

"Beyond Tradition: Modern Pharmacological Perspectives on *Justicia gendarussa* in Therapy"

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Date of Submission: 10-08-2024

Date of Acceptance: 20-08-2024

ABSTRACT

Introduction: Since ancient times, traditional medicines derived from medicinal plants have been utilized to cure people. Acanthaceae is a family of plants that includes the medicinal herb *Justicia gendarussa*. Its pharmacological activities have been scientifically confirmed, which supports its usage in traditional medicine for managing diseases. The plant displays numerous pharmacological properties, including hepatoprotective, antitumor, antibacterial, antioxidant, antinociceptive, and immunomodulatory properties.

Justicia gendarussa contains a variety of phytochemical components, including alkaloids such as justridisamide A, B, C, and D; flavonoids such as quercetin, kaempferol, naringenin, and apigenin; saponins such as luteol, beta sitosterol, and stigmasterol; aromatic amines; fatty acids; and essential oil.

Methods: We have used scientific databases including Pub Med®, Science Direct®, and Google Scholar® to gather the data that backed up our plan to perform an exhaustive study. An attempt was made to use terms such as natural medication therapy, herbal therapies instead of contemporary ones, and so on to search through all English-language papers published between 1985 and 2023.

Result and Discussion: Consequently, *Justicia gendarussa* is a medicinal plant that has great promise for treating a variety of ailments. Its phytochemical components have shown promise as novel therapeutic leads. It cannot, however, be advised for clinical use until its mechanisms of action, safety, and effectiveness are completely understood. This review discusses *Justicia gendarussa*'s pharmacological activities, future prospects, phytochemicals, and its privileged aspects.

Key words- *Justicia Gendarussa*, Cardio-protective, Hepato-proective, Anti-cancer, Anti-HIV, Hyperuricemia

I. INTRODUCTION

Acanthaceae is a family of plants that includes the species *Justicia gendarussa*. Commonly referred to as "Nili-Nirgundi" or willow-leaved *Justicia*, it is extensively found in China, Malaysia, Indonesia, India, and Sri Lanka.[1,2] Research has also been done on the plant's pharmacological effects and bioactive compounds, which have demonstrated potential therapeutic uses. These uses include hepatoprotective, anti-anxiety, cytotoxic, immune-suppressive anti-inflammatory, analgesic, antioxidant, anti-bactericidal, anti-angiogenic, antifungal, anthelmintic, larvicidal, and adulticidal effects, as well as inhibiting HIV type 1 reverse transcriptase and protein denaturation.[3,4]

A recent study suggests that *justicia gendarussa*, a common Chinese medication, may have an inhibitory impact on platelet aggregation in addition to its typical anti-inflammatory properties. Thus, it may be concluded that *Justicia gendarussa* has potential benefit in treating thrombosis. This review article provides a brief explanation of *Justicia gendarussa*'s traditional usage, phytochemical properties, and pharmacological effects.

II. BOTANICAL DESCRIPTION

The *Justicia gendarussa* is a little shrub with smooth, green leaves and clusters of tiny purple flowers that can reach a height of 1.5 metres. The plant grows best in warm, humid climates; it is frequently found in woodlands, riverbanks, and other damp areas.[4,5]

Taxonomy

Justicia gendarussa belongs to the phylum Tracheophytes, which is comprised of all vascular plants, within the plant kingdom according to taxonomy. Its members include numerous kinds of attractive and therapeutic plants in the order Lamiales and the class Angiosperms, that are

blooming plants. It belongs to the broad family of flowering plants known as Acanthaceae, which

typically occurs in the tropical regions and subtropical regions.

Table 1. Taxonomy of Justicia Gendarussa

Taxonomic	Justicia Gendarussa plant
Domain	Eukaryota
Kingdom	Plantae
Class	Magnoliopsida
Division	Tracheophyta
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Asterids
Order	Lamiales
Family	Acanthaceae
Genus	Justicia
Species	J. gendarussa

III. CHEMICAL CONSTITUENTS

Chemical components including alkaloids, flavonoids, tannins, saponins, phenolic, as well as vital oils are abundant in the plant.[6-12]

Alkaloids

There are several alkaloids found in Justicia gendarussa, such as Justridisamide A, B, C, and D. These alkaloids have a range of biological effects.

