**Plant based Antimicrobial drugs: Future of Medicine**

**Dr. Anshu Kumar Singh\* & Mrs. Hiba Khan\*\***

**\*Associate Professor, Department of Paramedical Sciences, Subharti Medical College, Swami Vivekanand Subharti Univrsity, Meerut, U.P**

**\*Assistant Professor, Department of Paramedical Sciences, Subharti Medical College, Swami Vivekanand Subharti Univrsity, Meerut, U.P**

**ABSTRACT**

**Plant-based medicines have a long history of safe and effective use in traditional medicine.** In recent years, there has been a growing interest in the scientific study of these medicines, and there is now a growing body of evidence to support their efficacy. Plant-based medicines have a number of potential advantages over conventional synthetic drugs, including their lower cost, their better safety profile, and their greater compatibility with the human body.

**As our understanding of plant-based medicines continues to grow,** they are likely to play an increasingly important role in the future of medical sciences. Plant-based medicines could be used to treat a wide range of diseases, including cancer, cardiovascular disease, and Alzheimer's disease. They could also be used to prevent diseases and to improve overall health and well-being.

**The development of plant-based medicines is also likely to be driven by advances in biotechnology.** Biotechnology can be used to improve the efficacy and safety of plant-based medicines, and to make them more affordable. Biotechnology can also be used to develop new plant-based medicines that target specific diseases.

**In conclusion, plant-based medicines have a promising future in medical sciences.** They are safe, effective, and affordable, and they have the potential to treat a wide range of diseases. Advances in biotechnology are likely to further improve the development and use of plant-based medicines in the years to come.

**INTRODUCTION**

Antimicrobial plants are essentially important in reducing the global burden of infectious diseases caused by micro-organisms which still widely affect people in developed as well as in developing countries. Many medicinal plants have been traditionally used worldwide because of their antimicrobial traits, which are due to Phytochemical synthesized in the secondary metabolism of the plant. Medicinal plants are rich in a wide variety of secondary metabolites such as Papain, Chymopapain, tannins, alkaloids, glycosides, terpenoids, phenolic compounds and flavonoids have antimicrobial properties which remedies for the treatment of various bacterial diseases including asthma, gastrointestinal diseases, skin disorders, urinary problems, cardiovascular disease etc. Antibiotics are used to fighting against bacterial infections and have great benefited the health-related quality of human life but over a few decades’ antibiotics have become less and less effective against certain bacterial infectious disease because of due to emergence of drug-resistant bacteria. Now it is very essential to investigate newer drugs with lesser resistance that are derived from natural sources like various medicinal plants which play a significant role in the prevention and treatment of human diseases.

Humans use the various plants as a traditional medicine since the middle Paleolithic age. Our ancestors were used plants as foods, spices, flavors, insect deterrents, ornamentals, Medicine, fumigants and cosmetics. In Current scenario various natural products lie plants and their various parts are used in clinical practices approximately 50% of all drugs that are used in clinical practice that are made up with natural derivatives, in which the 25 % are made up with higher plants. A report of World Health Organization (WHO) estimated that the over 80% peoples of developing countries including India depend on the use of traditional remedies and about 855 traditional medicines are prepared using the plants extracts. This means that about 3.5 to 4 billion of the global population depend on plant resources for drugs (Maridass and Britto, 2008).

Various diseases are treated successfully with the use natural plant remedies from the history of Humans. Medicines that are made up with plants and other natural products have maximum therapeutic but less adverse effects that have been demonstrated and checked by various scientific researches. Even in today’s world, various plant materials are used to play a major role in primary health care and first aid in many developing countries including India. (Maridass & Britto, 2008).

