PLANT PROFILE, PHYTOCHEMISTRY AND PHARMACOLOGY OF SPATHODEA CAMPANULATA

P. BEAUVAIS (AFRICAN TULIP TREE): A REVIEW

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ABSTRACT

Plants have been used as one of the important source for treating various diseases of human beings since ancient times. Numbers of plants are mentioned in different traditional system of medicine, among them Spathodea campanulata P. Beauvais is one of the important medicinal plant. Different parts of Spathodea campanulata such as flowers, leaves, stem, bark and roots have been reported for possessing anti-inflammatory, analgesic, cytotoxic, anti-diabetic and anticonvulsant activity. Phytochemical screening shows the presence of various secondary metabolites like alkaloids, tannins, flavonoids, glycosides and sterols. Relevant information and literature on Spathodea campanulata from electronic databases such as Academic Journals, Google, Google Scholar, Science Direct, PubMed and Web of Science were collected and analyzed. Available literatures evidently show that Spathodea campanulata possess a wide range of pharmacological activities that could be explained by the presence of variety of phytochemicals. The aim of the present review to provide detailed information regarding geographical distribution, phytochemicals and pharmacological properties of this plant.

Keywords: Spathodea campanulata P. Beauvais, Phytochemicals, Flavonoids, Pharmacology

INTRODUCTION

Medicinal plants play an important role in our natural wealth. They serve as an important therapeutic agent as well as valuable raw material for manufacturing numerous traditional medicines and also acts as the lead for modern medicines. The history of medicinal plants uses for treating disease and ailments is probably dated back to human civilization. World Health Organization (WHO) estimated that about three-quarters of the world’s population currently uses herbs or other forms of traditional medicines to treat illness. Even in the USA, the use of plants and phytomedicines has increased dramatically [1]. The large diversity of medicinal plant species is a huge source of potentially active phytochemicals with novel structures. Approximately 119 pure chemical substances isolated from higher plants are used in medicine throughout the world [2]. Spathodea campanulata P. Beauvais is one of the medicinally important perennial plants commonly used as folkloric medicine in Nigeria. The species Spathodea campanulata belong to the family Bignoniaceae and is native to Africa. It is often used in gardening in tropical and subtropical areas, including South America [3]. The flowers are used as diuretic and anti-inflammatory, while the leaves are against kidney diseases, urethra inflammations and as an antidote against animal poisons [4]. Several phytochemical studies were performed with different parts of Spathodea campanulata including stem barks, leaves, flowers and fruits. The leaves contain saponodial, caffeic acid, other phenolic acids and flavonoids, while fruits contain polyphenols, tannins, saponins and glycodies [5]. The plant leaves reported to have antiplasmodial, analgesic, anti-inflammatory and anti-larvicidal activity. The stem bark decoction of Spathodea campanulata have been displayed hypoglycemic, anticomplementary, antimalarial and anti-HIV activity [6].

Geographical distribution

Spathodea campanulata P. Beauvais tree is native to Africa. In tropical Africa it is planted as an ornamental plant, e. g. in Cape Verde, Zimbabwe and Madagascar. It is widely grown in tropical and subtropical regions outside Africa [7]. This plant is also commonly found in India as an ornamental plant.

Scientific classification, local and vernacular names

This plant is also called as African tulip tree or Flame tree, Spathodea campanulata P. beauv is the botanical name. It is a single species of the monotypic genus Spathodea in the flowering plant family Bignoniaceae which is composed of around 800 species distributed in 112 genera [8].