Justicia gendarussa leaves were used to isolate brazoides A-D, which included three recognised compounds and four novel alkaloids, in addition to squalene, β -sitosterol, and lupeol.

Flavonoids

One of the most prevalent chemical components in Justicia gendarussa is flavonoids. Numerous flavonoids, such as quercetin, kaempferol, naringenin, and apigenin, are present in the plant. These flavonoids have a range of biological functions.

Saponins

Saponins, a group of glycosides containing a steroid or triterpenoid aglycone, are present in Justicia gendarussa. Apart from gendarussin B, gendarussin C, and gendarussin D, the plant also includes beta sitosterol, stigmaterol, and luteol. These saponins have a range of biological functions.

Aromatic amines

In Justicia gendarussa, amines are present in the form of 2-(2' amino-benzyl amino) benzyl alcohol and their corresponding O-methyl ether, 2-amino benzyl alcohol. Many biological actions are exhibited by these amines.

Fatty acid

Several fatty acids are present in Justicia gendarussa, such as oleic acid, 6,9,12-octadecadienoic acid, 9,12-octadecadienoic acid, and estra-1,3,5(10)-trin-17-beta,ol.

Essential oils

Moreover, Justicia gendarussa has volatile substances called essential oils that have a powerful scent. These essential oils have a range of biological functions.

Others

This ethanol extract was made from the aerial portions of Justicia Gendarussa Burm.f., and the ethyl acetate fraction yielded three new compounds and six previously recognised compounds. Compounds demonstrate anti-inflammatory action, while compounds show antioxidant qualities, according to **Sitosterol** to an evaluation of the compounds' anti-inflammatory and antioxidant capacities.