**PLANT DERIVED MEDICINES DEMAND AND SUPPLY**

Approximately 95% of plants that are used in the production of medicine are collected from the forests and some other natural sources. All the plants that collected from different geographical locations have diversity in their active present compounds and therapeutic properties and also have a variation in their market rates. From Past few years various industries are developed in India that based on the use of plants for the production of medicines that why the demand of medicinal plants are increased simultaneously. As per latest estimate, in our country, there are about eight thousand licensed pharmacies of ISM (Institute for Supply Management) engaged in the manufacture of bulk drugs. The total annual requirement of the raw materials of these pharmacies was estimated to be thousands of quintals. The annual demand of the global market is $32 million of medicinal plants from developing countries. The herbal drug production in our country has been estimated to be Rs. 4000 crores in the year 2000. Out of 15,000-20,000 medicinal plants, our rural communities use 7,000-7,500 medicinal plants. About 130 pure compounds, which are extracted from 100 species of higher plants of Indian origin, are used throughout the world. Hence, India can play a major role for supplying the raw herbs, standardized extracted materials and pure compounds isolated from natural resources (Maridass and Britto, 2008). The number of higher plant species on our planet is estimated around 250,000 (lower level at 215,000 and an upper level as high as 500,000). Of these, only 6% have been screened for biological activity and only 15% have been pharmacologically screened. Moreover, plant extracts contain up to several thousands of secondary metabolites. The major types of compounds identified in Indian medicinal herbs include alkaloids, saponins, flavonoids, anthroquinones, terpenoids, coumarins, lignans, polysaccharides, polypeptides and proteins. Efficient detection and rapid characterization of these components based on molecular characterizations offer better understanding of the pharmacological applications of these herbal medicines (Maridass and Britto, 2008).

##### PLANT MEDICINE AND OLD MEDICINAL SYSTEMS

Customary frameworks of medication keep on being generally rehearsed on many records. Populace rise, lacking inventory of medications, restrictive expense of medicines, results of a few allopathic medications and advancement of protection from at present involved drugs for irresistible infections have prompted expanded accentuation on the utilization of plant materials as a wellspring of prescriptions for a wide assortment of human afflictions. Disregarding the staggering impacts and our reliance on current medication and huge advances in engineered drugs, an enormous portion of the total populace actually enjoys drugs from plants. In a significant number of the non-industrial nations the utilization of plant drugs is expanding on the grounds that advanced life saving medications is past the span of 3/4 of the third total populace, albeit numerous such nations burn through 40-half of their complete abundance on medications and medical services. As a piece of the procedure to lessen the monetary weight on agricultural nations, clearly an expanded utilization of plant medications will be continued from here on out (Joy et al., 2001).

Among old civilizations, India has been known to be rich archive of therapeutic plants. Around 8,000 home grown cures have been classified in Ayurveda. Plants, particularly utilized in Ayurveda can give naturally dynamic atoms and lead structures for the improvement of changed subsidiaries with upgraded movement as well as diminished poisonousness. The little part of blooming plants that have up to this point been researched have yielded around 120 helpful specialists of known structures from around 90 types of plants. A portion of the valuable plant drugs incorporate vinblastine, vincristine, taxol, podophyllotoxin, camptothecin, digitoxigenin, gitoxigenin, digoxigenin, tubocurarine, morphine, codeine, ibuprofen, atropine, pilocarpine, capscicine, allicin, curcumin, artemisinin and ephedrine among others (Joy et al., 2001).

At times, the rough concentrate of therapeutic plants might be utilized as medicaments. Then again, the disengagement and distinguishing proof of the dynamic standards and clarification of the instrument of activity of a medication is of vital significance. Thus, works in both combination of conventional medication and single dynamic mixtures are vital. Where the dynamic atom can't be blended monetarily, the item should be gotten from the development of plant material. Around 121 significant plant drugs have been distinguished for which no engineered ones are as of now accessible. The logical investigation of customary prescriptions, deduction of medications through bio prospecting and precise preservation of the concerned restorative plants is along these lines critical (Joy et al., 2001).

