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Review on pharmacology activities of *Justicia Gendarussa Burm F.*

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ABSTRACT

Introduction: Traditional remedies made from medicinal plants have been used for human treatment since ancient times. *Justicia gendarussa* is a medicinal plant belonging to the Acanthaceae family. Its use in traditional medicine for treating various ailments is supported by its scientifically proven pharmacological actions. The plant exhibits a wide range of pharmacological activities such as antidiabetic, antioxidant, antinociceptive, antimicrobial, anticancer, hepatoprotective, and immunomodulatory activities.

Methods: We have collected the data which supported this idea to conduct a comprehensive review by using scientific databases such as Pub Med ®, Science Direct ® and Google Scholar ®. The use of suitable keywords in listed scientific search engine like bioactive molecules of *Justicia gendarussa*, pharmacological activities of herbal plant, medicinal values of natural herbs etc. An attempt was made to refer to all English-language articles published between1987 and 2023.

Result & discussion: Therefore, *Justicia gendarussa* is a promising medicinal plant with various pharmacological activities, and its phytochemical constituents have demonstrated potential as new drug leads for the treatment of various diseases. However, further studies are needed to fully understand its mechanisms of action, safety, and efficacy before it can be recommended for clinical use. The plant was found to have broad spectrum of activities due to the presence of active constituents like alkaloids, flavonoids, phenolic compounds, steroids, carbohydrate, carotenoids and terpenoids.

Introduction

Justicia gendarussa is a plant species belonging to the *Acanthaceae* family. It is commonly known as "Nili-Nirgundi" or willow leaved *Justicia*and is widely distributed in China, Indonesia, India, Sri Lanka, and Malaysia [1,2].The plant has also been studied for its pharmacological effects and bioactive compounds, which have shown potential therapeutic applications, including cytotoxic, immunosuppressive, anti-inflammatory, analgesic, antioxidant, hepatoprotective, anti-anxiety, anti-bactericidal, anti-angiogenic, antifungal, ant sickling, anthelmintic, larvicidal, adulticidal, and for inhibiting both HIV type 1 reverse transcriptase and protein denaturation [3–4].

Justicia gendarussa, as a common Chinese medicine, is usually used for anti-inflammatory treatment and recent study indicates that it has an inhibitory effect on platelet aggregation. Therefore, it can be inferred that *Justicia gendarussa* can be used as a therapeutic drug for thrombosis. [88].This review article briefly explains the traditional uses, phytochemical and pharmacological actions of *Justicia gendarussa*.

Botanical description

Justicia gendarussa is a small shrub that can grow up to 1.5 meters in height, with green and smooth leaves and small, purple flowers arranged in clusters.The plant prefers humid and warm environments and is often found in forests, riverbanks, and other moist habitats [4,5].

Methodology

We have collected the data which supported this idea to conduct a comprehensive review by using scientific databases such as Pub Med ®, Science Direct ® and Google Scholar®. The records thus collected were then screened and sequentially arranged to divide those under different

Abbreviations: ROS, Reactive oxygen species; DNA, Deoxyribonucleic acid; JAK-STAT, Janus Kinase signal transducers and activators of transcription; IL, Interleukin; TNF-α, Tumour Necrosis Factor alpha; CuONPs, Copper oxide nanoparticles; COX-2, Cyclooxygenase 2; hPBMCs, Pooled human peripheral blood mononuclear cells; AIDS, Acquired immune deficiency syndrome; HIV, Human immunodeficiency virus.

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headings like bioactive molecules of *Justicia gendarussa*, pharmacological activities of herbal plant, medicinal values of natural herbs etc. Plant parts with similar pharmacological and therapeutic effects were combined and the isolated bioactive and phytochemical constituents were grouped for tailoring the study. This provided a clear path to the study and helped to organize the work much easier.

Taxonomy

The taxonomy of *Justicia gendarussa* places it in the plant kingdom and the phylum *Tracheophytes*, which includes all vascular plants. It belongs to the class Angiosperms, which are flowering plants, and the order *Lamiales*, which includes many species of medicinal and ornamental plants. Its family is *Acanthaceae*, which is a large family of flowering plants that are commonly found in the tropics and subtropics.

Chemical constituents

The plant is rich in chemical constituents such as alkaloids, flavonoids, tannins, saponins, phenolic, and essential oils Fig. 2. [6–12].

Alkaloids

Justicia gendarussa contains various alkaloids, including Justridisamide A, Justridisamide B, Justridisamide C and Justridisamide D. These alkaloids possess various biological activities.

Brazoides A-D, along with squalene, β-sitosterol, and lupeol, were isolated from Justicia gendarussa leaves, comprising a set of four new alkaloids and three known substances. [91]

Flavonoids

Flavonoids are one of the most abundant chemical constituents in Justicia gendarussa. The plant contains various flavonoids, including quercetin, kaempferol, Naringenin and apigenin. These flavonoids possess various biological activities.

Saponins

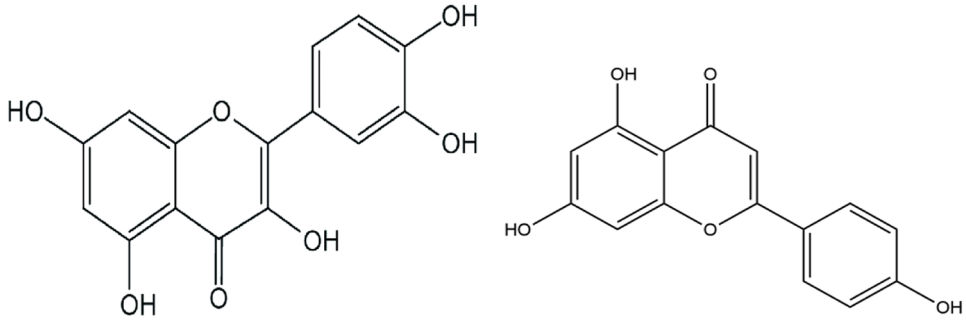
Justicia gendarussa contains saponins, which are glycosides with a steroid or triterpenoid aglycone. The plant contains various saponins, including gendarussin B, gendarussin C, and gendarussin D. other than this Lupeol, beta sitosterol and stigmasterol. These saponins possess various biological activities.

Aromatic amines

Justicia gendarussa contain amines including 2-(2′ amino- benzyl amino) benzyl alcohol and their respective O- methyl ether, 2- amino benzyl alcohol. These amines possess various biological activities.

Fatty acid

Justicia gendarussa contains various fatty acids including oleic acid, 9,12 octadecadienoic acid, 6,9,12- octadecadienoic acid and estra-1,3,5 (10)-trin- 17- beta -ol.