Table 1: Scientific classification, local and vernacular names

| Scientific classification | Vernacular names                  | Local names                      |
|---------------------------|----------------------------------|----------------------------------|
| Kingdom: Plantae          | English: African tulip tree       | Hindi: Rugtoora                  |
| Order: Lamiales           | Cantonese: Neerukayi mara         | Marathi: Pichakari               |
| Family: Bignoniaceae      | French: immortel entranger       | Malay: Panchut-Panchut           |
| Tribe: Tecomeae           | Spanish: Tulipán Africano,       | Tamil: Patadi                    |
| Genus: Spathodea          | in Puerto Rico mesita.            | English: Flame of the forest,tulip tree |
| Species: S. campanulata   | Sindhal: Kudulu                  | Kannada: Neerukayi mara          |
| P. Beauv.                 | Luganda: Kifabakazi              | Malayalam: Poomaram              |

Morphology of Spathodea campanulata P. Beauvais

Spathodea campanulata P. Beauvais is a large upright tree with a spreading crown (fig. 1a) and a slightly buttressed trunk (fig. 1b). The branches are thick and marked with small whitish-coloured corky spots. Younger branches vary from being almost hairless to having a sparse covering of small hairs (fig. 1c). The large leaves are up to 50 cm long, compound with 7-17 leaflets. These leaves are usually oppositely arranged along the stems (fig. 1d). The large, orange-red flowers are arranged in dense clusters (8-10 cm long) at the tips of the
branches. The reddish-orange coloured petals are also fused together and are shaped somewhat like a tulip flower i.e. tubular ([fig. 1e]. Flowering occurs throughout the year, but usually peaks during spring. The fruits are long, elongated capsules resemble pods ([fig. 1f]. When mature they split open and release about 500 papery seeds. These seeds are very light and surrounded by membranous wing[9].

**Fig. 1:** Different parts of *Spathodea campanulata* P. beauv [10]

**Traditional uses**

*Spathodea campanulata* is traditionally used in the treatment of various disorders. The bark pulp is used in oedemas, skin diseases like herpes and sores. In Gabon, the crushed bark and flowers have been applied to ulcers. The cold leaf infusion is used to treat urethral inflammation and bark decoction has been reported to be used to treat kidney disorders [11]. In Senegal, the bruised leaves and flowers are used in wound treatment and ulcers. The flowers are employed as diuretic and anti-inflammatory, while the leaves are used against kidney disease, urethra inflammation and as an antidote against animal poisons. Also, the leaf decoction has been used for the treatment of gonorrhoea and women’s pelvic disorders. In Ghana, the bark infusion is used for the treatment of dysentery and stomach ache [12].

**Phytochemical**

Preliminary phytochemical screening of *Spathodea campanulata* P. Beauvais revealed the presence of alkaloids, reducing sugars, carbohydrates, flavones, glycosides, and phenolic compounds [13]. Several compounds have been isolated from different parts of the *Spathodea campanulata* P. beauv (table 2).

**Table 2: Phytochemicals isolated from different parts of the plant**

| Parts of the plant | Isolated phytochemicals |
|--------------------|--------------------------|
| Stem bark          | Triterpenes and Steroids, N-alcohols (35%) octacosanol and triacontanol [14]. Spathoside, n-alkanes, linear aliphatic alcohols, sitosterol and their esters, beta-sitosterol-3-O-beta-D-glucopyranoside, oleanolic acid, pomolic acid, p-hydroxybenzoic acid and phenylethanol ester [15]. 13β-acetoxyoleanolic acid, siresinolic acid, 3β-acetoxy-12-hydroxyolean-28,13-olide and oleanolic acid [16]. |
| Leaves             | Spathosides A, B, and C, Vernimboside, 6'-O-trans-cafeoyl-koanic acid, Catalpol and Ajugol [17]. Spathodol, Caffeic acid, Phenolic acid and Flavonoids [18]. |
| Root peels         | Methyl p-hydroxybenzoate and p-hydroxybenzoic acid [19]. |
| Fruits             | Polyphenols, Tannins, Saponins and Glucosides [19]. |
| Flowers            | 1,1-diethoxy-3-methyl-butan-2-one, N-hexadecanoic acid, 1,2-benzenedicarboxylic acid diisooctyl ester, and oleic acid [20]. Phytol, α-methyl Cinnamaldehyde, β-sitosterol-3-acetate, naringenin, catechin-3-O-α-rhamnopyranoside and 5, 6, 4′-trihydroxy flavonol-7-O-α-rhamnopyranoside, Anthocyanins [21]. |
Table 3: Chemical structure of isolated phytochemicals from different parts of the plant