##### CHEMOTHERAPEUTIC AGENTS DERIVED FROM PLANTS

Infectious diseases are one of the major causes of death in all over the world including India. Death due to infectious diseases ranked 5th in 1981, and 3rd leading cause of death in 1992, with the increment of 58%. Approximately more than hundreds of plants and their various parts used world wide in the production of traditional medicine for the treatment of bacterial infections. Although various diseases have been treated by conventional pharmaceutical approaches, this is a growing interest in the medicinal industry to develop various drugs by using plant and their various parts. Furthermore the drug industry keeps on looking at their true capacity as wellsprings of novel development factor, immunomodulatory and antimicrobial action (Maridass and Britto, 2008).

##### ANTIMICROBIAL COMPOUNDS OF PLANTS: AN OVERVIEW

From various centuries human use medicinal plant for the treatment of various major and minor disease, even they do not have the idea how and which part and material of plant are able to treat the diseases till 19th century. Then, due to rapid growth of Organic Chemistry and Pharmacology man can become able and eligible to determine the active chemical and group of chemicals that are responsible for the therapeutic effects. The effect of medicinal plants is present in the medicinal plants in the form of the secondary metabolites and active compounds. As a Active compounds of medicinal plants mostly Steroids, Alkaloids, Tannins, Terpenoids and Phenolic compounds are present which are synthesized and deposited in the whole plant and specific parts of medicinal plant. Secondary products and metabolites of plant show their action by resembling their metabolites, Hormones, Ligands, Signal transduction molecule or neurotransmitters that have a required medicinal effect on humans due to similarities in their target sites. Therefore, random screening of plants for active chemicals is as important as the screening of ethno botanically targeted species (Ciocan and Bara, 2007).

**Phenol compounds**

Probably the easiest bioactive Phytochemical comprise of a solitary subbed phenolic ring. Cinnamic and Caffeic acids are normal delegates of a wide gathering of phenyl propane-inferred intensifies which are in the highest oxidation state.

Many herbs have these acids which are very effective against bacteria, viruses as well as fubgi. Catechol and pyrogallol are hydroxylated phenols, demonstrated to be poisonous to microorganisms. Catechol has two OH gatherings, and pyrogallol has three. The site (s) and number of hydroxyl bunches on the phenol bunch are believed to be connected with their overall harmfulness to microorganisms, with proof that expanded hydroxylation brings about expanded poisonousness. Moreover, a few creators have observed that all the more highly oxidized phenols show more restraint of the organisms (Ciocan and Bara, 2007).

### Quinones

Quinones are sweet-smelling rings with two ketone replacements. They are universal in nature and are typically highly responsive. These mixtures, being hued, are answerable for the caramelizing response in cut or harmed leafy foods and are a halfway in the melanin blend pathway in human skin.

As well as giving a wellspring of stable free extremists, quinones are known to complex irreversibly with nucleo- philic amino acids in proteins, frequently prompting inactivation of the protein and loss of capacity. Hence, the expected scope of quinone antimicrobial impacts is extraordinary. Plausible focuses in the microbial cell are surface-uncovered adhesins, cell divider polypeptides and film bound compounds.

### Flavonoids

Quinones are sweet-smelling rings with two ketone replacements. They are universal in nature and are typically highly responsive. These mixtures, being hued, are answerable for the carmelizing response in cut or harmed leafy foods and are a halfway in the melanin blend pathway in human skin.

As well as giving a wellspring of stable free extremists, quinones are known to complex irreversibly with nucleophilic amino acids in proteins, frequently prompting inactivation of the protein and loss of capacity. Hence, the expected scope of quinone antimicrobial impacts is extraordinary. Plausible focuses in the microbial cell are surface-uncovered adhesins, cell divider polypeptides and film bound compounds.