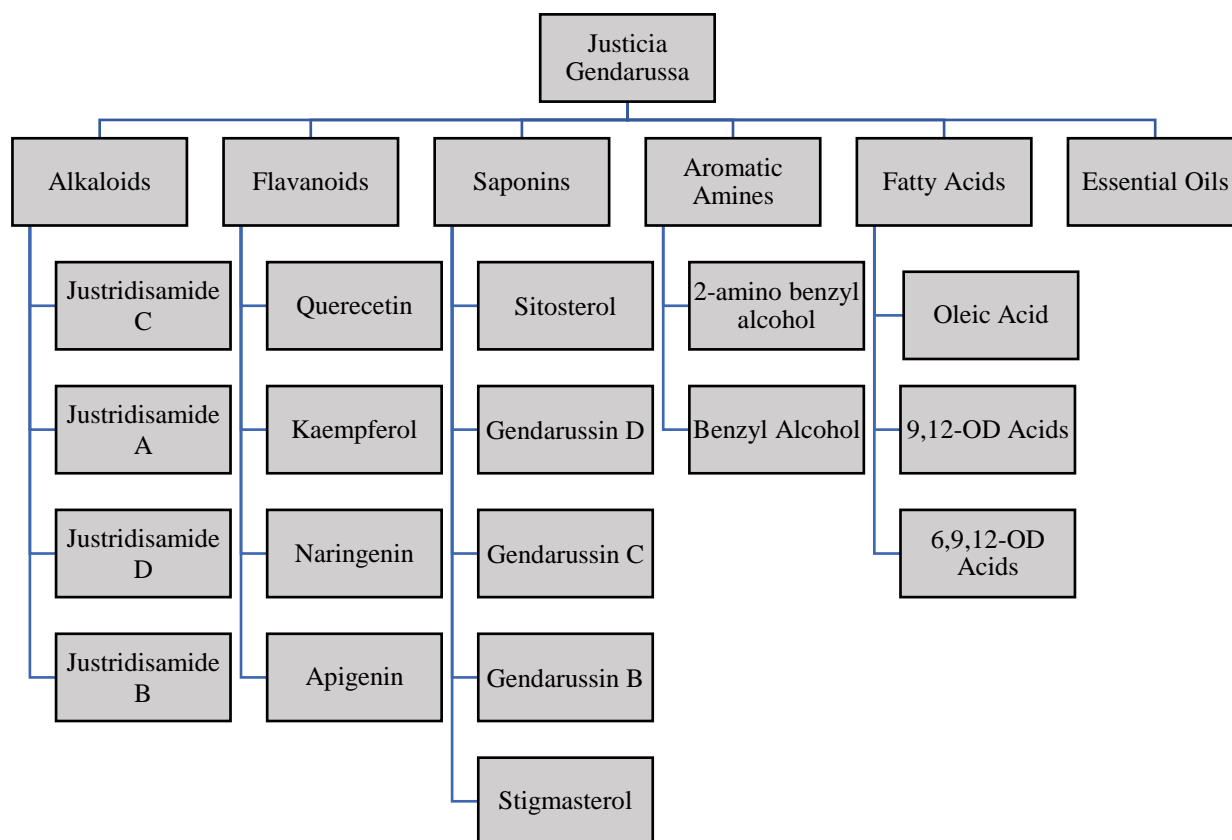


Fig. 1. Classification of Justicia Gendarussa's chemical components

IV. PHARMACOLOGICAL ACTIVITY OF JUSTICIA GENDARUSSA

Antioxidant activity

The methanolic extract of Justicia gendarussa demonstrates antioxidant activity through the reduction of ferric ions and peroxide of hydrogen scavenging activity. In addition, the callus made from methanol extract of Justicia gendarussa stems exhibited the highest scavenging and lowering capacity. In another investigation, the impact of Justicia gendarussa leaf extract on hydrogen peroxide-induced oxidative stress in human keratinocytes was assessed. Based on the findings, it was determined that the extract could lower the levels of ROS and lipid peroxidation while raising the event of antioxidant enzymes including superoxide dismutase and catalase.[13,14] Consequently, the data effectively illustrates Justicia gendarussa's capacity for antioxidant activities.

Anti-fungal

Dermatophytes, which are currently classified into six pathogenic genera—

Microsporum, Trichophyton, Epidermophyton, Nannizia, Lophophyton, and Arthroderma—cause most of these illnesses. The possibility of herbal medications is attracting attention in the development of novel antifungal chemotherapy treatments. According to some research, Justicia gendarussa possesses a variety of bioactive chemicals and has the potential to damage the fungal cell membrane, which could explain its promising antifungal efficacy against dermatophytes.[15-17]

According to one study, Justicia gendarussa's chloroform extract shown strong antifungal activity against a range of dermatophytes, such as Trichophyton mentagrophytes, Microsporum canis, and Epidermophyton floccosum. Additionally, the study hypothesised that Justicia gendarussa's antifungal effect might stem from its capacity to damage fungal cell membranes. Future research is required, though, in order to fully assess this plant.[18]

Anti-arthritis

In the world, one in five elderly persons suffer from arthritis. The disease is classified as systemic autoimmune because it causes persistent inflammation that results in pain, swelling, and decreased joint function. The exact pathophysiology of the disease is unknown, but some people with it release free radicals that are byproducts of cellular metabolism, such as superoxide and nitrous oxide. The secretion of such free radicals may induce T-cells to create interleukins (IL) and tumour necrosis factor (TNF- α), which may have an impact on the immune cells' ability to produce growth factors, cytokines, and sticky molecules that may lead to inflammation and tissue death.

