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Review Article

KIGELIA PINNATA: EXPLORATION OF POTENTIAL MEDICINAL USAGE IN HUMAN AILMENTS

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ABSTRACT

Purpose : The usage of medicinal herbs in the treatment or cure of various human ailments has been reported since past many centuries. Due to less toxicity of herbs when compared with allopathic drug, these are utilized in the development of formulations to increase efficacy. This review explores the various chemical constituents of the plant *Kigelia pinnata*, commonly called as Sausage tree, and their therapeutic effects in various human ailments.

Findings : *Kigelia pinnata* has been proven to contain many secondary metabolites like alkaloids, glycosides, tannins, saponins, terpenoids, flavonoids, sterols, fatty acids, naphthaquinones, etc. The plant possesses many traditional uses such as anticancer, antileprotic, antimalarial, antibacterial, analgesic and anti-inflammatory, antiurolithiasis, antidiarrhoeal, antioxidant, antidiabetic, etc.

Conclusion : *Kigelia pinnata* is an important plant bearing significant medicinal values in human. This review thus helps the researcher to evaluate and establish the use of plant in various conditions as a curative or as a prophylactic agent and it also highlights the potential of the plant as therapeutic agents in different human ailments.

Keywords : *Kigelia pinnata, Bignoniaceae, Traditional uses, Medicinal properties, Chemical constituents.*

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Introduction

From past centuries herbals are considered as medicinal agents and have been used in the treatment as well as cure for various human ailments. In the recent decades, many preliminary researches are being carried out for establishing therapeutic benefits of herbals due to their less toxicity when compared to allopathic drugs. Such potential herbals are being utilized in the development of formulations to increase their efficacy. The screening of therapeutic ability of such herbals is based upon the traditional uses of them. This review discusses the therapeutic potentials of *Kigelia pinnata* in treating or curing various human ailments.

Kigelia pinnata is widely distributed in the South Central and West Africa[1]. In India, it is distributed all over the country but found most abundantly in West Bengal[2]. The plant is evergreen (where rainfall occurs throughout the year) to deciduous (where there is a long dry season) and grows upto 20 m tall[3]. The tree's bark is grey and smooth and flakes in older specimens. Leaves are pinnately opposite or crowded near the tips of branches, and young leaves are brownish red[2,4]. Flowers bloom in long, loose, pendulous sprays of 5-12 flowers. Petals are a deep, velvety red with yellow veining on the outside. Flowering season is spring or summer[3]. The cylindrical fruit is pendulous on a long fruit stalk which can grow up to 1 m long and 20 cm wide. It is grey and rounded at the apex and found from December to June[4].

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Fig. 1: K. pinnata fruits

Fig. 2: K. pinnata leaves

Fig. 3: K. pinnata tree

Scientific Classification[5]

Kingdom	:	Plantae-Plants
Subkingdom	:	Tracheobionta-Vascular plants
Super-division	:	Spermatophyta-Seed plants
Division	:	Magnoliophyta-Flowering plants
Class	:	Magnoliopsida-Dicotyledons
Subclass	:	Asteridae
Order	:	Scrophulariales
Family	:	Bignoniaceae - Trumpet-creeper family
Genus	:	Kigelia DC. - Sausage tree
Species	:	Kigelia pinnata (Lam.) Benth.- Sausage Tree

Common names[6]

English	:	Sausage Tree, Cucumber Tree
Hindi	:	Balamkheera
Kannada	:	Aanethoradu Kaayi, Mara Sowthae
Malayalam	:	Shiva Kundalam

Synonyms[4]:

Bignonia africana, K. abyssinica, K. acutifolia, K. aethiopum, K. africana, K. ellioti, K. elliptica, K. impressa, and K. sprague ana

Traditional uses of the plant[4]:

The plant has been used traditionally in the treatment of many ailments. It is used to treat wounds, abscesses, ulcers, syphilis and rheumatism, backache. It has also been used as a snakebite antidote, abortifacients, and an aphrodisiac. It is used for dysentery, stomach and kidney ailments, sores, constipation, gynecological disorders, hemorrhoids, lumbago, dysentery, and as a purgative and galactagogue. It also possesses purgative properties. There are various anecdotal reports of the use of crude creams of the *Kigelia* fruit extract in South Africa for the treatment of solar keratosis (a pre-cursor to skin cancer) and malignant melanoma.