| Name of isolated compound | Chemical structure |
|---------------------------|--------------------|
| Verminoside [17]          | ![Verminoside](image) |
| Oleanolic Acid [15]       | ![Oleanolic Acid](image) |
| β-Sitosterol [15]         | ![β-Sitosterol](image) |
| Ajugol [17]               | ![Ajugol](image) |
| Methyl-P-Hydroxy benzoate [19] | ![Methyl-P-Hydroxy benzoate](image) |
| Caffeic Acid [18]         | ![Caffeic Acid](image) |
| P-Hydroxy benzoic Acid [19] | ![P-Hydroxy benzoic Acid](image) |
| Spathodol [18]            | ![Spathodol](image) |
Pharmacological activities

Molluscicidal activity

Mendes et al. investigated molluscicidal activity of hexane and ethyl acetate extract of flowers and stem bark of Spathodea campanulata P. beauv against adults and egg masses of Biomphalaria glabrata [13].

Hypoglycemic, anti-complement and Anti-HIV activities

Niyonzima et al. evaluated hypoglycemic, anti-complement and anti-HIV activities of stem bark decoction of Spathodea campanulata P. beauv. The decoction was separated into different fractions by column chromatography by using different non-polar to polar solvents and fractions were evaluated for hypoglycemic activity in mice. The most polar fraction showed a prominent hypoglycemic activity in mice. Spathodea campanulata stem bark fractions also showed anti-HIV and anti-complement activities. Anti-HIV activity was evaluated on MT-4 cells using MTT assay [6].

Analgesic and anti-inflammatory activity

Emmanuel and Peter investigated analgesic and anti-inflammatory activity of Spathodea campanulata. The isolated compound was determined using pentylenetetrazole and maximal electroshock seizures. Acute toxicity studies, as well as the structural elucidation of the isolated compound was determined using pentylenetetrazole and maximal electroshock seizures. Analgesic and anti-inflammatory activity was evaluated on MT-4 cell lines using MTT assay [6].

Antioxidant activity

Heim et al. studied antioxidant activity of flower and bark extract of Spathodea campanulata P. beauv by lipid peroxidation mechanism. Ethanolic extracts of bark and flowers showed antioxidant activity on lipid peroxidation of liver microsome induced by Fe 3+-ascorbic acid. The results showed that the extract (250-1000 mg/kg) significantly (P<0.05) and dose-dependently suppressed the lipid peroxidation rate. An increased concentration of Fe 3+ (20-100 μm) which resulted in a decreased activity of the extract. Therefore the aqueous extract did not show any significant antioxidant property [27].

Anticonvulsant activity

Emmanuel et al. evaluated the anticonvulsant activity of a glycoside isolated from the leaf of Spathodea campanulata P. beauv by lipid peroxidation mechanism. Ethanolic extracts of bark and flowers showed antioxidant activity on lipid peroxidation of liver microsome induced by Fe 3+-ascorbic acid. Bark extracts were 5 times more efficient than flower extract. Antioxidant activity of flower extract previously complexed with increasing concentrations of Fe 3+ (20-100 μm) which resulted in the antioxidant activity of flower extract increased significantly (P<0.05) and dose-dependently. The results showed that the extract (250-1000 mg/kg) significantly (P<0.05) and dose-dependently abolished the convulsant activity in mice. Spathodea campanulata stem bark fractions also showed anti-HIV and anti-complement activities. Anti-HIV activity was evaluated on MT-4 cells using MTT assay [6].