**Tannins**

### Tannin is an overall illustrative name for a gathering of polymeric phenolic substances equipped for tanning calfskin or accelerating gelatine from arrangement, a property known as astringency. Their sub-atomic weights territory from 500 to 3000 and they are found in pretty much every plant part: bark, wood, leaves, natural products, and roots. They are separated into two gatherings, dense and hydrolysable tannins. Hydrolysable tannins depend on Gallic corrosive, normally as different esters with D-glucose; while the more various consolidated tannins (frequently called proanthocyanidins) are gotten from flavonoid monomers. Tannins might be shaped by buildups of flavan subsidiaries which have been moved to woody tissues of plants. On the other hand, tannins might be framed by polymerization of quinone units (Ciocan and Bara, 2007).

Feeling of phagocytic cells, have interceded cancer action, and a wide scope of against infective activities, has been assigned to tannins. Their method of antimicrobial activity might be connected with their capacity to inactivate microbial adhesins, compounds, cell envelope transport proteins, and so forth. As per a few investigations, tannins can be poisonous to filamentous organisms, yeasts, and microbes. Consolidated tannins not entirely settled to tie cell dividers of ruminal microorganisms, forestalling development and protease action (Ciocan and Bara, 2007).

### Terpenoids

The aroma of plants is conveyed in the supposed quinta essentia, or natural balm portion. These oils are optional metabolites that are highly advanced in intensifies in view of an isoprene structure. They are called terpenes, their overall compound construction is C10H16, and they happen as diterpenes, triterpenes, and tetraterpenes (C20, C30, and C40), as well as hemiterpenes (C5) and sesquiterpenes (C15). Whenever the mixtures contain extra components, normally oxygen, they are named terpenoids (Ciocan and Bara, 2007).

Terpenoids are combined from acetic acid derivation units and offer their origins with unsaturated fats. They contrast from unsaturated fats in that they contain broad spreading and are cyclized. Instances of normal terpenoids are menthol and camphor (monoterpenes) and farnesol and artemisinin (sesquiterpenoids). Terpenes or terpenoids are dynamic against microorganisms, growths, infections, and protozoa. In 1977, it was accounted for that 60% of medicinal oil subordinates analyzed to date were inhibitory to parasites while 30% hindered microorganisms.

**Polypeptides**

Peptides inhibitory to microorganisms were first announced in 1942. Late interest has been centered for the most part on concentrating on enemy of HIV peptides and lectins, however the hindrance of microorganisms and organisms by these macromolecules, for example, that from the herbaceous Amaranthus, has for quite some time been known. Thionins are peptides generally found in grain and wheat. They are poisonous to yeasts and Gram negative bacteria’s.

### Alkaloids

Alkaloids rank among the most productive and remedially significant plant substances. They are synthetically exceptionally assorted gathering of natural nitrogen compounds. By and large they are very harmful however they truly do have an obvious helpful impact in minute amounts. Thus plants containing alkaloids were not frequently utilized in people medication, and in the event that utilized, just for skin application. Unadulterated, segregated plant alkaloids and their manufactured subsidiaries are utilized as fundamental therapeutic specialists all around the world for their pain relieving, antispasmodic and bactericidal impacts (Ciocan and Bara, 2007).

### Other Antimicrobial Compounds of Plants

##### Numerous phytochemicals not referenced above have additionally been found to apply antimicrobial properties. There are reports of antimicrobial properties related with polyamines (specifically spermidine), Papain, Chymopapain, isothiocyanates, thiosulfinates, glycosides, and glucosides. Polyacetylenes merit exceptional notice. Acetylene mixtures and flavonoids from plants customarily utilized for treatment of intestinal sickness fever and liver problems have additionally been related with anti malarial movement. In the mid 1990s, analysts observed that the monosaccharide fructose present in cranberry and blueberry squeezes seriously restrained the adsorption of pathogenic Escherichia coli to urinary lot epithelial cells, going about as a simple for mannose. Clinical examinations have borne out the defensive impacts of cranberry juice. Numerous scientists are currently looking for a subsequent dynamic compound from cranberry juice which adds to the antimicrobial properties of this juice (Ciocan and Bara, 2007).