Long-term use of anti-arthritic drugs already on the market can result in myelosuppression, impaired kidney function, cardiovascular issues, and gastrointestinal concerns. Thankfully, nature has a remedy for this condition, and a combination of herbs, including rheumatoid arthritis, can effectively reduce chronic joint inflammation. It has been demonstrated that using herbal treatment to treat rheumatoid arthritis is safe and effective. According to certain scientific research, the plant *Justicia gendarussa* has anti-arthritis properties.[19-21]

In rats with adjuvant-induced arthritis, an ethanol-based extract of *Justicia gendarussa* leaves demonstrated a strong anti-arthritic effect, according to one study. According to the study, the extract considerably decreased the rats' joint stiffness, pain, and paw edema, suggesting that it may be used to treat arthritis. In parts of China including Guangdong, Guangxi, and Taiwan, the whole plant has been used as a traditional medical cure to treat rheumatic illnesses and accidents.[22]

Cardio-protective

The primary cause of death is increasingly cardiovascular disease (CVD). The term "heart and blood vessel condition" (CVD) is used. It includes angina, myocardial infarction (MI), congestive heart failure (CHF), peripheral arterial disease (PAD), and coronary heart disease (CHD).[23] Medical plants can prevent certain illnesses in a number of ways. They can lower blood pressure and cholesterol, lessen oxidative stress and chronic inflammation, and enhance the function of the endothelium, the blood vessel's inner lining.[24]

Notwithstanding claims of *Justicia gendarussa*'s application in cardiac conditions and its cardioprotective properties. Despite claims that *Justicia gendarussa* is used to treat cardiac

conditions and that its flavonoid content confers cardioprotective benefits. It has biological properties similar to those of a cardioprotective. Naturally occurring apigenin is a powerful cardioprotective flavonoid. [25]

A study found that the ethanol-based extract of *Justicia gendarussa* has a protective effect on cardiomyocytes against the toxic effects of doxorubicin (DOX) through the oxidation-reduction of two enzyme activities: superoxide dismutase (SOD) and catalase.[26]

Another study found that the methanolic extract of *Justicia gendarussa* exhibited substantial thrombolytic activity, as demonstrated via clot lysis for the soluble fractions in pet ether and carbon tetrachloride. In addition, a different study demonstrates that by regulating the NOXs-ROS-NF-B signalling pathway, treatment with a decoction of *Centella asiatica*, *Justicia gendarussa*, and *Imperata cylindrica* (CJI) lowers the thoracic aortic oxidative stress response in spontaneously hypertensive rats (SHRs). These findings imply that CJI protects against hypertension-induced SHR vascular remodelling.[14]

Antibacterial and antimicrobial activities

Bacterial infections caused by invasive pathogenic bacteria or opportunistic pathogens are the most prevalent infectious illnesses worldwide. Many ailments, such as pneumonia, periodontal disease, TB, conjunctive inflammation gastroenteritis, and others, can be brought on by these infections and septic shock.[27]

The capacity of the bacteria to get past the body's natural defences, like the skin and mucous membranes, is the first stage in the mechanism of bacterial infection. Once within the body, the bacteria can penetrate and infect the host by attaching themselves to the cells through structures like fimbriae and pili. Subsequently, bacteria have the ability to produce toxic substances or enzymes that can cause injury to tissues and disrupt regular biological processes. In response to an infection, the immune system often produces white blood cells, which have the ability to identify and eliminate invasive microorganisms. Certain bacteria, however, have the ability to elude the immune system and cause persistent or recurrent illnesses.[28]

Because traditional herbal remedies contain phytochemicals, they naturally aid in the fight against bacterial infections. Important phytochemicals found in the leaves of the plant *Justicia gendarussa* include lupeol, friedelin, 2-aminobenzyl alcohol, 2-di-substituted aromatic

amines, and -sitosterol. Recent times have witnessed a surge in investigations about their antibacterial characteristics. In a study, methanol fractions of *Justicia gendarussa* showed the most effective range of inhibition against *E. coli* and *Bacillus subtilis*. Each and every extract of *Justicia gendarussa* (hexane, diethyl ether, dichloromethane, ethyl acetate, and methanol) inhibited one of the eight microorganisms that were being tested. Its antibacterial properties and highest suppression of *Escherichia coli* and *Bacillus subtilis* could be due to many compounds present in the plant.[29,30]

