibited salt-induced hypertension by preventing the increase of systolic and diastolic arterial pressures in rats. It was inferred that the antioxidant and modulatory effects of the plant extract at the vasculature might be the reason for its overall antihypertensive activity. The effects of aqueous and methanolic leaf extracts of the plant were examined on arterial blood pressures and heart rates of normal (normotensive) and spontaneously hypertensive rats using invasive and non-invasive techniques. Both the extracts produced dose-related, significant decreases in arterial blood pressures and heart rates of anaesthetised rats. The leaf extracts also decreased the rate and force of contractions of isolated atria of guinea pig. The inhibitory effects of the leaf extracts on the cardiovascular system of the laboratory animals used in this study were resistant to physiological doses and concentrations of standard antagonist drugs. Cardiodepression and vasodilation may be associated with the antihypertensive effect of the plant, says Ojewole (2002). Ghasi *et al.,* (2011) observed that the fall in adrenaline-induced increase in blood pressure of cats was due to the administration of aqueous extract of the plant. The blood pressure decreased with increasing dose of the extract. But, this study also reported the presence of bioactive compounds that cause toxic effects to animals as well as humans. The laboratory animals experienced loss of appetite and showed signs of dullness. Animals died at higher dosage of extract administration. Hence, at the end of the study, it was concluded that though the plant is known to possess too many medicinal properties, the dosage of the plant extracts should be validated to avoid adverse reactions while experimenting with laboratory specimens.

CONCLUSION

A consolidated review on the pharmacological uses of the medicinal plant *K. pinnata* (Linn.) Pers. which included a broad spectrum of activities like wound-healing, antioxidant, anticancerous, antiproliferative, antimicrobial, antiviral, antiprotozoal, antileishmanial, anthelmentic, insecticidal, anti-allergic, analgesic antinociceptive, anti-oedematogenic, anti-inflammatory, muscle-relaxant, antipyretic, anticonvulsant, anti-depressant, sedative, antilithiatic, hepatoprotective, gastro-protective, antidiabetic, nephroprotective, haemoprotective, anti-histamine, antihypertensive, immunosuppressive, tocolytic and anthroposophic effects have been briefly discussed. Research studies have been made to analyse the therapeutical ability of isolated biomolecules of the plant and its extracts. Though, the plant is traditionally known for its high clinical value, few scientists have reported presence of poisonous chemicals that harm animals. Yet, a knowledge base is required to carry on research and clinical trials in the future for industrialisation of the plant metabolites.

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How to cite this article:

Rajsekhar PB, Arvind Bharani RS, Maya Ramachandran, Jini Angel K, Sharadha Priya Vardhini Rajsekhar. The “Wonder Plant” *Kalanchoe pinnata* (Linn.) Pers.: A Review. J App Pharm Sci, 2016; 6 (03): 151-158.