##### CHALLENGE AND THREAT OF ANTIMICROBIAL RESISTANCE

The advancement of opposition in microorganisms is one of the systems of regular transformation to the presence of an antimicrobial specialist that restrains powerless organic entities and chooses the safe ones. Under preceded with determination tension, they chose safe creatures duplicate and spread to other geographic areas as well as to different organisms by move of opposition qualities. Choice of safe strains happens so quick for certain microbes that clinical helpfulness of the anti-toxins is lost throughout some undefined time frame. The rise and spread of microorganisms impervious to modest and compelling first-line drugs has turned into a typical event. The issue is much more clear in bacterial contaminations, for example, diarrheal, respiratory lot, meningitis, physically communicated diseases and tuberculosis, which contribute most to the worldwide irresistible illness trouble. Protection from penicillin in *Staphylococcus aureus* first showed up in 1942, quickly following its clinical use. By the last part of the 1960s, over 80% of both local area and medical clinic obtained staphylococcal segregates were impervious to penicillin (Sibanda and Okoh, 2007).

##### MECHANISMS OF ANTIMICROBIAL RESISTANCE IN BACTERIA

### Protection from antimicrobials emerges because of three principle techniques: enzymatic inactivation of the medication, alteration of target destinations and expulsion by efflux. While compound alterations could be significant in anti-microbial obstruction, prohibition from the cell of unaltered anti-toxin addresses the essential technique in denying the anti-toxin, admittance to its objectives (Sibanda and Okoh, 2007).

### Target site alteration

Substance alterations in the anti-toxin target might bring about decreased liking of the anti-microbial to its limiting site. This is an instrument utilized by various pathogenic microorganisms in dodging the impact of anti-toxins. Changes are normally intervened by constitutive and inducible compounds. Protection from macrolides, lincosamide and streptogramin B anti-toxins (MLSB opposition) in pathogenic Streptococcus species is a consequence of methylation of the N6 amino gathering of an adenine buildup in 23S rRNA. This is attempted to cause conformational changes in the ribosome prompting diminished restricting partiality of these anti-microbials to their limiting locales during the 50S ribosomal subunit. β-lactam anti-microbials work by restricting to and hindering the biosynthetic action of penicillin restricting proteins (PBPs), in this manner obstructing cell divider blend. In *Staphylococcus aureus* protection from β-lactams can be an aftereffect of transformations prompting the creation of PBP2a and PBP2b separately. The two proteins have a decreased fondness for β-lactams but they assume control over the elements of typical PBPs within the sight of inhibitory degrees of β-lactams.

### Inactivation of Enzymes

The creation of hydrolytic chemicals and gathering transferases is a technique utilized by various microorganisms in sidestepping the impact of anti-microbials. Qualities that code for anti-infection corrupting proteins are in many cases carried on plasmids and other portable hereditary components. The protection from β-lactam anti-toxins by both gram negative and gram positive microorganisms has for some time been credited to β-lactamases. These catalysts give critical anti-toxin protection from their bacterial hosts by hydrolysis of the amide obligation of the four-membered β-lactam ring. Protection from aminoglycosides in Gram negative microscopic organisms is most frequently intervened by an assortment of chemicals that adjust the anti-infection particle by acetylation, adenylation or phosphorylation (Sibanda and Okoh, 2007).

### Antibiotic efflux

It is currently generally perceived that constitutive articulation of efflux siphon proteins encoded by house-keeping qualities that are far and wide in bacterial genomes are to a great extent answerable for the peculiarity of natural anti-microbial opposition. A few investigations have shown that dynamic efflux can be a system of obstruction for practically all anti-infection agents. Most of the efflux frameworks in microscopic organisms are non-drug-explicit proteins that can perceive and siphon out a wide scope of synthetically and fundamentally inconsequential mixtures from microbes in an energy-subordinate way, without drug adjustment or corruption. The result of this medication expulsion is that, it prompts a diminished intracellular centralization of the antimicrobial with the end goal that the bacterium can make due under states of raised antimicrobial focus. The MIC of the medication against such life forms will be higher than anticipated (Sibanda and Okoh, 2007).