Another study demonstrates that the *Justicia gendarussa* was capable to use a hydroponic culture technique to root and produce biomass. The antibacterial activity of the harvested biomass of leaves, stems, and roots was evaluated against a range of human pathogenic microorganisms, such as *Klebsiella pneumoniae*, *Escherichia coli*, *Shigella* spp., and *Pseudomonas* spp. *E. coli* was affected by the methanolic extract of *Justicia gendarussa* root. The growth of *K. pneumoniae*, *Pseudomonas* sp., and *Shigella* sp. was inhibited by leaf extract.[31] The biggest inhibitory zone against *S. aureus* was observed in the stem extract treatment. *Justicia gendarussa* leaf extract's antibacterial testing was evaluated in an in vitro study utilising the Agar well diffusion method. The findings demonstrated that leaf extracts in ethanol and ethyl acetate had significant antibacterial activity.[32]

A study claims that *Justicia gendarussa* exhibits antibacterial qualities against *Pseudomonas pneumonia* and *vulgaris* pathogens.[33] In another study, the bactericidal effects of copper oxide nanoparticles (CuONPs) were seen against both Gram-positive and Gram-negative bacteria when the CuONPs were functionalized using the leaf extract of *Justicia gendarussa*. [34]

Hepato-protective

A significant worldwide public health concern is hepatotoxicity. Numerous pathological traits, including non-inflammatory (hepatitis), inflammatory (acute or chronic hepatitis), and tumorous (hepatic adenoma or hepatocellular carcinoma) illnesses, are indicative of liver diseases. Medicinal plants are widely used to treat hepatotoxicity and other illnesses because they are effective, safe, and reasonably priced.[35]

A study found that *Justicia gendarussa* leaf extract had a slight hepatoprotective effect. This effect may be related to the extract's antioxidant and free radical eliminating properties. Its high total phenolic and flavonoid content contributes to its liver-protective and antioxidant qualities. Further investigation is required to identify the specific phytochemical (s) and their mechanism behind the hepatoprotective effect of *Justicia gendarussa*. [36] *Justicia gendarussa* leaf (JGMe) methanol extract shows a strong protective effect against the detrimental effects of carbofuran (CF) in the hepatocellular cell, which could lessen oxidative damage as shown by the histopathological and biochemical results, according to an in-vivo study.[37]

Anti-helminthic

Helminths have developed a variety of methods to suppress the immune system or reduce host reactivity. One of these methods is to encourage the production of regulatory T-cells (Tregs). In addition to increasing parasite lifespan, this Treg expansion protects against illnesses associated with filarial infection parasites. Furthermore, helminth-produced Tregs have been connected to the suppression of bystander immune-pathologies in a range of inflammatory conditions, such as autoimmune diseases and allergies.[38,39]

Consequently, because herbal therapy may have less side effects, helminthic infections may be treated with herbal remedies.[40] Numerous secondary metabolites, such as terpenoids, alkaloids, flavonoids, chalcones, coumarins, and tannins, are formed by herbs and have a variety of biological properties, including anti-helminthic action.[41] According to certain isolation studies, the plant *Justicia gendarussa* contains several secondary metabolites, which have been used to treat helminthic infections.

The plant was shown to contain stigmasterol, lupeol, and 16-hydroxy lupeol in an in vitro experiment. The worm *Pheretima posthuma* is killed and paralysed by the extract of methanol of *Justicia gendarussa* leaves at a concentration of 50 mg/ml. The worm *Pheretima posthuma* is also killed and paralysed by the methanolic extract of *Justicia gendarussa* stem at the same concentration. Nevertheless, further research on this activity has to be considered.[42]