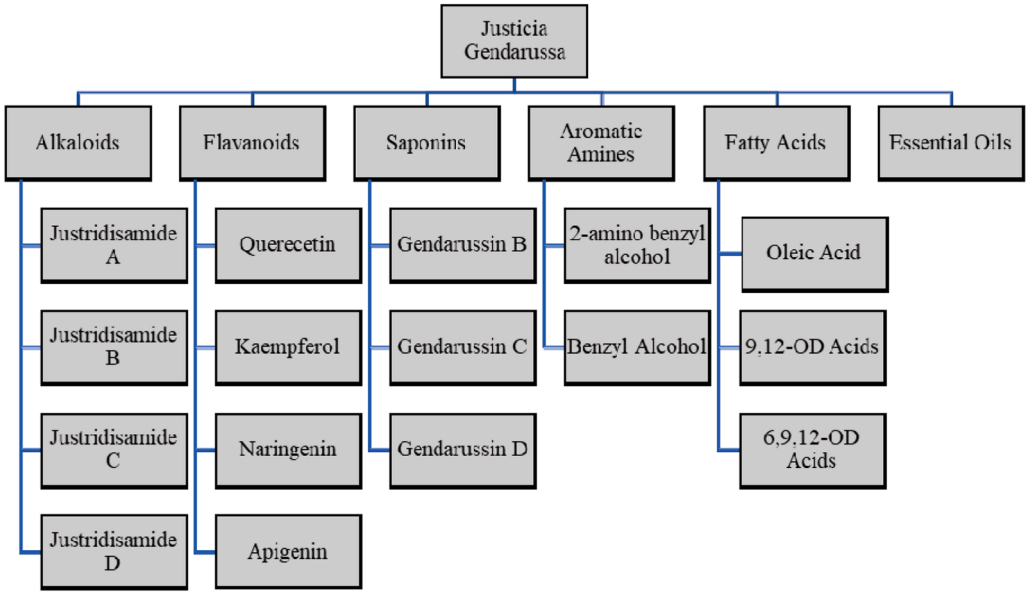


Fig. 1. Classification of *Justicia Gendarussa's* phytoconstitutents.

Essential oils

Justicia gendarussa also contains essential oils, which are volatile compounds with a strong aroma. These essential oils possess various biological activities.

Others

Three novel compounds (1–3) and six previously identified compounds (4–9) were obtained from the ethyl acetate fraction of the ethanol extract derived from the aerial parts of Justicia gendarussa Burm.f. The antioxidant and anti-inflammatory capabilities of compounds 1–9 were assessed, revealing that compounds 5 and 8 exhibit antioxidant properties, while compounds 2 and 3 display anti-inflammatory activity [90] Fig. 1.

Pharmacological activity of Justicia gendarussa

Antioxidant activity

Justicia gendarussa methanolic extract revealing Antioxidant activity by reducing ferric ion and hydrogen peroxide scavenging activity. Besides *Justicia gendarussa* stem methanol extract callus produced highest reducing capacity and scavenging activity [6].Another study evaluated the effect of *Justicia gendarussa* leaf extract on the oxidative stress induced by hydrogen peroxide in human keratinocytes. The results showed that the extract was able to reduce the levels of Reactive oxygen species (ROS) and lipid peroxidation and increase the activity of antioxidant enzymes such as catalase and superoxide dismutase [13–14]. Thus, the information successfully demonstrates the ability of *Justicia gendarussa* in antioxidants activities. And pharmacokinetics activity of the *Justicia Gendarussa's* chemical components are valuable as shown in Table 1.

Anti-fungal

The majority of these infections are caused by dermatophytes which are currently grouped into six pathogenic genera which is *Microsporum, Trichophyton, Epidermophyton, Nannizzia, Lophophyton*, and *Arthroderma* [16]. The development of innovative antifungal chemotherapeutics is attracted by the potential of herbal medicines. Some studies suggest that *Justicia gendarussa* has promising antifungal activity against dermatophytes, which may be due to its ability to disrupt the fungal cell membrane and the presence of various bioactive compounds. [15–17]

One study found that the chloroform extract of *Justicia gendarussa* exhibited significant antifungal activity against various dermatophytes, including *Trichophyton mentagrophytes, Microsporumcanis*, and *Epidermophyton floccosum*. The study also suggested that the antifungal activity of *Justicia gendarussa* may be due to its ability to disrupt the fungal cell membrane. However future studies are necessary for more evaluation of this plant [18].

Anti-arthritis

Arthritis affects one in five older people worldwide. It is a systemic autoimmune disease characterized by chronic, inflammatory condition leads to pain, tenderness, swelling, and decreased function of joints although the specific pathophysiology is unknown but certain release free radicals like nitrous oxide and superoxide radicals that are by-products of cellular metabolism. The release of these free radicals may produce interleukins (IL) and tumor necrosis factor (TNF-α) from T-cells which may affect the production of growth factors, cytokines and adhesive molecules on immune cells as such factors may cause tissue destruction and inflammation. Consequences of long-term usage of currently available anti-arthritic medications include myelosuppression, renal impairment, cardiovascular problems, and gastrointestinal complaints. Fortunately, Nature provides a cure for this illness, and there are several herbs that alleviate chronic joint inflammation in a synergistic manner, including Rheumatoid arthritis. herbal therapy has proven to be secure and efficient enough to treat rheumatoid arthritis [19–21].

Some scientific studies showed the anti-arthritis activity of plant-*Justiciagendarussa.* One study found that the ethanolic extract of *Justicia gendarussa* leaves exhibited significant anti-arthritic activity in rats with adjuvant-induced arthritis. The study showed that the extract significantly reduced paw edema, joint stiffness, and pain in the rats, indicating its potential use in the treatment of arthritis. The entire plant has been employed as a traditional medicinal remedy in regions of China, such as Guangdong, Guangxi, and Taiwan, for addressing injuries and rheumatic conditions [22].

Cardioprotective

Cardiovascular disease (CVD) is becoming leading cause of death. CVD is referred as heart and blood vessel condition. It consists of peripheral arterial disease (PAD), coronary heart disease (CHD), angina, myocardial infarction (MI) and congestive heart failure (CHF) [23]. These diseases can protect by medicinal plants in various ways. They can reduce chronic inflammation and oxidative stress, lower blood pressure and cholesterol levels, and improve the function of the endothelium, which is the inner lining of blood vessels [24]. Despite reports of the use of *Justicia gendarussa* in cardiac diseases and it's cardioprotective properties due to presence of flavonoids. It possesses a biological activity like cardioprotective.

Apigenina naturally occurring flavonoid has a strong cardioprotective effect. According to a study the ethanolic extract of *Justicia gendarussa* show a protective effect by oxidationreduction of two enzymes activities, superoxide dismutase (SOD) and catalase activities against the toxicity of doxorubicin (DOX) in cardiomyocytes [25].

According to another study the *Justicia gendarussa*'smethanolic extract showed significant thrombolytic activity as evidenced by clot lysis for the pet ether and carbon tetrachloride soluble fractions [26]. Apart from this another study show that the Treatment with *Centella asiatica, Justicia gendarussa and Imperata cylindrica* (CJI) decoction reduces spontaneously hypertensive rats (SHRs)' thoracic aortic oxidative stress response via controlling the NOXs-ROS-NF-B signaling pathway. These results suggest that CJI has a protective impact on SHR vascular

Table 1
Pharmacokinetics of *Justicia Gendarussa's* chemical components.