Histochemical Color Reactions (Chemical Tests)[7]:

The different color reactions performed on the fruit transverse sections of *K. pinnata* revealed following result:

Table1: Color reactions of Kigelia pinnata

Reagents	Constituent	Color
Phloroglucinol + Hcl	Lignin	Pink
Conc. H2SO4	Cellulose	Green
Weak Iodine Solution	Starch	Pale violet
Picric Acid (10%)		Yellow

The presence of different phytoconstituents was confirmed by observing the behavior of fruit powder with different chemical reagents and the result obtained was:

Table 2: K. pinnata with various reagents

Reagents	Color/ppt	Constituents
Picric acid	Precipitations	Alkaloids present
Dragendroff's reagent	Precipitations	Alkaloids present
Aqueous Ferric Chloride	Greenish black ppt	Flavonoids present
Aqueous Sodium Hydroxide	Yellow	Flavonoids present
Iodine solution	Purple to black	Starch present
Aqueous Lead acetate	White ppt	Tannins present
Conc. H2SO4	Reddish brown	Steroids/ triterpenoids present
Aqueous Silver nitrate	White ppt	Proteins present
Ammonia solution	No change	Anthraquinone glycoside absent
5% aqueous solution	No change	Anthraquinone glycoside absent

Chemical composition:

Exploring the chemical constituents or the secondary metabolites present in plants provides the basis for the traditional use mentioned in the literature. It shows that the medicinal values of plant lies in the bioactive compounds like alkaloids, glycosides, flavonoids, tannins, etc. which possess some physiological action in human body. Hence a systematic study of a medicinal plant is crucial.

Bignoniaceae family is proved to contain many secondary metabolites such as alkaloids, glycosides, flavonoids, tannins, saponins, quinines, reducing sugars, carbohydrates, kaempferol, iridoids, alpha sitosterol, terpenes, steroids, coumarins, etc.

Many chemical constituents have been isolated by different researchers from different parts of *Kigelia pinnata*. The major constituents present in the different parts of the plant are given below:

Fruit

In addition to seven known iridoids (namely, jiofuran, jioglutolide,1-dehydroxy-3,4-dihydro-aucubigenin, des-p hydroxybenzoyl kisasagenol B, ajugol, verminoside and 6-transcaffeoyl ajugol), a new furanone derivative formulated as 3-(2'-hydroxyethyl)-5-(2''-hydroxypropyl) dihydrofuran-2-(3H)one and four new iridoids named: 7-hydroxyviteoid II, 7-hydroxyeucommic acid, 7-hydroxy-10-deoxyeucommiol and 10-deoxyeucommiol have been isolated from the fruits. Fruit extract also led to the isolation and identification of the naphthoquinones, kigelinone, isopinnatal, dehydro-alpha lapachol and the phenylpropanoids p-coumaric acid and ferulic acid. Further phytochemical investigation of the fruits of Kigelia pinnata yielded a new phenylpropanoid derivative identified as 6-p-coumaroylsucrose together with ten known phenylpropanoid and phenylethanoid derivatives and a flavonoid glycoside[8].

Stem

The aqueous stem bark extract of *Kigelia pinnata* revealed the presence of two naphthoquinones kigelinone and isopinnatal[9,10]. Three known iridoids: specioside, verminoside and minecoside have also been isolated from the stem bark[11]. Also kigelin, ß-sitosterol, 1,3-dimethylkigelin, balaphonin and ferulic acid have been isolated from the bark, and kigeliol from the wood[12,13]. By using various column chromatography techniques from n-butanol fraction, one new iridoid, together with nine known compounds was isolated and characterized with the help of extensive spectroscopic methods including 1D, 2D NMR techniques and mass spectrometry. The known compounds were identified as rehmaglutin C[14], 7-hydroxy viteoid II[15], leonuride (=ajugol)[16], catalpol[16], specioside[17], verminoside[18], shoreaphenol[19], 4-hydroxy cinnamic acid[20] and caffeic acid[21] by comparison of their spectroscopic and physical data with reported values in the literatures.

Leaf

The hexane extract of the leaf of *Kigelia pinnata* has been reported to be rich in hydrocarbons and some volatile compounds. It was revealed to contain twelve compounds with the major ones identified as nhentriacontane, 1-tricosene, 11-(2,2-dimethyl-propylheneicosane, 2,6,10-trimethyldodecane, pentafluoroheptadecyl ester, 2-ethylhexyloctadecyl sulfurous acid ester, heneicosane and hexyloctylsulfurous acid ester[22,23,24]. Others are 4,4-dimethylundecane, methyl-12-methyltetradecanoate, 1-iodohexadecane and 1-iododecane. Hentriacontane have been reported to have a possible anti-tumour activity while methyl-12-methyltetradecanoate has also been reported for its inhibition capacity on the development of coneal angiogenesis, which is responsible for blindness and other infections[9]. Flavonoids and iridoids[25] and a 7-O-glucoside[26,27] have also been found in the leaves.