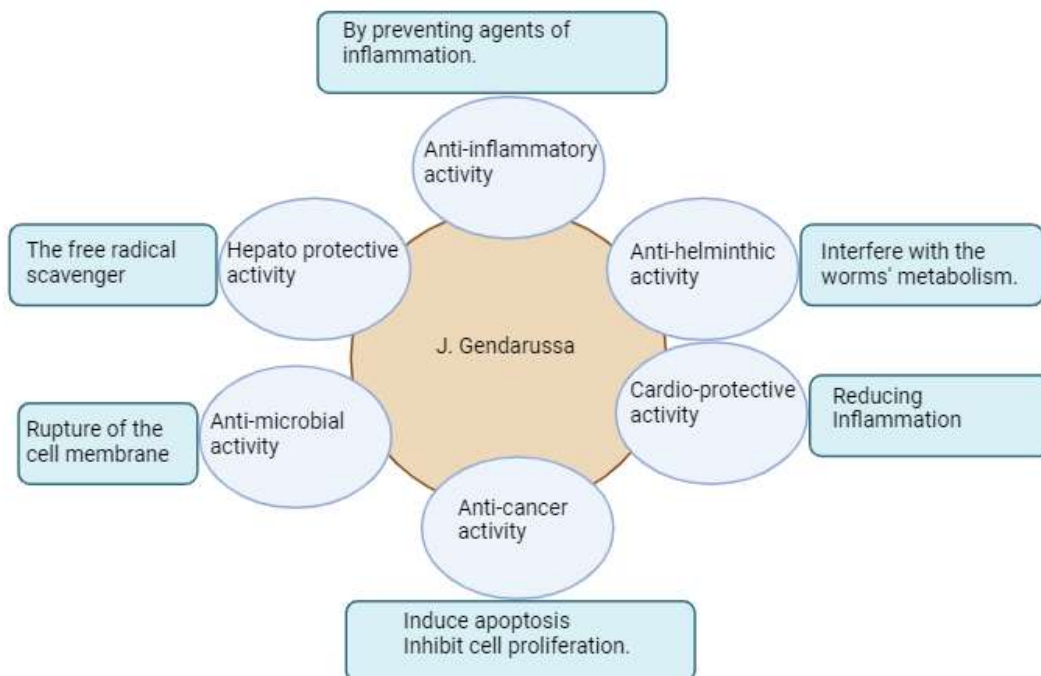


Fig.2.Pharmacology activity and its mechanism of Justicia Gendarussa

Anti-inflammatory activity

For millennia, people have used *Justicia gendarussa* to treat inflammatory disorders as a prophylactic strategy. *Justicia gendarussa* is used in Chinese traditional medicine to treat inflammation-related ailments such as bronchitis, arthritis, muscle soreness, and respiratory problems. *Justicia gendarussa* exhibits anti-inflammatory properties by blocking the production of cyclooxygenase-2 (COX-2) and iNOS through NF- κ B pathways. Research indicated that *Justicia gendarussa* has anti-inflammatory properties and can be used as a medicine. In an *in vitro* investigation, an ethyl acetate fraction derived from methanolic extracts of *Justicia gendarussa* roots demonstrated its anti-inflammatory properties by inhibiting the release of COX, interleukin-6, cyclooxygenase, 5-lipoxygenase, nuclear factor kappa B, and LPS-stimulated human peripheral blood mononuclear cells (hPBMCs).[43,44]

Apigenin, a bioflavonoid found in *Justicia gendarussa*, exhibits anti-inflammatory properties by decreasing the expression of toll-like receptor 4, myeloid differentiation primary response-88 (MyD88), TIR-domain-containing adapter-inducing interferon-BETA (TRIF), tumour necrosis factor receptor associated factor 6 (TRAF6), NF- κ B, COX-2, prostaglandin E2 (PGE2), interleukin -1

(IL-1BETA), and tumour necrosis factor (TNF-ALPHA). Apigenin's anti-inflammatory properties were demonstrated in an *in vitro* investigation using oxidised low-density lipoprotein (Ox-LDL)-induced hPBMCs prior to treatment.[45]

Another study found that when *Justicia gendarussa* beta-sitosterol chloroform extraction is used instead of regular diclofenac, it produces more histamine, bradykinin, prostaglandin, and serotonin, which all have stronger anti-inflammatory effects.[46] Because it stabilizes the cell membrane and stops prostaglandin or other inflammatory mediators from leaking out, the methanolic leaf extract of *Justicia gendarussa* possesses potent anti-inflammatory qualities. The antibacterial properties of the extract of methanol of *Justicia gendarussa* leaves were observed in both gram-positive and gram-negative bacteria.[47] The pharmacological effect of *Justicia gendarussa* is particular to treating the disorders.

