Volume 6. Issue 2, 2025

Trends in
Natural Products Research

An Insight into the Ethnopharmacology and Pharmacological Properties of *Calliandra portoricensis* (Jacq) Benth Fabaceae

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Abstract

Calliandra portoricensis, a perennial shrub of the Fabaceae family, has long been acknowledged for its numerous traditional medicinal applications in various cultures. Its substantial therapeutic potential is underscored by ethnomedical reports documenting its use in the treatment of gastrointestinal disorders, respiratory conditions, inflammation, and parasitic infections. Phytochemical investigations have revealed the presence of alkaloids, flavonoids, tannins, saponins, and other bioactive compounds, which serve as the basis for its pharmacological efficacy. Their value in drug discovery and development is underscored by biological studies that have confirmed their broad-spectrum pharmacological activities, including anti-inflammatory, antimicrobial, antioxidant, antidiabetic, and anticancer properties. Nevertheless, toxicity assessments suggest that caution is warranted as specific extracts demonstrate dose-dependent toxic effects. This review synthesizes the current body of knowledge regarding the traditional uses, phytochemistry, and pharmacology of *C. portoricensis*, proposes future directions, and identifies research gaps to further its potential therapeutic applications.

Keywords: *Calliandra portoricensis*, phytochemistry, pharmacology, anticancer, anticonvulsant, antisickling

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https://doi.org/10.61594/tnpr.v6(2).2025.121
Page No.: 54-59
Volume: Volume 6 Issue 2, 2025
Trends in Natural Products Research

Introduction

Historically, medicinal plants have been essential to traditional healthcare systems, as they provide medicinal remedies for many ailments. *Calliandra portoricensis*, a member of the Fabaceae family, is notable for its vast ethno-medical uses. *Calliandra portoricensis*, referred to as powderpuff or fairy duster, has been extensively used in traditional medicine, particularly in Africa and tropical areas. Ethnomedical applications have demonstrated therapeutic efficacy in the treatment of various diseases. Across many cultures, traditional healers have used the roots, leaves, and bark of plants for their therapeutic effects to prepare various plant components, such as decoctions, infusions, and poultices (Irvine 1961; Ofusori and Adejuwon 2011; Abd El Ghani 2016). This perennial plant has been used in traditional practices throughout many areas to address gastrointestinal illnesses (Dalziel 1948), convulsions (Adesina and Akinwusi 1984), pain (Agunu *et al.* 2005), inflammation (Adefisan *et al.* 2020), laxative and parasite infections (Folade *et al.* 2018, Nvau *et al.* 2020), cancer (Segun *et al.* 2018, Oyebode *et al.* 2019), and abortifacients in humans (Ayensu 1978). This extensive use highlights their potential as sources of innovative medicinal compounds.

Phytochemical studies of *C. portoricensis* have shown a diverse spectrum of bioactive chemicals, such as alkaloids, flavonoids, tannins, and saponins, associated with its therapeutic effectiveness (Aguwa and Lawal 1988, Moharram *et al.* 2006; El-Sayed, 2014; Chan *et al.* 2014, Siemuri *et al.* 2017). These chemicals facilitate established biological actions, including anti-inflammatory (Adefisan *et al.* 2020) and antibacterial effects (Enwuru *et al.* 2017, Oguegbulu *et al.* 2020, Ogbole *et al.* 2020), antioxidant (Siemuri *et al.* 2015), anticonvulsant (Akah and Nwaiwu 1988), anticancer (Adaramoye *et al.* 2015, Adefisan *et al.* 2015, Oyebode *et al.* 2019) and anti-sickling properties (Amujoyegbe *et al.* 2014). Its root extract has been documented to possess anthelmintic properties, rendering it a prevalent medicine in rural populations (Falode *et al.* 2018).

Notwithstanding these encouraging results, the toxicological profile of *C. portoricensis* continues to be a significant issue, as several investigations have indicated possible detrimental effects of elevated dosages (Siemuri *et al.* 2017). Despite the broad use of *C. portoricensis* in traditional medicine and its notable pharmacological potential shown in scientific investigations, substantial research gaps remain. The absence of thorough investigations combining its traditional usage, phytochemical composition, and pharmacological effects with stringent toxicity assessments have impeded its medicinal potential. The lack of standardized techniques for isolating and assessing bioactive components hinders their advancement into drug development. This review aims to bridge the existing gaps by consolidating the current information on *C. portoricensis*, pinpointing research requirements, and suggesting future avenues to enhance its therapeutic efficacy.

Phytochemical Constituents

The pharmacological characteristics and historical uses of *Calliandra portoricensis* are fundamentally based on its varied phytochemical composition. Several bioactive substances have been identified in plants, including alkaloids, flavonoids, tannins, saponins, terpenoids, phenolic compounds, and glycosides (Aguwa and Lawal 1988; Orishadipe *et al.* 2010), which have been acknowledged for their substantial contribution to the medicinal properties of plants.