S. No.	Compound	Absorption	Distribution	Metabolism	Metabolites	Excretion	Bioavailability	References
1.	Quercetin	Rapid	Widely distributed	Extensive (mainly in liver)	Quercetin glucuronide Quercetin sulfate	Primarily in urine	Low	76,77
2.	Apigenin	Rapid	Widely distributed	Extensive (mainly in liver)	Apigenin glucuronide Apigenin sulfate	Primarily in urine	Low to moderate	78,79
3.	Naringenin	Rapid	Widely distributed	Extensive (mainly in liver)	Naringenin lucuronide Naringenin sulfate	Primarily in urine	Low to moderate	80,81
4.	Kaempferol	Rapid	Widely distributed	Extensive (mainly in liver)	Kaempferol glucuronide Kaempferol sulfate	Primarily in urine	Low to moderate	82,83
5.	Oleic acid	Rapid	Widely distributed	Extensive (mainly in liver)	Metabolite to various lipid specie	Primarily in urine	High	84,85
6.	Sitosterol	Variabke	Widely distributed	Extensive (mainly in liver)	Sitosterol glucuronide Sitosterol sulfate	Primarily in faces	Low to moderate	86,87

remodeling brought on by hypertension [14].

Antibacterial and antimicrobial activities

The most common infectious diseases in the world are bacterial infections brought on by opportunistic pathogens or invasive pathogenic bacteria. These infections can lead to a variety of illnesses, including pneumonia, periodontitis, TB, conjunctivitis, gastroenteritis, and sepsis [27].

The mechanism of bacterial infection involves a series of steps, beginning with the ability of the bacteria to overcome the body's natural defences, such as the skin and mucous membranes. Once the bacteria enter the body, they can attach themselves to host cells using structures like pili and fimbriae, allowing them to invade and infect the host. Bacteria can then produce harmful toxins or enzymes, which can damage tissues and interfere with normal cellular function. The immune system will usually respond to the infection by producing white blood cells, which can recognize and destroy the invading bacteria. However, some bacteria can evade the immune system, leading to chronic or recurrent infections [28].

Since old time herbal treatment help to fight bacterial infection naturally due to presence of phytochemicals. The plant *Justicia gendarussa* leaves have important phytochemicals include O-di-substituted aromatic amines, 2-aminobenzyl alcohol, O methyl ethers, friedelin, lupeol, and -sitosterol. Recent years have seen an increase in research into their antibacterial properties. According to a research study the better zone of inhibition against *E. coli* and *Bacillus subtilis* was seen with methanol fractions of *Justicia gendarussa*. The eight bacteria under test were inhibited by all *Justicia gendarussa* extracts (hexane, diethyl ether, dichloromethane, ethyl acetate and methanol). Its antibacterial activity and the greatest inhibition of *Bacillus subtilis* and *E. coli* could be attributed to several chemicals found in the plant [29–30].

Another study shows that the *Justicia gendarussa* was able to rooting and produce biomass by using a hydroponic culture technique. The collected biomass of leaves, stems, and roots were tested for antibacterial activity against a variety of human pathogenic organisms, including *Staphylococcus aureus, E. coli, Shigella* sp., *Pseudomonas* sp., *and Klebsiella pneumoniae. Justicia gendarussa* root methanolic extract had an effect on *E. coli*. Leaf extract prevented the growth of *Shigella* sp., *Pseudomonas sp*., and *K pneumonia*. The treatment with stem extract showed the largest inhibition zone against *S. aureus* [31].*In-vitro* study show by using the Agar well diffusion method, *Justicia gendarussa* leaf extract's antibacterial testing was assessed and the results showed that leaf extracts in ethanol and ethyl acetate had substantial antibacterial activity [32].

According to a study *Justicia gendarussa* show antibacterial properties against microorganisms, *Pseudomonas vulgaris* and *Pseudomonas pneumonia* [33]. Other study, when copper oxide nanoparticles (CuONPs) were functionalized using *Justicia gendarussa* leaf extract, the Gram-negative and Gram-positive pathogens were both susceptible to the bactericidal effects of the CuONPs [34].

Hepatoprotective

Hepatotoxicity is a major global public health concern. Liver diseases are characterised by a variety of pathological characteristics, such as non-inflammatory (hepatitis), inflammatory (acute or chronic hepatitis), and tumorous (hepatic adenoma or hepatocellular carcinoma) disorders. Hepatotoxicity and other disorders are frequently treated using medicinal plants because they are efficient, affordable, and secure [35].

According to a study the leaf extract of *Justicia gendarussa* possesses mild hepatoprotective effect, which may be attributed to its antioxidant and free radical scavenging potential. Its hepatoprotective and antioxidant properties are due to its high total phenolic and flavonoid content. To determine the precise phytochemical (s) and their mechanism behind *Justicia gendarussa*'s hepatoprotective potential, more research is needed [36]. According to an*In-vivo* study, the methanol extract of *Justicia gendarussa* leaf (JGMe) exhibits a significant protective effect against the negative effects of carbofuran (CF) in the hepatocellular cell, which could reduce oxidative damage as demonstrated by the histopathological and biochemical findings [37].

Anti-helminthic

Helminths have established many mechanisms that cause immunological suppression or hypo responsiveness in their hosts among these mechanisms the common mechanisms are to promote the induction of regulatory T-cells (Tregs). These Treg expansion not only improves parasite survival but also helps to avert diseases that are linked to parasites in filarial infection Moreover, Tregs produced by helminth infection have been linked to the inhibition of bystander immune-pathologies in a variety of inflammatory disorders, including allergies and autoimmune illness [38–39].

Consequently, helminthic diseases, can be treated with medicinal herbs because herbal therapy may have fewer adverse effects [40]. Herbs produced many secondary metabolites including alkaloids, flavonoids, chalcones, coumarins, terpenoids, and tannins which exhibit many biological activities including anti-helminthic activity [41]. Some isolation study show that these secondary metabolites found in plant *Justicia gendarussa* which resulted to treat helminthic infection.

In-vitro experiment study examined the plant contains stigmasterol, lupeol and 16-hydroxylupeol.The methanol extract of *Justicia gendarussa* leaves at a concentration of 50 mg/ml, which is responsible for paralysis and death of the worm *Pheretimaposthuma* and also the Methanolic extract of *Justicia gendarussa* stem at same concentration cause paralysis and death of worm *Pheretimaposthuma*. However more study should be evaluated for this activity [42] Fig. 2.

Anti-inflammatory activity

Justicia gendarussa has been utilised as a preventive measure for treating inflammatory illnesses for centuries. In Chinese traditional medicine, *Justicia gendarussa* is employed to address conditions such as arthritis, muscle pain, respiratory issues, bronchitis by reducing inflammation [92] *Justicia gendarussa* show anti-inflammatory activity through inhibiting of iNOS and cyclooxygenase-2 (COX-2) expression via NF-KB pathways. The studies showed inflammation reducing abilities of *Justicia gendarussa* for medicinal use. *In-vivo* study, an ethyl acetate fraction obtained from methanolic extracts of *Justicia gendarussa* roots show its anti-inflammatory activity, by suppressing the release of nuclear factor kappa B, cyclooxygenase, 5-lipoxygenase, interlukin-6 and COX in the bacteriallipo-polysaccharide stimulated (LPS) human peripheral blood mononuclear cells (hPBMCs) [43–44].

Apigenin is a bioflavonoid of*Justicia gendarussa*, show its anti-inflammatory activity via reducing the level of toll-like receptor 4, myeloid differentiation primary response-88 (MyD88), TIR-domain-containing adapter-inducing interferon-BETA (TRIF), tumor necrosis factor receptor associated factor6 (TRAF6),NF-KB,COX-2, prostaglandin E2 (PGE2), interleukin −1 (IL-1BETA) and tumor necrosis factor (TNF-ALPHA). In vitro study, apigenin show its anti-inflammatory property via pre-treatment inoxidized low-density lipoprotein (Ox-LDL) induced hPBMCs [45].