Antimicrobial activity

Ofori-Kwakye et al. studied antimicrobial activity of different extracts of the stem bark of Spathodea campanulata P. beauv against B. subtilis, E. coli, P. aeruginosa and S. aureus. The minimum inhibitory concentration of the methanol extract was determined against the four bacteria strains i.e. B. subtilis, E. coli, P. aeruginosa, S. aureus and C. albicans using the broth dilution method. The coarsely milled stem bark of Spathodea campanulata P. beauv was extracted by soxhlet apparatus separately using water, ethanol (96 % v/v), methanol and petroleum ether as solvent. The methanol and ethanol extracts exhibited high activity while the aqueous and petroleum ether extracts showed little activity against the test organisms. The minimum inhibitory concentration of the methanol extract of Spathodea campanulata P. beauv was found to be C. albicans (45-50 mg/ml), B. subtilis and E. coli (50-55 mg/ml), P. aeruginosa (60-65 mg/ml), S. aureus (145-150 mg/ml). For the methanol extract, antimicrobial activity was in the order as E. coli>B. subtilis>P. aeruginosa>S. aureus. For the ethanol extract, antibacterial activity followed the order: B. subtilis>E. coli>P. aeruginosa>S. aureus. On the whole, the methanol extract of the stem bark of Spathodea campanulata P. beauv showed the highest antibacterial activity against the test organisms [26].

Antifungal activity

Makinde et al. investigated the antifungal activity of the extracts of the stem bark of Spathodea campanulata P. beauv on Plasmodium berghei in mice. Sun-dried stem bark material was extracted with hexane, methanol, chloroform and water. The blood schizontocidal activity of the extracts was studied in early and established infections using chloroquine as the reference drug against Plasmodium berghei. The prophylactic action of the extracts was also investigated with standard drug pyrimethamine. Both the hexane and chloroform extracts demonstrated significant antifungal activity in the 4-Day test and Rane test. The chloroform extract demonstrated some prophylactic properties. Whereas the result obtained with aqueous extracts was not significantly different from the control used in the test. Therefore the aqueous extract did not show any significant antifungal property [27].

Cytotoxicity activity

Victor et al. investigated the cytotoxic activity of the methanolic extract of Spathodea campanulata P. beauv. Methanolic extract was obtained by soaking the air-dried material in methanol for 48 h at room temperature activity and studied for cytotoxic activity by Resazurin Reduction assay against sensitive leukemia CCRF-CRM cell lines. The methanolic extract displayed IC 50 value below 80μg/ml [28].

Anti-cataract activity

Adio et al. evaluated the anti-cataract activity of fresh flower bud exudates of Spathodea campanulata P. beauv against cataractogenesis using rat lenses. Cataractogenesis was evaluated through the determination of the levels of anti-oxidant parameters such as total protein, glutathione, malondialdehyde and activities of superoxide dismutase and catalase was evaluated in the lens homogenates. Exudates significantly decreases the levels of glutathione and total protein, reduction in superoxide dismutase and Catalase activities as well as an increase in malondialdehyde content were observed in cataractous lenses when compared with the normal control. Flower bud exudates of Spathodea campanulata P. beauv displayed a dose related anti-cataract activity [29].

Antifungal activity

Driana et al. isolate Irrioid glycoside (ajugol) and two phenolic derivatives (p-hydroxybenzoic acid and methyl p-hydroxybenzoate)
from the ethanolic extract of *Spathodea campanulata* P. beav (Bignoniaceae) roots peels. These isolated compounds evaluated against fungus *Cladosporium herbarum*. The Iridoid glycoside (ajugol) did not exhibit any antifungal activity against *Cladosporium herbarum*, while phenolic constituents (p-hydroxybenzoic acid and methyl p-hydroxybenzoate) displayed antifungal activity [30].