The air-dried and powdered leaves were sequentially extracted with adequate volume of hexane, dichloromethane, ethyl acetate, methanol and water at room temperature for five days each. The aqueous extract was concentrated and partitioned with

butanol. The resulting aqueous fraction was filtered and concentrated under reduced pressure to obtain a crude extract, which was further subjected to a silica gel column chromatography (CC). The column was eluted with the increasing polarity of the mixture of DCM, ethyl acetate, methanol and water. Forty-seven fractions were obtained and pooled to a group of eight (fractions A to H), based on their TLC profile. Further purification of fraction C (CC,MeOH) afforded a yellow syrup, a glycoside tagged "tolaside" with Rf 0.5 (DCM : MeOH, 1:1)[28].

Root

KPRH; UV (Hexane) ?max (log e) 426 (3.4), 419.5 (3.4), 348.5 (4.0), 305.5 (4.0), 250.5 (2.3) nm; IR ?max 3429, 3007, 2955, 2854, 1743, 1710, 1465, 1379, 1166, 1100-721 cm-1; In the GC-MS analysis, 19 bioactive phytochemicals were identified in the root oil of *Kigelia pinnata*. Elaidic acid, (C18H34O2) with RT 31.915 with peak area 56.12 % was identified as the major compound identified in the oil. Other notable compounds that are present include palmitic acid (18.02 %), stearic acid (12.08 %), squalene (2.95 %) and lapachol (1.67 %), (R)-(-)-14-methyl-8-hexadecyn-1-ol (1.52 %) and 6(Z)-octadecenoic acid (1 %). Lapachol has been reportedly isolated from the root of the plant[15].

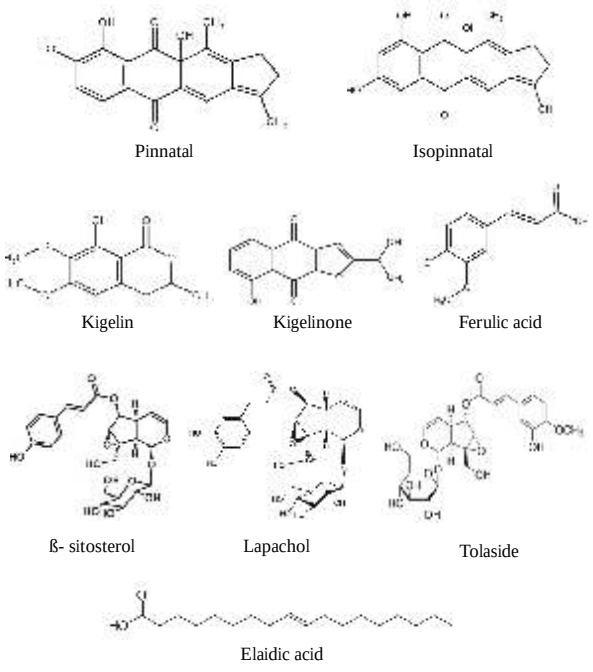

Fig. 4: Chemical constituents present in Kigelia pinnata

Pharmacological Review of Kigelia pinnata:

Analgesic

A study was carried out to screen analgesic activity of *Kigelia pinnata* leaf extract at the dose of 200 mg/kg and 400 mg/kg administered to Wistar rats against the standard drug Pentozocine (10 mg/kg) by hot plate and tail flick method. It revealed that the extract exhibited significance analgesic effect[29].

In another study, the ethanolic extract of the plant was administered at the dose of 250 mg/kg and 500 mg/kg body weight to mice and were followed by acetic acid writhing test. *Kigelia pinnata* leaf extract produced 11.5% and 47.29% of writhing protection[30].

Anti-diabetic

The antidiabetic activity of *Kigelia pinnata* leaves extract has been evaluated by amylase inhibition assay which revealed that it has potent activity against diabetes[31].

Anti-inflammatory

The anti-inflammatory activity of *Kigelia pinnata* leaf extract has been carried out in wistar rats at a dose of 200 mg/kg and 400 mg/kg against the standard drug Indomethacin (10 mg/kg) by Carrageenan induced paw edema method. It showed that there was a significant reduction in the paw edema volume[32].

The ethanolic extract of stem bark was shown to have strong analgesic and anti-inflammatory activities[33].

Anti-malarial

The wood extract of the plant has been shown to possess antimalarial activity against drug resistant strains of Plasmodium falciparum superior to Chloroquine and Quinine[34].

Anti-oxidant

Methanolic leaf and fruit extracts of *K. pinnata* has shown significant reduction in free radical related complications, lipid peroxidation, blood cholesterol and low density lipoproteins[35].