According to another study, beta-sitosterol chloroform extraction of *Justicia gendarussa*, exhibits more potent anti-inflammatory effect via producing histamine, bradykinin, prostaglandin, serotonin, when it compared to the standard diclofenac [46].*Justiciagendarussa's* methanolic leaf extract has strong anti-inflammatory properties because it prevents the release of prostaglandins or other inflammatory mediators from cell membrane by stabilizing membrane. Both gram-negative and gram-positive bacteria were suspectable to the antibacterial effects of the methanolic extract of *Justicia gendarussa* leaves [47]. *Justicia gendarussas* how specific pharmacological action to treat the diseases.

Anti-cancer activity

The illness or group of illnesses known as cancer is mysterious and terrifying. Multicellular living things have been affected by cancer around 200 million years ago, and there is evidence that malignancies

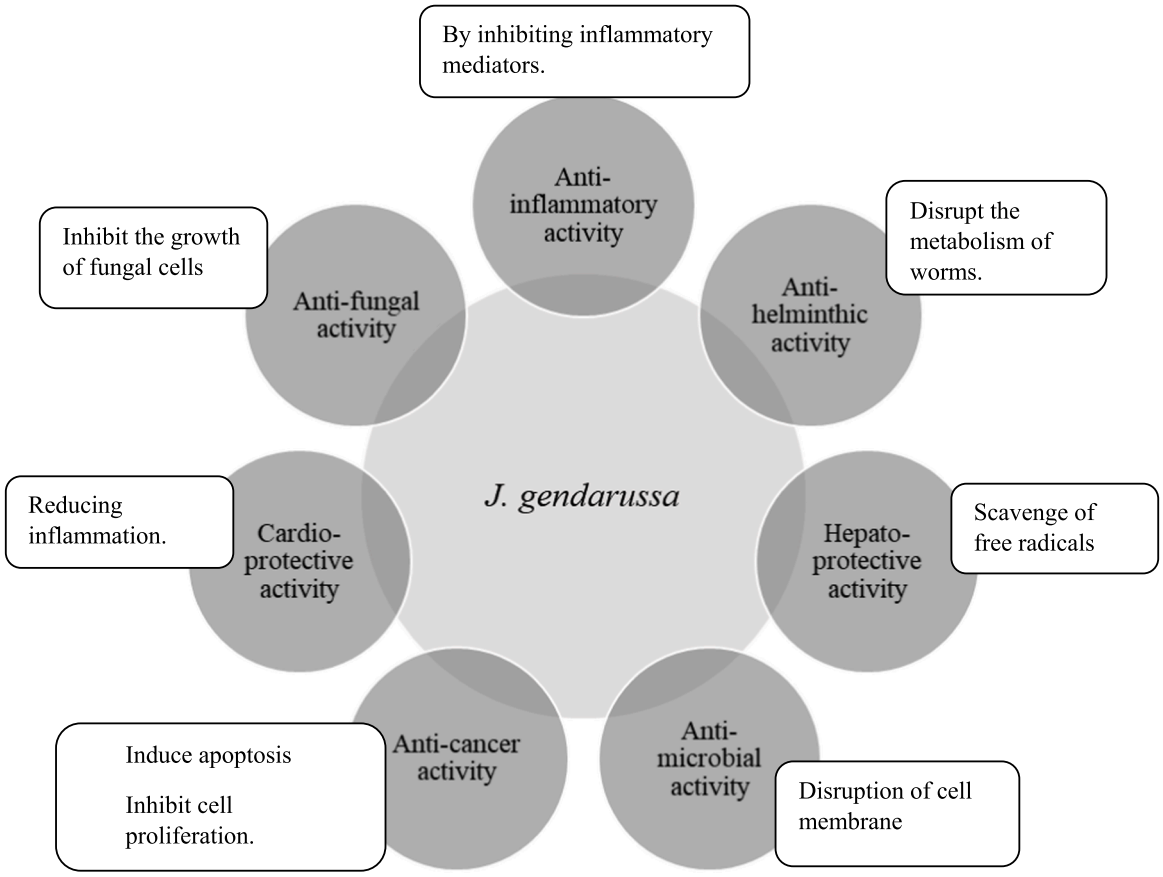


Fig. 2. Pharmacology activity and its mechanism of *Justicia Gendarussa.*

occurred among the ancestors of contemporary humans well over a million years ago.Cancer is not largely brought on by an outside agent, unlike infectious diseases, parasites, and many environmental diseases. Its destructive agents are human cells that have, in a sense, let go of their control and have been recruited or, to some extent, changed into pathological organisms or the nuclei of tumours [48].

Previous studies show that *Justicia gendarussa* is one of the possible medicinal plants that could be used to treat breast cancer. This is the most prevalent malignancy in women and the second-largest cancer in the world after lung cancer. *Justicia gendarussa*'s methanolic leaf and root extracts shown cytotoxic action against brine shrimp in the brine shrimp lethality assay, with IC50 values of 48.71 g/mL and 93.25 g/mL, respectively [49].

Anti-HIV activities

A condition known as AIDS is brought on by the HIV retrovirus, which weakens the human immune system. HIV infection leads to a significant number of deaths worldwide [50]. HIV is a member of the Retroviridae family's Lenti virus genus and is related to it genetically. Currently, the HIV isolates are divided into HIV-1 and HIV-2. Although AIDS could be caused by either virus, HIV-2 infection may be more probably lead to central nervous system illness. Additionally, HIV-2 seems to have lower severity than HIV-1, and the development of AIDS takes longer after infection [51].

HIV anti-retroviral medications have issues with unpleasant side effects that put HIV patients' lives in peril. It has been empirically demonstrated that a number of herbs can inhibit reverse transcriptase to help eradicate HIV. *Justicia gendarussa* is one such antiviral plant whichmay prove to be a valuable source for treating HIV infections. It was discovered that the anti-HIV activity of *Justicia gendarussa* as 70%-fractionated extract of ethanol withalkaloid on HIV-infected MOLT-4 cells are higher [52].

Another study shows that Justiprocumins A and B, two anti-HIV substances, were found in a methanol extract of this plant's stems and bark. The substances are novel arylnaphthalide lignans (ANL) glycosides, which are the chemical components that contribute to this plant's anti-HIV effect. justiprocumin B demonstrated strong effectiveness against a variety of HIV strains. Both the NNRTI (non-nucleoside reverse transcriptase inhibitor)-resistant isolate (HIV-1N119) of the analogue (nevaripine) and the NRTI (nucleoside reverse transcriptase inhibitor)-resistant isolate (HIV-11617–1) of the analogue (AZT) were effectively inhibited by the substance [53]. Another study shows that *Justicia gendarussa* may have anti-HIV properties by examining the impact of incubation time on the antiviral activity of a 70% ethanol extract of the plant's leaves on HIV-infected MT-4 cells in vitro [54]. Another study shows Twenty Thai medicinal herbs used to cure AIDS to inhibit HIV type 1 reverse transcriptase [55,89].