**Antidiabetic activity**

Tanayen *et al.* investigated the antidiabetic activity of methanolic bark extract of *Spathodea campanulata* P. beav. The methanolic extract was subjected to serial solvent fractionation with hexane, ethyl acetate and chloroform and evaluated for antidiabetic activity using a modification of the oral glucose tolerance test. The activity result indicated that the various fractions reduced glucose-induced hyperglycemia though there was no statistically significant reduction (p=0.05). Considering the percentage reduction of hyperglycemia, the control had a reduction of 44.7%. The hexane fraction had a dose-dependent reduction 44.4% at 50 mg/kg, 48.2% at 100 mg/kg and 49% at 200 mg/kg. The ethyl acetate fraction reduced hyperglycemia by 48.5% at 50 mg/kg, 46.5% at 100 mg/kg and 42.3% at 200 mg/kg. The residual aqueous fraction reduced hyperglycemia by 67.3% at 50 mg/kg, 53.4% at 100 mg/kg and 74.7% at 200 mg/kg. Metformin the standard euglycemic agent reduced the hyperglycemia by 48% at the dose of 500 mg/kg. All the three fractions tested possess antimicrobial activity and the hexane fraction exhibiting a clearer dose-dependent activity [31].

**Anti-solar activity**

Patil VV *et al.* evaluated the UV absorption ability of flowers of *Spathodea campanulata* as an anti-solar agent. The flower petal were extracted with distilled water: methanol (2:5) by maceration. The UV absorption spectrum for the extract was taken in the range of 200–400 nm using double beam UV-visible spectrophotometer. The extract showed a prominent absorbance at 200–240 nm, while good absorbance at a range of 240–325 nm. The moderate absorbance was noted at the range of 310–340. The result obtained were showed the ability of extract to absorb UV radiation and proved its UV protection ability hence can be used as an anti-solar agent [32].

**Acute and subchronic toxicities study**

Ilodigwe *et al.*, evaluated the acute and subchronic toxicities of the ethanol leaf extract of *Spathodea campanulata* P. beav as an anticonvulsant drug. For the acute toxicity study, 1000-5000 mg/kg of the ethanol leaf extract were administered to rats and toxic symptoms and mortality 24 h post administration of the extract were determined. The median lethal dose (LD₅₀) of the extract was determined. In the subchronic study, 750-3000 mg/kg of the extract were administered daily for 90 d. The food and water consumption, body weight changes, as well as haematological and biochemical parameters, were determined periodically. The estimated LD₅₀ of the extract was 4466.84 mg/kg. There was no mortality during the period of study but the animals showed signs of anorexia, weakness, sluggishness and significant (p<0.05) reduction in food and water intake and body weight. The effects on haemoglobin concentration, packed cell volume, red blood cell and white blood cell counts were non-significant (P>0.05). The extract caused significantly (p<0.05) increases in serum liver enzymes, Aspartate Aminotransferase, Alkaline Phosphatase and Alanine Aminotransferase. These changes showed recovery after 28 d post-treatment. These results suggested that the leaf extract of *S. campanulata* is safe in the treatment of epilepsy [33].

**Search criteria**

- Electronic databases-Academic Journals, Google,Google Scholar, PubMed, Web Science, Science Direct, data sheets, Record from PROTA4U.
- Key Words-Spathodea campanulata, Traditional Use, Phytochemicals, Pharmacology.
- Software-Chemdraw, Chemsketch, Ginger, Grammar checker.

**CONCLUSION**

From the review of the existing work, it was concluded that *Spathodea campanulata* P. Beauvais has been used in the treatment of various diseases and reported to have antimalarial, anticancer, antidiabetic, antioxidant and antibacterial activities. In the recent year’s traditional medicines received more attention and evaluated for its efficacy and generally, they are safe for human beings. Numerous phytochemical and pharmacological studies have been conducted on different parts of the *Spathodea campanulata* P. Beauvais. Further investigation to explore the therapeutic action of the individual phytochemicals and their mechanism of action can be encouraged.

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**AUTHOR CONTRIBUTION**

Both the authors had contributed equally to the review work.

**CONFLICT OF INTERESTS**

We declare that we have no conflict of interest.

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