Multi-drug obstruction efflux siphons are universal proteins present in both Gram positive and Gram negative microorganisms as either chromosomally encoded or plasmid encoded. Albeit, such proteins are available constitutively in microscopic organisms, the proceeded with presence of the substrate incites over-articulation. This expanded record is liable for the gained opposition. In Gram negative microorganisms, the impact of the efflux siphons in mix with the diminished medication take-up because of the twofold film hindrance is liable for the high innate and procured anti-infection obstruction. Efflux carriers establish around 6 to 18% of all carriers found in some random bacterial cell. Presently, much consideration is being paid towards understanding the working systems of these siphons which has expected applications in the plan of transport inhibitors that could be utilized in mix with anti-toxins being developed of clinically valuable medications (Sibanda and Okoh, 2007).

##### PLANTS USED FOR THE NEW ANTIMICROBIALS AND RESISTANCE MODIFYING AGENTS

Plants have customarily given a wellspring of desire to novel medication compounds, as plant home grown combinations have made huge commitments to human wellbeing and prosperity. Inferable from their famous use as solutions for some irresistible illnesses, looks for substances with antimicrobial movement in plants are incessant. Plants are wealthy in a wide assortment of auxiliary metabolites, like tannins, terpenoids, alkaloids, and flavonoids, which have been seen as in vitro to have antimicrobial properties. Writing is overwhelmed with intensifies that have been separated from an assortment of therapeutic plants. In spite of this plentiful writing on the antimicrobial properties of plant removes, none of the plant determined synthetics have effectively been taken advantage of for clinical use as anti-toxins (Sibanda and Okoh, 2007).

The perception that plant inferred compounds are for the most part feeble contrasted with bacterial or parasitic created anti-toxins and that these mixtures frequently show significant movement against Gram positive microbes than Gram negative species has been made by numerous scientists. It was estimated that plants produce intensifies that can be powerful antimicrobials assuming they track down their direction into the cell of the microorganism; particularly across the twofold film hindrance of gram negative microbes. Creation of efflux siphon inhibitors by the plant would be one method for guaranteeing conveyance of the antimicrobial compound (Sibanda and Okoh, 2007).

These investigations have given the bases to getting the activity of plant antimicrobials, specifically that larger part of such mixtures are specialists with frail or limited range exercises that demonstration in cooperative energy with naturally created efflux siphon inhibitors. There is reason along these lines to accept that, plants could be a wellspring of mixtures that can expand the awareness of bacterial cells to anti-microbials. Such mixtures could be valuable especially against anti-toxin safe strains of pathogenic microbes. The rich synthetic variety in plants vows to be an expected wellspring of anti-toxin opposition altering compounds and presently can't seem to be satisfactorily investigated (Sibanda and Okoh, 2007).

**CONCLUSION**

Plant-based antimicrobial drugs have a promising future in medicine. They are safe, effective, and have the potential to treat a wide range of bacterial and fungal infections. Advances in biotechnology are likely to further improve the development and use of plant-based antimicrobial drugs in the years to come.

Here are some of the reasons why plant-based antimicrobial drugs are attractive:

1. They are often less expensive than conventional synthetic drugs.
2. They have a better safety profile, with fewer side effects.
3. They are more compatible with the human body, and are less likely to cause allergic reactions.
4. They can often be used to treat chronic infections that are not effectively treated by conventional drugs.

The development of plant-based antimicrobial drugs is also likely to be driven by advances in biotechnology. Biotechnology can be used to improve the efficacy and safety of plant-based antimicrobial drugs, and to make them more affordable. Biotechnology can also be used to develop new plant-based antimicrobial drugs that target specific bacteria or fungi.