Anti-cancer activity

Cancer, as a disease or cluster of diseases, is enigmatic and scary. Cancer first appeared in multicellular organisms about 200 million years ago, and there is evidence that cancers first appeared in the progenitors of modern humans more than a million years ago. Unlike many

environmental diseases, parasites, and infectious disorders, cancer is not primarily caused by an external factor. Human cells that have, in a way, lost control and been drawn to or partially transformed into pathogenic organisms or tumour nuclei are its destructive agents.[48]

Justicia gendarussa is one of the potential medicinal plants that could be utilised to cure breast cancer, according to earlier research. This is the second most common cancer worldwide, after lung cancer, and the most common cancer in women. In the brine shrimp lethality assay, *Justicia gendarussa*'s methanolic leaf and root extracts demonstrated cytotoxic effect against brine shrimp, showing IC₅₀ values 48.71 g/mL and 93.25 g/mL, respectively.[49]

Anti-HIV activity

The HIV retrovirus impairs the human immune system, resulting in the disease known as AIDS. Globally, HIV infection is a major cause of mortality.[50] HIV belongs to the Lenti virus genus within the Retroviridae family and shares genetic ancestry with it. There are now two types of HIV isolates: HIV-1 and HIV-2. Both viruses have the potential to cause AIDS, but HIV-2 infection may increase the risk of central nervous system disease. Moreover, HIV-2 appears to be less severe than HIV-1, and AIDS takes longer to manifest after infection.[51]

HIV anti-retroviral drugs have unfavourable side effects that endanger the life of HIV patients. Several plants have been shown through empirical evidence to block reverse transcriptase, which may aid in the eradication of HIV. One such antiviral plant that could be useful for treating HIV infections is *Justicia gendarussa*. The 70%-fractionated ethanol extract of *Justicia gendarussa* containing alkaloid was found to have better anti-HIV activity on HIV-infected MOLT-4 cells.[52]

Justiprocumins A and B, two anti-HIV compounds, were discovered in a methanol extract of this plant's stems and bark, according to another study. The compounds that are responsible for this plant's anti-HIV properties are new aryl-naphthalide lignans (ANL) glycosides. Strong efficacy against many HIV strains was shown by justiprocumin B. The chemical efficiently inhibited both the non-nucleoside reverse transcriptase inhibitor (NNRTI)-resistant isolate (HIV-1N119) of the analogue nevirapine and the nucleoside reverse transcriptase inhibitor (NRTI)-resistant isolate (HIV-11617-1) of the analogue AZT.[53] By analysing the effect of incubation time on the antiviral activity of a 70%

ethanol extracts of the leaves of the plant on HIV-infected MT-4 cells in-vitro, another study suggests that *Justicia gendarussa* may have anti-HIV characteristics.[54] Twenty Thai medicinal plants are shown in another study to suppress HIV type 1 reverse transcriptase, which is used to treat AIDS.[55]

Antianemic Activity

One of the most frequent causes of morbidity and death among individuals of African, Caribbean, South and Central American, Arab, and East Indian descent is sickle cell disease, also known as drepanocytes. A genetic mutation that results in the substitution of a nonpolar amino acid (valine) for a polar amino acid (glutamic acid) at the sixth position of the beta-globin chain causes SCD, a debilitating illness. This alteration decreases hemoglobin's affinity for oxygen. Furthermore, the solubility of haemoglobin is impacted by this structural shift, leading to aberrant haemoglobin, or haemoglobin S (HbS), polymerizing inside erythrocytes into a gel or even further into fibres, changing RBCs from their normal biconcave form to the sickle form under hypoxia conditions. The sickling of the red blood cell and the HbS polymerization are areas associated with sickle cell disease. A lot of the drugs that are available to treat the illness are either too costly, too toxic, or not effective enough.[56-58]