Phytochemical analyses of *C. portoricensis* roots, bark, and leaves have consistently shown elevated levels of flavonoids and tannins, which are known to have significant antioxidant effects. Phytochemical analysis of different parts of the plant revealed the presence of saponins, tannins, flavonoids, glycosides, alkaloids, anthraquinones, cardiac glycoside, fatty acids, gallic acid, methyl gallate, myricitrin, quercitrin, afzelin, betulinic acid, galloyl sitosterol, z-cartecyl (Akah and Nwaiwu 1988, Moharram *et al.* 2006). Moharram *et al.* (2006) indicated that the flavonoid concentration in *C. portoricensis* enhances its capacity to scavenge free radicals, mitigates oxidative stress, and regulates inflammatory pathways. These chemicals are essential for safeguarding biological systems against degenerative illnesses that result from oxidative damage.

Alkaloids, a significant class of compounds present in *C. portoricensis*, are renowned for their various pharmacological properties including analgesic, antimicrobial, and antimalarial effects (Orishadipe *et al.* 2010, Ogbole *et al.* 2020). Saponins are another significant class of compounds found in *C. portoricensis*. These chemicals possess antiinflammatory and antiulcer properties (Aguwa and Lawal 1988; Adefisan *et al.* 2020). The presence of phenolic compounds in *C. portoricensis* is associated with potent antioxidant activity. Phenolics such as tannins and lignans are crucial for mitigating cellular damage induced by reactive oxygen species (ROS) (Siemuri *et al.* 2015). These compounds enhance the antimicrobial properties of plants (Adaramoye *et al.* 2015), corroborating their

traditional applications in the treatment of skin infections and gastrointestinal disorders. Terpenoids and glycosides have been extracted from *C. portoricensis*; however, their precise pharmacological functions remain underexplored. Initial research has indicated that these compounds may enhance the anti-inflammatory and antimalarial properties of plants, necessitating additional exploration (Adefisan *et al.* 2020). Notwithstanding these encouraging results, the phytochemical profile of *Calliandra portoricensis* remains poorly characterized. Advanced analytical methodologies, including high-performance liquid chromatography (HPLC), gas chromatographymass spectrometry (GC-MS), and nuclear magnetic resonance (NMR) spectroscopy, may yield more accurate insights into the structures and functions of bioactive compounds. Such studies are essential to understand its complete therapeutic potential and to enable its incorporation into contemporary pharmacology.

Pharmacological and Biological Properties of Calliandra portoricensis

The extensive phytochemical composition of *C. portoricensis* has prompted several investigations of its pharmacological and biological properties. These studies have revealed its potential medicinal properties, including antimicrobial, antiinflammatory, antioxidant, anticancer, anthelmintic, molluscicidal, and anticonvulsant activities.

Antimicrobial Efficacy

The antimicrobial efficacy of *C. portoricensis* has been thoroughly investigated, especially its capacity to suppress bacterial proliferation (Enwuru *et al.* 2017, Oguegbulu *et al.* 2020, Ogbole *et al.* 2020). Peptide-rich root extracts have been reported to exhibit significant antibacterial activity and brine shrimp lethality (Ogbole *et al.* 2020). Similarly, Oguegbulu et al. (2020) documented the antimicrobial effects of leaf and root extracts on human serum pathogens.

Anti-inflammatory Attributes

Research has corroborated the conventional use of *Calliandra* spp. for the treatment of inflammatory disorders. Many *Calliandra* species—especially *C. haematocephala*, *C. portoricensis*, and *C. surinamensis*—with compounds like betulinic acid and myricetin, play important roles (Moharram *et al.* 2006, Gupta *et al.* 2013, Siddhi *et al.* 2024). Their anti-inflammatory properties are mostly associated with flavonoids and tannins, which are recognized for their ability to block critical enzymes, including cyclooxygenase and lipoxygenase, which participate in the inflammatory process.

Antioxidant Capability

Numerous reports have emphasized the antioxidant properties of *C. portoricensis*, particularly its capacity to neutralize free radicals and mitigate oxidative stress-related damage (Moharram *et al.* 2006, Onyema *et al.* 2012, Adaramoye *et al.* 2015). Siemuri *et al.* (2015) indicated the antioxidant potency of the methanol root bark extract in an experimental rat model. This action is associated with elevated phenolic and flavonoid concentrations in plants. Antioxidants in *C. portoricensis* are essential for alleviating oxidative stress associated with chronic illnesses, including cancer (Onyema *et al.* 2012).