The ethyl acetate fraction of the plant root has high antioxidant activity against DPPH which may be due to the presence of high phenolic content[36].

Flavonoid and saponin contents of the fruit also attributes to the antioxidant property of *Kigelia pinnata*[37].

Anti-urolithic

The aqueous extract of the fruits of *Kigelia pinnata* has shown significant anti-lithiac activity in dissolution of generated Calcium oxalate crystals[37].

The antiurolithiatic activity of *Kigelia pinnata* fruit extract may possibly be mediated through the inhibition of Calcium oxalate crystallization and the extract may have curative as well as prophylactic use in urolithiasis[38].

The effect of ethanolic extract of *Kigelia pinnata* fruit on Calcium oxalate urolithiasis has been studied in male Wistar albino rats. Ethylene glycol feeding resulted in hyperoxaluria as well as increased renal excretion of calcium, magnesium and phosphate. Supplementation with ethanolic extract of *Kigelia pinnata* fruit significantly reduced the elevated urinary oxalate, uric acid and phosphate. The ethanolic extract of *Kigelia pinnata* fruit also significantly lowered the increased deposition of stone forming constituents in the kidneys of calculogenic rats. The results indicate that the ethanolic extract of *Kigelia pinnata* fruit posseses antiurolithic activity[39].

Antibacterial

In vitro antibacterial activity of extracts was tested against six bacterial strains viz. Staphylococcus aureus, Proteus vulgaris, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae and Citrobacter amalonaticus by agar-disc diffusion method. Ethanol and n-hexane were used as negative control and oxytetracycline was used as a positive control. Ethanolic and aqueous extracts of bark and leaves of *Kigelia pinnata* showed remarkable activity against various bacterial strains as compared to n-hexane. S. aureus and E. coli were proved as highly sensitive strains while K. pneumonia was the resistant strain as the extracts formed no inhibition zone against it[40].

The aqueous, methanol and chloroform extracts of the bark of *Kigelia pinnata* was tested against E. coli, Enterobacter aerogens, Klebsiella pneumoniae, Salmonella typhi, Proteus vulgaris, Pseudomonas aeruginosa (Gram-negative), Staphylococcus aureus and Bacillus cereus (Gram-positive) by disc diffusion method. The methanol extract showed a higher activity than the aqueous and chloroform extracts. It exhibits the greatest activity against Salmonella typhi and Proteus vulgaris, moderate activity against E.coli, Staphylococcus aureus and Bacillus cereus but lower activity against Enterobacter aerogens, Klebsiella pneumoniae and Pseudomonas aeruginosa. The inhibition zone was recorded and compared with standard antibiotic drug streptomycin and the results obtained purports the use of drug as a good source of antimicrobial agent[41].

Anticancer

Methanolic extract of *Kigelia pinnata* displayed significant cytotoxicity against human tumor cell lines. The extract exhibited strong antineoplastic activity against Lewis lung carcinoma with the significant increase of the life span of treated animals and tumor growth inhibition[42].

The root bark extract has been tested against melanoma cells. The extract inhibited the growth of cultured melanoma cells to a significant degree. The extract of stem bark and fruit are reported for their cytotoxic activities and showed promising results in treating melanoma and renal carcinoma[43].

Antitumor activity of methanolic extracts of 100, 200 mg/kg of *Kigelia pinnata* leaves was evaluated against Ehrlich ascites carcinoma (EAC) tumor induced in to mammary glands of mice. Acute and short-term toxicity studies were performed initially in order to ascertain the safety of methanolic extracts of *Kigelia pinnata.* After 12 days of tumor inoculation, the extract was administered daily for 30 days. The effect of methanolic extracts of *Kigelia pinnata* on the growth of tumor, life span of EAC bearing hosts and simultaneous alterations in the haematological profile and histopathological profile were estimated. The methanolic extracts of *Kigelia pinnata* showed decrease in tumor size, average body weight,

and mean survival time thereby increasing life span of EAC tumor bearing mice[44].

Anticonvulsant

Anticonvulsant activity of aqueous and methanolic extract of Kigelia pinnata was evaluated in wistar rats using PTZ and MES induced convulsions method. Both the extracts demonstrated potent anticonvulsant activity which may be due to the presence of linoleic acid, cinnamic acid, and/or flavonoids. 250 mg/kg and 500mg/kg of methanolic extract and aqueous extract were given intra-peritonially. The latency of seizures, death time and % of mortality were observed. Methanolic extract gave significant protection against the PTZ (pentylene tetrazole) and MES (maximal electro shock) induced convulsions[45].