Antianemic activity

Sickle cell disease or drepanocytes is one of the most common causes of morbidity and mortality in people with African, Caribbean, South, Central American, Arab, and East Indian ancestry. SCD is a painful condition caused by a genetic mutation that causes a polar amino acid (glutamic acid) to be replaced by a nonpolar one (valine) on the sixth position of the beta-globin chain. By this modification the affinity of hemoglobin for oxygen is reduced. Additionally, this structural modification affects the solubility of hemoglobin, causing abnormal hemoglobin, hemoglobin S (HbS), to polymerize inside erythrocytes into a gel or further into fibres, alterations of RBCs from the typical biconcave form into the sickle form in hypoxic conditions. The HbS polymerization and the sickling of the RBC are regions for sickle cell disease. Numerous medications that are available to treat the condition are either

poisonous, prohibitively expensive, or insufficiently effective [56–58].

Justicia gendarussa is one of the among medicinal plants show anti sickling activities. *Justicia gendarussa* plants are used in place of costly and harmful medications or treatments for sickle cell anemia. This study shows that anthocyanin chemicals contribute to anti-sickling activity. The anthocyanin concentrations in the leaves of the *willow-leaved justicia* plant were 0.44 g/ml, 87.1%, and 7.6 g/ml, respectively, for ED50, NRmax, and MCN. The absorbance value, which fell by 28% from 1.80 to 1.30 in 60 minutes, demonstrates that this anthocyanin promotes hemolysis of drepanocytes. This study suggest that this plant's anthocyanins have antihemolytic activity in sickle cell anemia erythrocytes [59,60].

Anti-anxiety activity

According to estimates from the 1990s, anxiety impacted 26.9 million people. Anxiety affects the ability to pay attention, learn, think critically, digest information, and succeed academically or at work. Additionally, it has been shown that anxiety affects blood pressure, the ability to withstand discomfort, stress levels, and immune system activity and also anxiety effects decision-making, high alcohol intake, migraines, skin disorders (particularly psoriasis and atypical dermatitis), and post-event unpleasant ruminating. It is a predictor of depression. [61–65]. The key targets of the mechanisms causing anxiety disorders are the immunological, neurotransmitter, and neuroendocrine systems [66].

Globally, there is a lot of concern about the investigation of novel medications for the therapy of anxiety. A possible source of new remedy as anxiolytic is medicinal plants [67]. *Justicia gendarussa* is an effective plant in anti-anxiety disorder according to a study the plant extract of *Justicia gendarussa* was tested for anti-anxiety screening examinations at different doses, in an effort to confirm the validity of its historical use anxiety disorder. EJG increased the length of time spent in the elevated plus-maze and the number of arm entries when given orally in two different doses. It also increased the length of time spent by mice in the illuminated side of the light-dark test and significantly decreased the freezing time when compared to control animals. This study showed that the Justicia *gendarussa*'s ethanolic extract effectively reduces anxiety [68].

Hyperuricemia activity

Hyperuricemia is caused by impaired renal uric acid excretion and uric acid overproduction. Xanthine Oxidase (XO) catalyses the conversion of hypoxanthine and xanthine to uric acid in the purine catabolic pathway. Medications that block the activity of xanthine oxidase are frequently used in the relief of excessive urine production [69]. It is thought to be a significant contributor to the development of numerous long-termillnesses, such as malignant tumours, cardiovascular problems, and renal failure, as well as a powerful risk factor for gout [70,71].

In studies using rats with oxonate-induced hyperuricemia, ethanol extract from Justicia gendarussa leaves dramatically lowers the plasma level of uric acid. In rats with hyperuricemia, the test material can lower blood uric acid levels, the extract shown its peak activity [72].

Larvicidal activity

Mosquitoes transmit infections that result in diseases such as Filariasis, Dengue, Chikungunya, Japanese encephalitis, and malaria in humans. Malaria is spread throughout India's plains, both in rural and urban regions, by the larvae of the *Anopheles stephensi* malaria vector. 2020 million people worldwide, or 36% of the world's population, suffer from malaria, which is prevalent in 107 tropical and subtropical nations and territories. Recently, natural plant-based treatments with insecticidal characteristics have been tested to manage a variety of insect pests and vectors. Plants are thought to be a rich source of bioactive compounds and could serve as an alternate source of insect repellents. Natural materials are typically favoured because of their inherent biodegradability and the fact that they are less toxic to creatures other than the target ones [73,74].

According to a study *Justicia gendarussa's* leaves had larvicidal and adulticidal effects on *Anopheles stephensi* and to be utilised as inexpensive mosquito medication.The larval death rates of the *Justicia gendarussa* ethanol extract was 55.6%, mortality was 19.3%, and 25.1% of the adults were deformed [75].

Limitation

This study has some limitations because not verified research data's for claimed therapeutically actions of this herbs. Tough it is used as folk medicine, no clinical study has been conducted to evaluate the efficacy or to evaluate the toxic potential of *Justicia gendarussa*. Inadequate education of clinicians and patients regarding medicinal properties of *Justicia gendarussa*must be addressed regionally and globally to ensure consumer safety.

Conclusion

Justicia gendarussa is a plant species that has been traditionally used for medicinal purposes in Chinese medicine system. It has been reported to have a wide range of biological activities, including antibacterial, antifungal, antiviral, anti-inflammatory, and antioxidant properties. Research on the potential health benefits of *Justicia gendarussa* is still in its early stages, and further studies are needed to fully understand its medicinal properties and potential applications. However, the available scientific evidence suggests that this plant has significant therapeutic potential and could be a valuable source of natural remedies for various health conditions.*Justicia gendarussa* is a promising plant species that merits further scientific investigation to fully explore its potential health benefits and therapeutic applications.

CRediT authorship contribution statement

Tanya Jain: Writing – review & editing. **Manish Pal Singh:** Writing – original draft. **Harsh Bhardwaj:** Formal analysis. **Kashmira J. Gohil:** Writing – review & editing, Formal analysis, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] S. Patel, K. Nayana, S. Bakula, S. Mamta, Botanical identification and physicochemical investigation of leaf of Nili-Nirgundi (Justicia Gendarussa), I.J.P.R. (2011) 116–121.
[2] T. Dennis Thomas, H. Yoiochiro, In vitro propagation for the conservation of a rare medical plant Justicia Gendarussa Burm. F. by nodal explants and shoot regeneration from callus, Acta Physiol. Plant. 32950 (2010) 943–950.
[3] P. Indrayoni, D. Purwanti, S. Wongso, B. Prajogo, G. Indrayanto, Metabolite profiles in various plant organs of Justicia Gendarussa Burm. F. and its in vitro cultures, Sci. Pharm. 84 (3) (2016) 555–566.
[4] S. Chandra, D. Lo, A review on the bioactivities of Justicia Gendarussa, EES. 794 (1) (2021), 012137.
[5] N. Subramanian, C. Jothimanivannan, D.M. Kannaiyan, Antimicrobial activity and preliminary phytochemical screening of Justicia gendarussa (Burm. f.) against human pathogens, Asian J.Pharm. Clin. Res. (2012) 229–233.
[6] K. Kavitha; K.S. Sridevi Sangeetha; K. Sujatha; S. Umamaheswari. Phytochemical and pharmacological profile of Justicia Gendarussa Burm F. - review. 2016, 990–997.
[7] K. Pal, C.H. Rahaman, Phytochemical and antioxidant studies of Justicia Gendarussa Burm. F. an ethnomedicinal plant, Int. J. Pharm. Sci. Res. (2015).
[8] D. Yadav, M.S. Reshi, C. Uthra, S. Shrivastava, N. Srivastava, S.K.K. Narayana, S. Shukla, Botanical and chemical fingerprinting of medicinal roots of Justicia Gendarussa Burm F, Pharmacognosy Res. 9 (2) (2017) 208–214.
[9] A.V. Putri, Zulharmita, R. Asra, C. Boy, Overview of phtochemical and pharmacological of Gendarussa Extract (Justicia Gendarussa Burm), EAS. J. Pharm. Pharmacol. (2020) 2663. -0990.