Anthelmintic Attributes

Conventional assertions regarding the anthelmintic properties of *C. portoricensis* have been substantiated empirically (Falode *et al.* 2018). The leaves and branches of *C. calotyrsus* and *C. portoricensis* have been reported to contain compounds that exhibit activity against intestinal nematodes in ruminants (Wabo *et al.* 2014), including parasitic helminths such as *Ascaris lumbricoides* and *Haemonchus contortus*. The demonstrated anthelmintic efficacy was attributable to tannins, which disrupt the nervous system and energy metabolism of the parasites.

Anticonvulsant Activity

Callliandra portoricensis has notable sedative and anxiolytic properties, validating its historical use in the treatment of convulsions (Adesina 1982, Adesina and Akinwusi 1984). Akah and Nwaiwu (1988) have documented the anticonvulsant activity of *C. portoricensis* root and stem extracts in mice.

Anti-sickling Activity

Callliandra portoricensis has a long history of traditional use in the management of sickle cell disease in the western part of Nigeria. Extracts of the root of the plant have been reported to possess antisickling potential, contributing to the management of sickle cell disease by stabilizing the sickled erythrocyte membrane. Lawal and Moody (2015) suggested that the extract and fractions of the root inhibited hemoglobin polymerization, with the ethyl acetate fraction exhibiting the highest

inhibition. The inhibition and reversal of sickling by *Calliandra* species (Amujoyegbe *et al.*, 2014) are linearly related.

Additional Pharmacological Activities

C. portoricensis has also been reported to possess other pharmacological effects. These activities include: analgesic (Agunu *et al.* 2005), antiulcer (Aguwa and Lawal 1988; Rehman *et al.* 2021), antisnake venom (Onyema *et al.* 2014), and molluscicidal (Adewunmi and Marquis 1980; Kloos and McCullough 1982) effects.

Prospective Outlook

Although this review has yielded information about the pharmacological properties of *Calliandra portoricensis*, several aspects need to be investigated. Numerous studies have been restricted to in vitro and animal models, underscoring the need for rigorously planned clinical trials to validate these benefits in humans. Moreover, few toxicological studies (Ofosori and Adejuwon 2011, Siemuri *et al.* 2017) have been conducted on the plant. The isolation and structural elucidation of bioactive substances using improved analytical methods may enhance their incorporation into contemporary therapeutic frameworks.

Recommendations

Considering the intriguing pharmacological properties of *Calliandra portoricensis*, further scientific research should concentrate on clinical studies to validate its therapeutic efficacy in humans. Although the existing evidence from preclinical models is promising, human studies are crucial to validate its safety, effectiveness, and optimal dose. Research should specifically investigate the efficacy of the plant in addressing chronic disorders such as cancer, inflammation, and microbial infections, for which it has shown considerable potential. The extraction of particular bioactive chemicals from *C. portoricensis* using modern methods, such as high-performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS), may facilitate the discovery of new molecules with significant therapeutic potential. Prioritizing the standardization of plant extracts according to their active ingredients is essential for ensuring consistency and effectiveness in future medicinal applications.

In addition, *Calliandra portoricensis* may be integrated into pharmacological and ethnomedicinal research as part of a comprehensive examination of the efficacy of plant-derived medicines in addressing multidrug-resistant microbial infections, which is an escalating global issue (Chan *et al.* 2014). Given its extensive use in traditional medicine and potential for commercialization, research is also necessary to assess the ecological sustainability of harvesting *C. portoricensis*. The exploration of sustainable harvesting techniques and farming practices is essential to provide a consistent supply, while preventing the overexploitation of natural populations.

Conclusion

Calliandra portoricensis is a plant of considerable pharmaceutical relevance owing to its varied biological activities, including antibacterial, antiinflammatory, antioxidant, anticancer, anthelmintic, anticonvulsant, and antisickling properties. These functions are primarily ascribed to their abundant phytochemical contents, including flavonoids, alkaloids, saponins, and phenolic compounds. Scientific studies have validated the traditional use of this herb for controlling many diseases, supporting its inclusion in future medicinal applications.

Nonetheless, although *C. portoricensis* has significant potential as a source of bioactive compounds for pharmaceutical development, more comprehensive studies are required to fully elucidate its pharmacological range. Clinical studies and investigations of the molecular mechanisms of action are essential for their incorporation into contemporary medicine. The medicinal potential of the plant, together with its ecological significance and sustainability issues, necessitate a measured approach to its use. This analysis underscores the need for ongoing investigations into the therapeutic characteristics of *Calliandra portoricensis* and its potential to enhance current pharmacological therapies. Should more studies validate its effectiveness, this plant might emerge as a significant natural resource for the formulation of novel, safer, and more cost-effective medicines.

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CITATION: Ofokansi MN, Akah PA (2025) An Insight into the Ethnopharmacology and Pharmacological Properties of *Calliandra Portoricensis* (Jacq) Benth Fabaceae
Trend Nat Prod Res Vol 6(2). 54-59. https://doi.org/10.61594/tnpr.v6(2).2025.121