In conclusion, plant-based antimicrobial drugs have a bright future in medicine. They are safe, effective, and affordable, and they have the potential to treat a wide range of bacterial and fungal infections. Advances in biotechnology are likely to further improve the development and use of plant-based antimicrobial drugs in the years to come.

**REFERENCES**

* Maridass, M. and Britto, A.J.De. (2008) Origins of plant derived medicines. *Ethnobotanical Leaflets* 12, p373-387.
* Ciocan, I.D. and Bara, I.I. (2007) Plant products as antimicrobial agents. *Analele Stiintifice Ale Universitatii, Alexandru Ioan Cuza, Sectiunea Genetica Si Biologie Moleculara,* TOM VIII, p151-156.
* Sibanda, T. and Okoh, A.I. (2007) The challenges of overcoming antibiotic resistance: Plant extracts as potential sources of antimicrobial and resistance modifying agents. *Afr. J. Biotechnol.* 6 (25), p2886-2896.
* In [North America](https://en.wikipedia.org/wiki/North_America), [papaw](https://en.wikipedia.org/wiki/Asimina_triloba) or pawpaw usually means the plant belonging to the [Annonaceae](https://en.wikipedia.org/wiki/Annonaceae" \o "Annonaceae) family or its fruit. Ref.: [Merriam-Webster's Collegiate Dictionary](https://en.wikipedia.org/wiki/Merriam-Webster%27s_Collegiate_Dictionary) (2009), published in United States.
* Ward, D.B. 2003. Native or Not: Studies of problematic species. No. 1: Introduction. Palmetto 22(2): 7-9
* Wunderlin, R. P. 1998. Guide to the vascular plants of Florida. Univ. Presses of Florida, Gainesville. 806 pp.
* Ordoñez VP, Vega EM, Malagón AO. Phytochemical study of native plant species used in traditional medicine in Loja province. Lyonia. 2006;10:65–71.
* [*Calotropis gigantea* (L.) W.T.Aiton | Plants of the World Online | Kew Science"](http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:95173-1). *Plants of the World Online*. Retrieved 2022-05-27.
* Wang, Zhu-Nian; Wang, Mao-Yuan; Mei, Wen-Li; Han, Zhuang; Dai, Hao-Fu (4 December 2008). ["A New Cytotoxic Pregnanone from Calotropis gigantea"](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6244834). *Molecules*. **13** (12): 3033–3039.
* Upadhyay, RaviKant (2014). "Ethnomedicinal, pharmaceutical and pesticidal uses of Calotropis procera (Aiton) (Family: Asclepiadaceae)". *International Journal of Green Pharmacy*. **8** (3): 135–146.
* Sarma, Kishore; Roychoudhury, Shubhadeep; Bora, Sudipta; Dehury, Budheswar; Parida, Pratap; Das, Saurav; Das, Robin; Dohutia, Chandrajit; Nath, Sangeeta; Deb, Bibhas; Modi, Mahendra (23 March 2017). "Molecular Modeling and Dynamics Simulation Analysis of KATNAL1 for Identification of Novel Inhibitor of Sperm Maturation". *Combinatorial Chemistry & High Throughput Screening*. **20** (1): 82–92.
* Wang, Shih-Chung; Lu, Mei-Chin; Chen, Hsiu-Lin; Tseng, Hsing-I; Ke, Yu-Yuan; Wu, Yang-Chang; Yang, Pei-Yu (December 2009). "Cytotoxicity of calotropin is through caspase activation and downregulation of anti-apoptotic proteins in K562 cells". *Cell Biology International*. **33** (12): 1230–1236.
* Wang, Shih-Chung; Lu, Mei-Chin; Chen, Hsiu-Lin; Tseng, Hsing-I; Ke, Yu-Yuan; Wu, Yang-Chang; Yang, Pei-Yu (December 2009). "Cytotoxicity of calotropin is through caspase activation and downregulation of anti-apoptotic proteins in K562 cells". *Cell Biology International*. **33** (12): 1230–1236.