[10] G. Shamili, G. Santhi, Identification and characterization of bioactive compounds of leaves of Justicia Gendarussa Burm, F. Int. J. Sci. Res. Bio. Sci. 6 (1) (2019) 145–153.
[11] F. Assola, Silva, A.A. Borghi, M.G. Lusa, A. Christine, V.L. Garcia, J. Lischka, Morphoanatomical characteristics, chemical profiles, and antioxidant activity of three species of Justicia L.(Acanthaceae) under different growth conditions, Ind. Crops Prod. 131 (2019) 257–265.
[12] R. Sinansari; B. PrajogoEw; P. Widiyanti. In silico screening and biological evaluation of the compounds of Justicia Gendarussa leaves extract as interferon gamma inducer: a study of anti-human immunodeficiency virus (hiv) development. 2018, 12 (1 Suppl), 140–147.
[13] J. Patel Chiraag, S. Tyagi, N. Halligudi, J. Yadav, Yadav, S. Pathak, S.P. Singh, A. Pandey, D.S. Kambo, P. Shankar, Antioxidant activity of herbal plants: a recent review, J. Drug Discov. Ther. (2013).
[14] Sulistyowati, E.; Chang, Y.-S.; Liou, S.-F.; Chen, Y.-F.; Wu, B.-N.; Hsu, J.-H.; Yeh, J.-L. Vasculoprotective effects of Centella asiatica, Justicia gendarussa and Imperata cylindrica decoction via the NOXs-ROS-NF-KB pathway in spontaneously hypertensive rats. 2020.
[15] F. Bongomin, S. Gago, R. Oladele, D. Denning, Global and multi-national prevalence of fungal diseases—estimate precision, J. Fungi. 3 (4) (2017) 57.
[16] J. Begum, N.A. Mir, M.C. Lingaraju, B. Buyamayum, K. Dev, Recent advances in the diagnosis of dermatophytosis, J. Basic Microbiol. 60 (4) (2020) 293–303.
[17] W. Noé, S. Murhekar, A. White, C. Davis, I.E. Cock, Inhibition of the growth of human dermatophytic pathogens by selected Australian and Asian plants traditionally used to treat fungal infections, J.M.M. 29 (4) (2019) 331–344.
[18] K.K. Sharma, S. Rubul, J. Kotoky, J. Kalita, R. Devi, Antifungal activity of Solanum melongena L, Lawsoniainermis L. and Justicia gendarussa B. against dermatophytes, Int. J. Pharm. Tech. Res. (2011) 1635–1640.
[19] G. Murugananthan, G. Sudheer Kumar, P. Sathya Chethan, S. Mohan, Anti-arthritic and anti-inflammatory constituents from medicinal plants, J. Appl. Pharm. Sci. (2013) 161–164.
[20] R.K. Gautam, K. Roy, G. Thapa, D. Arora, S. Parashar, L. Deb, B. G, Perspective of plant medicine in therapy of rheumatoid arthritis, Indian J. Pharm. Sci. (5) (2020) 82.
[21] M. Choudhary, V. Kumar, H. Malhotra, S. Singh, Medicinal plants with potential anti-arthritic activity, J. Intercult. Ethnopharmacol. 4 (2) (2015) 147.
[22] Paval, J.; Kaitheri, S.K.; Potu, B.K.; Govindan, S.; Kumar, R.S.; Narayanan, S.N.; Moorkoth, S. Anti-arthritic potential of the plant Justicia Gendarussa Burm F., 2009, 64 (4), 357–362.
[23] Khan, I.A.; Hussain, M.; Hussain, N.; Alqahtani, A.M.; Alqahtani, T. Cardioprotective effect of Rumex Vesicarius Linn. leaf extract against catecholamine-induced cardiotoxicity, 2022, 27 (11), 3383.
[24] Shah, S.M.A.; Akram, M.; Riaz, M.; Munir, N.; Rasool, G. Cardioprotective potential of plant-derived molecules: a scientific and medicinal approach, 2019, 17 (2), 155932581985224.
[25] P.K. S, F.P. Vijayan, C.M. Pareeth, J. Padikkala, T.D Babu, Cardioprotective effect of Justicia Gendarussa on doxorubicin induced toxicity in mice, J.B.C.P.P. (2022).
[26] M.A.A. Sikder, A.B. Siddique, A.K.M.N. Hossian, M.K. Miah, M.A. Kaisar, M. A. Rashid, Evaluation of thrombolytic activity of four Bangladeshi medicinal plants, as a possible renewable source for thrombolytic compounds, J. Pharm. Nutr. Sci. (2022).
[27] N. Liu, X. Pang, H. Zhang, P. Ji, The CGAS-STING pathway in bacterial infection and bacterial immunity, Fronti. Immunol. (2022).
[28] Doron, S.; Gorbach, S.L. Bacterial infections: overview, 2008, 273–282.
[29] G. Yuan, Y. Guan, H. Yi, S. Lai, Y. Sun, S. Cao, Antibacterial activity and mechanism of plant flavonoids to gram-positive bacteria predicted from their lipophilicities, Sci. Rep. 11 (1) (2021) 10471.
[30] S. Nirmalraj, Mani Ravikumar, M. Mahendrakumar, B. Bharath, P. Kanthraj, Antibacterial and anti-inflammatory activity of Justicia gendarussa Burm, F. Leaves. J. plant Sci. (2015) 70–74.
[31] P. Sugumaran, N. Kowsalya, R. Karthic, S. Seshadri, Biomass production and antibacterial activity of Justicia Gendarussa Burm. F. - a valuable medicinal plant, J. Trop. Life Sci. 3 (1) (2013) 8–13.
[32] Reddy, Y.S.; Anitha G.;Nagulu, M.; Reddy, M.; Prasad, P.;Sweth, M.; Kumar, V.; Reddy, G.P. In vitro antibacterial activity of leaf extracts of justicia gendarussa wild, 2013, 101–103.
[33] S. Murugesan, Phytochemical evaluation, GC–MS analysis of bioactive comp-55ounds and antibacterial activity studies from Justicia gendarussa Burm, F. Leaf. Int. J. Pharmacogn. Phytochem. (2017) 400–406.
[34] Vasantharaj, S.; Shivakumar, P.; Sathiyavimal, S.; Senthilkumar, P.; Vijayaram, S.; Shanmugavel, M.; Pugazhendhi, A. Antibacterial activity and photocatalytic dye degradation of copper oxide nanoparticles (CuONPs) using Justicia Gendarussa, 2021.
[35] B.A. Venmathi Maran, M. Iqbal, P. Gangadaran, B.-C. Ahn, P.V. Rao, M.D. Shah, Hepatoprotective potential of Malaysian medicinal plants: a review on phytochemicals, oxidative stress, and antioxidant mechanisms 27 (5) (2022) 1533.
[36] K.L. Krishna, K. Mruthunjay, J.A. Patel, Antioxidant and hepatoprotective activity of leaf extract of Justicia Gendarussa Burm, Int. J. Biol. Chem. 3 (3) (2009) 99–110.
[37] Mondal, M.; Hossain, M.; M.M. Rahman; Saha, S.; Uddin, N.; M.R. Hasan; M.A. Kader; T.B. Wahed; S.K. Kundu; M.N. Islam; Mubarak, M.S. Hepatoprotective and antioxidant activities of Justicia Gendarussa leaf extract in carbofuran-induced hepatic damage in rats, 2019, 32 (12), 2499–2508.
[38] B. Bharti, S. Bharti, S. Khurana, Worm infestation: diagnosis, treatment and prevention, I.J.P 85 (11) (2018) 1017–1024.