Among the therapeutic herbs with anti-sickling properties is *Justicia gendarussa*. For sickle cell anaemia, herbs called *Justicia gendarussa* are utilised instead of pricy and hazardous drugs or therapies. According to this study, anthocyanin-containing compounds have an anti-sickling effect. For ED₅₀, NR_{max}, and MCN, the anthocyanin concentrations in the leaves of the willow-leaved *Justicia* plant were 0.44 g/ml, 87.1%, and 7.6 g/ml, correspondingly. The absorbance value, which decreased by 28% in 60 minutes from 1.80 to 1.30, indicates that this anthocyanin encourages drepanocyte hemolysis. This study indicates that in sickle cell anaemia erythrocytes, the anthocyanins in this plant exhibit antihemolytic activity.[59,60]

Anti-anxiety Activity

In the 1990s, estimates put the number of persons affected by anxiety at 26.9 million. Anxiety impairs one's capacity to focus, study, exercise critical thought, assimilate knowledge, and do well in school or the workplace. It has also been demonstrated that anxiety influences blood pressure, stress levels, immune system activity, and

the capacity to tolerate discomfort. Anxiety also impacts decision-making, excessive alcohol consumption, migraines, skin conditions (especially psoriasis and atypical dermatitis), and unpleasant ruminating that occurs after an unpleasant experience. It is a depression predictor.[61-65] The immune, neurotransmitter, and neuroendocrine systems are the main targets of the mechanisms generating anxiety disorders.[66]

The research of new drugs for the treatment of anxiety is a major source of worry worldwide. Medicinal plants may be a source of novel anxiolytic remedies. A study found that *Justicia gendarussa* is a useful plant for treating anxiety disorders.[67] To verify the efficacy of this plant's traditional use for treating anxiety disorders, several doses of the plant extract were evaluated for anti-anxiety screening tests. When administered orally in two separate doses, EJG enhanced the number of arm entries and the amount of time spent in the elevated plus-maze. In comparison to control animals, it also caused mice to spend more time in the lit side of the light-dark test and significantly less time freezing. This study demonstrated how well the ethanolic extract of *Justicia gendarussa* lowers anxiety.[68]

Hyperuricemia Activity

Overproduction of uric acid and poor renal uric acid excretion are the causes of hyperuricemia. In the purine catabolic pathway, xanthine oxidase (XO) catalyses the conversion of xanthine and hypoxanthine to uric acid. Medications that inhibit xanthine oxidase activity are commonly used to treat excessive urine production.[69] It is believed to be a strong risk factor for gout and a major factor in the development of many chronic ailments, including malignant tumours, cardiovascular issues, and renal failure.[70]

The plasma level of uric acid is significantly reduced by an ethanol extract from *Justicia gendarussa* leaves in rats that have been subjected to oxonate-induced hyperuricemia. The test substance can lower blood uric acid levels in rats with hyperuricemia; the extract exhibited its maximum effectiveness in these animals.[71]

FUNDING

None.

CONFLICT OF INTEREST

The authors declared no conflict of interest, financial or otherwise.

CONCLUSION

A plant species called *Justicia gendarussa* has long been utilised in Chinese medicine for therapeutic purposes. Numerous biological actions, such as antibacterial, antifungal, antiviral, anti-inflammatory, and antioxidant qualities, have been documented for it. *Justicia gendarussa* has been the subject of little research up to this point, and more investigation is required to completely comprehend its therapeutic qualities and possible uses. But based on the research that is currently available, it appears that this plant has a lot of medicinal potential and may be a useful source of natural treatments for a range of illnesses. In order to fully explore its potential health advantages and therapeutic applications, *Justicia gendarussa* is a fascinating plant species that warrants additional scientific inquiry.

Abbreviations

hPBMCs: Pooled Human Peripheral Blood Mononuclear cells

IL: Interleukin

DNA: Deoxyribonucleic Acid

TNF- α : Tumour Necrosis Factor alpha

AIDS: Acquired Immune Deficiency Syndrome

ROS: Reactive oxygen species

CuONPs: Copper oxide nanoparticles

COX-2: Cyclooxygenase 2

HIV: Human Immunodeficiency virus.

JAK-STAT: Janus Kinase Signal transducers and activators of transcription

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