Antidiarrhoeal

Aqueous leaf extract of *Kigelia pinnata* was examined for antidiarrheal activity using experimental animal models. Evidence for antidiarrheal activity was provided by the reduced fecal output and protection from castor oil-induced diarrhea in the extract-treated animals. The extract remarkably decreased the propulsive movement of the gastrointestinal contents. On the isolated guineapig ileum, the extract did not appreciably affect acetylcholine and histamine induced contractions, but significantly reduced nicotine evoked contractions. The i.p. LD50 of the extract in mice was estimated to be 785.65 ± 24 mg/kg[46].

The anti-diarrhoeal activity of the ethanolic extract of *Kigelia pinnata* was evaluated using Swiss albino mice. Mice were divided into five groups of five animals each. Diarrhoea was induced by administering 0.3ml of castor oil orally to mice. Group one served as control (normal saline 10 ml/kg), groups 2, 3 and 4 received the ethanolic extract (100, 200 and 500 mg/kg respectively) while group 5 received atropine (0.1 mg/ kg). For the small intestinal motility, groups of overnight fasted mice (n=5) received the ethanolic extract of the bark (100, 200 and 500 mg/ kg), atropine (0.1 mg/kg) and 10 ml/kg of distilled water prior to the administration of 0.2 ml of activated charcoal. *Kigelia pinnata* at oral doses of 100 mg/kg, 200 mg/kg and 500 mg/kg caused a marked inhibition of the diarrhoea response following castor oil administration ($P<0.05$). It also significantly ($p<0.0001$) inhibited the small intestinal motility in mice, with the 500 mg/kg dose giving the highest effect in both castor oil-induced diarrhoea and in the small intestinal motility. When compared with Atropine, its antidiarrhoeal effect at 500 mg/kg was found to be 82 % and 62.7 % respectively on castor oil-induced diarrhoea and on small intestinal motility. The plant thus possesses anti-diarrhoeal properties[47].

Other activities carried out

Study suggesting the use of plant as antileprotic has also been reported[48].

Aqueous preparation of the roots, fruits and flowers are administered orally or as a vaginal pessary while the fruits and bark are used to promote breast development in young women or in contrast to reduce swelling and mastitis of the breasts[49].

The ethanolic stem bark extract was administered in mice using barbiturate induced sleeping time and Rota rod bar to check the extract effect on muscle coordination. The result revealed that the extract has stimulant effect on CNS[50].

The flower extract was evaluated for hypolipidemic activity in Streptozocin induced diabetic wistar rats and it was found that the daily oral treatment with the extract and standard drug for 21 days significantly reduced blood glucose, serum cholesterol and triglycerides levels[51].

The wound healing activity of the bark extract of *Kigelia pinnata* was evaluated on albino rats using incision, excision and dead space wound models at the doses of 250 mg/kg and 500 mg/kg. Result showed a significant increase in skin tensile strength and dead space wound model showed a significant increase in dry granuloma weight, granuloma breaking strength and the level of hydroxyproline content at both doses level[52].

Cosmetic/Marketed Preparations[53]:

There are many cosmeceutical formulations of *Kigelia pinnata* available in the market. Some of the formulations available are-

Kigelia Rejuvenating Treatment Face Cream (Sausage Tree Cream): An ultra-rich, nourishing face cream rich in natural actives and antioxidants that deeply moisturizes without being greasy and deeply hydrates the skin to help smooth, firm and tone.

Kigelia Treatment Shampoo & Conditioner: A combined shampoo and conditioner treatment rich in natural actives and antioxidants, containing olive sqalene enriched with vitamins A and E which proves nourishment and shine to hair.

Kigelia Soothing Body Milk: A lighter, day cream helps the skin to retain moisture.

Conclusion:

Kigelia pinnata is an important plant bearing significant medicinal values in human. This review highlights the potential of the plant as therapeutic agents in different human ailments. The plant is proved to contain many secondary metabolites such as alkaloids, glycosides, flavonoids, tannins, saponins, quinines, reducing sugars, carbohydrates, kaempferol, iridoids, alpha sitosterol, terpenes, steroids, coumarins, etc. which are responsible to produce physiological changes in human ailments. The plant has been traditionally used for treating cancer of various kinds viz. liver, uterus, ovary etc. and also in various other disorders like diabetes, epilepsy, microbial and fungal infections, malaria, leprosy, inflammation, etc. the plant also possesses antioxidant, wound healing, hypolipidemic, antiurolithic, antiprotozoal, antidiarrhoeal, analgesic, CNS stimulant, and other activities. This review thus helps the researcher to evaluate and establish the use of plant in various conditions as a curative or as a prophylactic agent.

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