[39] M.P.J. White, C.M. McManus, R.M. Maizels, Regulatory T-Cells in Helminth infection: induction, Funct. Therap. Potential 160 (3) (2020) 248–260.
[40] N. Bizhani. Herbal therapy and treatment of worm infections, emphasizing Taenia Solium. 2015, 44 (11), 1555–1556.
[41] Jayawardene, K.L.T.D.; Palombo, E.A.; Boag, P.R. Natural products are a promising source for anthelmintic drug discovery, 2021, 11 (10), 1457.
[42] M.R. Saha, P.C. debnath, M.A. Rahman, M.A.U. Islam, Evaluation of in vitro anthelmintic activities of leaf and stem extracts of Justicia gendarussa, bangladesh J. pharmacol. 7 (1) (2012).
[43] Chen, L.; Deng, H.; Cui, H.; Fang, J.; Zuo, Z.; Deng, J.; Li, Y.; Wang, X.; Zhao, L. Inflammatory responses and inflammation-associated diseases in organs, 2018, 9 (6), 7204–7218.
[44] K.S. Kumar, V. Vijayan, S. Bhaskar, K. Krishnan, V. Shalini, A. Helen, Anti-inflammatory potential of an ethyl acetate fraction isolated from Justicia gendarussa roots through inhibition of INOS and COX-2 expression via NF-KB Pathway, Cell. Immunol. 272 (2) (2012) 283–289.
[45] K.S. Kumar, V. Sabu, G. Sindhu, A.A. Rauf, A. Helen, Isolation, identification and characterization of apigenin from Justicia Gendarussa and its anti-inflammatory activity, Int. Immunopharmacol. 59 (2018) 157–167.
[46] N.D. Phatangare, K.K. Deshmukh, V.D. Murade, P.H. Naikwadi, D.P. Hase, M. J. Chavhan, H.E. Velis, Isolation and characterization of β-sitosterol from Justicia Gendarussa Burm. F.-an anti-inflammatory compound, Int. J. Pharmacogn. Phytochem. Res. (09) (2017) 9.
[47] Perinbam, K.; Nirmalraj, S.; Ravikumar, M.; Mahendraku, M.; Bharath, B. Antibacterial and anti-inflammatory activity of Justicia Gendarussa Burm. F. leaves, 2015, 10 (2), 70–74.
[48] D.M. Hausman, What is cancer? Perspect. Biol. Med. 62 (4) (2019) 778–784.
[49] Z. Ayob, S.P. Mohd Bohari, A. Abd Samad, S. Jamil, Cytotoxic activities against breast cancer cells of local Justicia gendarussa crude extracts, eCAm 2014 (2014) 1–12.
[50] Reviews and notes: infectious diseases: sherris medical microbiology: an introduction to infectious diseases, Annal. Intern. Med. 122 (11) (1995) 888.
[51] Fanales-Belasio, E.; Raimondo, M.; Suligoi, B.; Buttò, S. H.IV virology and pathogenetic mechanisms of infection: a brief overview, 46 (1).
[52] N.P.E. Hikmawanti, P. Widiyanti, E.W. Prajogo, B. In, Vitro anti-HIV activity of ethanol extract from Gandarusa (Justicia Gendarussa Burm. F) leaves, Infect. Dis. Rep. (2020).
[53] H.-J. Zhang, E. Rumschlag-Booms, Y.-F. Guan, K.-L. Liu, D.-Y. Wang, W.-F. Li, V. H. Nguyen, N.M. Cuong, D.D. Soejarto, H.H.S. Fong, L. Rong, Anti-HIV Diphyllin glycosides from Justicia Gendarussa 136 (2017) 94–100.
[54] Widodo, A.; Widiyanti, P. Antiviral activity of Justicia Gendarussa Burm. F. leaves against HIV- infected MT-4 cells, 2018, 36–43.
[55] W. Woradulayapinij, N. Soonthornchareonnon, C. Wiwat, In vitro HIV type 1 reverse transcriptase inhibitory activities of Thai medicinal plants and Canna Indica L. rhizomes, J. Ethnopharmacol. 101 (1–3) (2005) 84–89.
[56] I.O. Nurain, C.O. Bewaji, J.S. Johnson, R.D. Davenport, Y. Zhang, Potential of three ethnomedicinal plants as antisickling agents, Mol. Pharmaceutics. 14 (1) (2016) 172–182.
[57] J.M. Kitadi, P.P. Mazasa, Damien, F.M. Kasali, D.D. Tshilanda, Koto-te-NyiwaNgbolua, P.T. Mpiana, Ethnopharmacological Survey and Antisickling Activity of Plants Used in the Management of Sickle Cell Disease in Kikwit City, DR Congo, 2020, 2020, pp. 1–10.
[58] Eaton, W.; Hofrichter, J.>Hemoglobin S gelation and sickle cell disease,1987, 70 (5), 1245–1266.
[59] P. Mpiana, Antisickling activity of three species of Justicia from Kisangani (D.R. Congo): J. Tenella, /I>, J. Gendarussa And J. Insularis, I.J.B.C.S. 4 (6) (2011).
[60] D. Nechita, F. Nechita, R. Motorga, A review of the influence the anxiety exerts on human life, Rom. J. Morphol. Embryol., S 59 (2018) 1045–1051.
[61] T.B. Kashdan, J.E. Roberts, Social anxiety, depressive symptoms, and post-event rumination: affective consequences and social contextual influences, J. Anxiety Disord. 21 (3) (2007) 284–301.
[62] Lantéri-Minet, M.; Radat, F.; Chautard, M.-H.; Lucas, C. Anxiety and depression associated with migraine: influence on migraine subjects' disability and quality of life, and acute migraine management,2005, 118 (3), 319–326.
[63] S.R. Lawyer, R.S. Karg, J.G. Murphy, F. Dudley McGlynn, Heavy drinking among college students is influenced by anxiety sensitivity, gender, and contexts for alcohol use, J. Anxiety Disord. 16 (2) (2002) 165–173.
[64] G. Parker, K. Wilhelm, P. Mitchell, M.-P. Austin, J. Roussos, G. Gladstone, The influence of anxiety as a risk to early onset major depression, JAD 52 (1–3) (1999) 11–17.
[65] R. Raghunathan, M.T. Pham, All negative moods are not equal: motivational influences of anxiety and sadness on decision making, Organ. Behav. Hum. Decis. Process. 79 (1) (1999) 56–77.
[66] Advanced in studies on anxiolytic effects of natural flavonoids,2016.
[67] A. Khan, M. Akram, M. Thiruvengadam, M. Daniyal, S.A. Zakki, N. Munir, R. Zainab, M. Heydari, S.H. Mosavat, M. Rebezov, M.A. Shariati, Anti-anxiety properties of selected medicinal plants, Curr. Pharm.Biotechnol. 23 (8) (2022) 1041–1060.
[68] Jothimaniv, C.; Subramania, N.; Kumar, R.S.; Kameshwara, S. Evaluation of anti-anxiety activity of Justicia Gendarussa Burm., 2013, 4 (5), 404–407.
[69] C.-Y. Kuo, E.-S. Kao, K.-C. Chan, H.-J. Lee, T.-F. Huang, C.-J. Wang, Hibiscus Sabdariffa L. extracts reduce serum uric acid levels in oxonate-induced rats, JFF 4 (1) (2012) 375–381.
[70] I.A. Ramallo, S.A. Zacchino, R.L.E. Furlan, A rapid TLC autographic method for the detection of xanthine oxidase inhibitors and superoxide scavengers, PCA 17 (1) (2005) 15–19.
[71] A. Mehmood, L. Zhao, C. Wang, M. Nadeem, A. Raza, N. Ali, A.A. Shah, Management of hyperuricemia through dietary polyphenols as a natural

medicament: a comprehensive review, Crit. Rev. Food Sci. Nutr. 59 (9) (2017) 1433–1455.
[72] K. Basah, B. Elya, J. Amin, M.I. Julian, Activity of ethanolic extract from Justicia Gendarussa Burm. leaves on decreasing the uric acid plasma, Makara J. Sci. (2011).
[73] Abbas, M.G.; Haris, A.; Binyameen, M.; Nazir, A.; Mozūratis, R.; Azeem, M. Chemical composition, larvicidal and repellent activities of wild plant essential oils against Aedes Aegypti, 2022, 12 (1), 8.
[74] C. Kamaraj; Hasan, A.; A. Bagavan; A.A. Zahir; Gandhi Elango; P. Kandan; G. Rajakumar; S. Marimuthu; T. Santhoshkumar. Larvicidal efficacy of medicinal plant extracts against Anopheles Stephensi and Culex Quinquefasciatus (Diptera: culicidae), 2010, 27 (2), 211–219.
[75] N. Senthilkumar, P. Varma, G. Gurusubramanian, Larvicidal and adulticidal activities of some medicinal plants against the malarial vector, Anopheles Stephensi (Liston), Parasitol. Res. 104 (2) (2008) 237–244.
[76] Yang, L.-L.; Xiao, N.; Li, X.-W.; Fan, Y.; Alolga, R.N.; Sun, X.-Y.; Wang, S.-L.; Li, P.; Qi, L.-W. Pharmacokinetic comparison between Quercetin and Quercetin 3-O-β-glucuronide in rats by UHPLC-MS/MS, 2016, 6 (1).
[77] X. Chen, O.Q.P. Yin, Z. Zuo, M.S.S. Chow, Pharmacokinetics and modeling of quercetin and metabolites, Pharm. Res. 22 (6) (2005) 892–901.
[78] A. Gradolatto, J.-P. Basly, R. Berges, C. Teyssier, M.-C. Chagnon, M.-H. Siess, M.-C. Canivenc-Lavier, Pharmacokinetics and metabolism of Apigenin in female and male rats after a single oral administration, Drug Metab. Dispos. 33 (1) (2005) 49–54.
[79] D. Tang, K. Chen, L. Huang, J. Li, Pharmacokinetic properties and drug interactions of Apigenin, a natural flavone, Expert Opin. Drug Metab. Toxicol. 13 (3) (2016) 323–330.
[80] C.J. Rebello, R.A. Beyl, J.J.L. Lertora, F.L. Greenway, E. Ravussin, D.M. Ribnicky, A. Poulev, B.J. Kennedy, H.F. Castro, S.R. Campagna, A.A. Coulter, L.M. Redman, Safety and pharmacokinetics of naringenin: a randomized, controlled, single-ascending-dose clinical trial, Diabetes, Obes. Metabol. 22 (1) (2019) 91–98.
[81] F.I. Kanaze, M.I. Bounartzi, M. Georgarakis, I. Niopas, Pharmacokinetics of the Citrus Flavanone Aglycones Hesperetin and Naringenin after single oral administration in human subjects, E.J.C.N. 61 (4) (2006) 472–477.
[82] A. Barve, C. Chen, V. Hebbar, J. Desiderio, C.L.-L. Saw, Kong, A.-N. Metabolism, Oral bioavailability and pharmacokinetics of chemopreventive kaempferol in rats, Biopharm. Drug Dispos. 30 (7) (2009) 356–365.
[83] Zabela, V.; Sampath, C.; Oufir, M.; Moradi-Afrapoli, F.; Butterweck, V.; Hamburger, M. Pharmacokinetics of dietary kaempferol and its metabolite 4-hydroxyphenyl-acetic acid in rats,2016, 115, 189–197.
[84] Su, H.; Zhang, Y.; Huang, W.; Wen, L.; Zhuang, Z.; Chen, G. Pharmacokinetics and tissue distribution of oleic and linoleic acids following oral and rectal administration of Brucea Javanica oil in rats. 2016, 12 (5), 461–482.
[85] H. Su, Y. Zhang, W. Huang, L. Wen, Z. Zhuang, G. Chen, Pharmacokinetics and tissue distribution of oleic and linoleic acids following oral and rectal administration ofbruceajavanica oil in rats, Int. J. Pharm. (2016) 461–482.
[86] G. Duchateau, B. Cochrane, S. Windebank, J. Herudzinska, D. Sanghera, A. Burian, M. Müller, M. Zeitlinger, G. Lappin, Absolute oral bioavailability and metabolic turnover of β-sitosterol in healthy subjects, Drug Metab. Dispos. 40 (10) (2012) 2026–2030.
[87] Ritschel, W.A.; Kastner, U.; Hussain, A.; Koch, H. Pharmacokinetics and bioavailability of beta-sitosterol in the beagle dog,1990, 40 (4), 463–468.
[88] Z. Hong, T. Zhang, Y. Zhang, et al., Reveals of candidate active ingredients in Justicia and its anti-thrombotic action of mechanism based on network pharmacology approach and experimental validation, Sci. Rep. 11 (2021) 17187.
[89] Z. Hong, B. Emiley, et al., Anti-HIV diphyllin glycosides from *Justicia gendarussa*, Phytochemistry (2017) 94–100.
[90] H.X. Zhang, Z. Xia, T.Q. Xu, Y.M. Chen, G.X. Zhou, New compounds from the aerial parts of Justicia gendarussa Burm.f. and their antioxidant and anti-inflammatory activities, Nat. Prod. Res. 35 (20) (2021) 3478–3486, https://doi.org/10.1080/14786419.2019.1710708.
[91] L.G.S. Souza, M.C.S. Almeida, T.L.G. Lemos, et al., Brazoides A-D, new alkaloids from Justicia gendarussa Burm. F. species, J. Braz. Chem. Soc. 28 (2017) 1281–1287.
[92] H.X. Zhang, Z. Xia, T.Q. Xu, Y.M. Chen, G.X. Zhou, New compounds from the aerial parts of Justicia gendarussa Burm. f. and their antioxidant and anti-inflammatory activities, Nat. Prod. Res. 35 (20) (2021 Sep 23) 3478–3486.