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Genus *Justicia* as a Source of Antidiabetic Agents: A Critical Review of Phytochemistry, Pharmacological Evidence, and Future Prospects with Special Reference to *Justicia tranquebarensis*

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ABSTRACT:

Diabetes mellitus remains one of the most challenging global health burdens, with its prevalence increasing to rise and existing pharmacotherapies often limited by adverse effects, high cost, and declining long-term efficacy. These challenges have intensified interest in plant-derived antidiabetic agents, many of which offer multifaceted mechanisms, improved safety, and suitability for long-term management. Among such plant-based sources, the genus Justicia (Acanthaceae) holds significant ethnomedicinal relevance, particularly in traditional systems where numerous species are used for metabolic, inflammatory, and hepatic disorders. This review critically provides the current evidence on the phytochemistry and antidiabetic pharmacology of Justicia species, integrating data from in-vitro, in-vivo, and in-silico investigations. Reported constituents including, flavonoids, alkaloids, terpenoids, phenolics, and glycosides demonstrate potential for inhibiting carbohydrate-hydrolyzing enzymes, increasing insulin sensitivity, modulating oxidative stress, and improving glucose–lipid homeostasis. Several species such as J. adhatoda, J. gendarussa, J. spicigera, and J. procumbens exhibit substantial antidiabetic activity in preclinical models, supported by mechanistic insights from docking and molecular interaction studies. Special emphasis is placed on Justicia tranquebarensis, an underexplored species with preliminary reports indicating promising phytochemical richness and potential antidiabetic effects, yet comprehensive pharmacological validation is lacking. Overall, the genus Justicia represents a valuable reservoir of bioactive compounds with promising therapeutic prospects against diabetes. This review highlights current advances, existing limitations, and future research needs including compound isolation, mechanistic clarification, pharmacokinetic evaluation, and translational studies to position J. tranquebarensis and related species as strong candidates for next-generation phytopharmaceutical development.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin secretion, insulin action, or a combination of both. It represents one of the most significant global public health challenges of the 21st century. According to the International Diabetes Federation (IDF), approximately 537 million adults worldwide were living with diabetes in 2021, and this number is projected to rise to 783 million by 2045, with the majority of cases occurring in low- and middle-income countries [1]. The rapid escalation of diabetes prevalence has been attributed to multiple factors, including urbanization, sedentary lifestyles, dietary transitions toward high-calorie processed foods, obesity, and aging populations [2]. Diabetes is associated with substantial morbidity and mortality, largely due to microvascular complications such as retinopathy, nephropathy, and neuropathy, and macrovascular complications including cardiovascular

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diseases and stroke [3]. The economic burden of diabetes is profound, encompassing direct healthcare costs for treatment and indirect costs related to productivity loss and disability [4].

The molecular pathophysiology of diabetes is multifactorial. Type 1 diabetes results from autoimmune-mediated destruction of pancreatic β-cells, whereas Type 2 diabetes is characterized by a combination of peripheral insulin resistance and progressive β-cell dysfunction [5]. Hyperglycemia triggers a cascade of metabolic disturbances, including dyslipidemia, chronic low-grade inflammation, oxidative stress, and formation of advanced glycation end-products (AGEs), which collectively exacerbate tissue damage and insulin resistance [6]. Current pharmacological strategies—including biguanides (e.g., metformin), sulfonylureas (e.g., glibenclamide), thiazolidinediones (e.g., pioglitazone), DPP-IV inhibitors, GLP-1 receptor agonists, and SGLT2 inhibitors—primarily target specific molecular pathways to lower blood glucose. Despite their efficacy, these drugs often exhibit limitations such as gastrointestinal disturbances, hypoglycemia, weight gain, hepatotoxicity, reduced long-term effectiveness, and high costs, which compromise patient compliance and quality of life [7]. Furthermore, the conventional monotherapy approach fails to address the complex, multifactorial pathogenesis of diabetes, highlighting the need for safer, multi-targeted, and cost-effective alternatives.

Medicinal plants have served as a cornerstone of healthcare for millennia, offering a rich source of structurally diverse bioactive compounds. Phytochemicals including flavonoids, alkaloids, terpenoids, phenolics, saponins, and glycosides produce multiple antidiabetic effects through diverse mechanisms such as inhibition of carbohydrate-hydrolyzing enzymes (α-amylase, α-glucosidase, and DPP-IV), modulation of insulin secretion, enhancement of glucose uptake, attenuation of oxidative stress, and suppression of pro-inflammatory pathways [8]. Numerous traditional medicine systems—such as Ayurveda, Siddha, Unani, and ethnomedicine across Asia, Africa, and Latin America—have employed plant-based remedies for managing diabetes and its complications [9]. These ethnopharmacological insights provide a strong foundation for modern drug discovery, enabling identification of lead compounds and mechanistic validation in preclinical and clinical studies. Several plant-derived molecules, including metformin (derived from *Galega officinalis*) exemplify successful translation from natural products to clinical antidiabetic therapy [10].

The genus *Justicia* (family Acanthaceae) comprises over 600 species distributed throughout tropical and subtropical regions of Asia, Africa, and the Americas [11]. Traditionally, *Justicia* species have been employed to treat respiratory disorders, inflammation, fever, wounds, hepatic dysfunction, and metabolic diseases. Ethnobotanical surveys indicate that several species, including *J. adhatoda*, *J. gendarussa*, *J. spicigera*, and *J. procumbens*, have been used specifically for diabetes management and related metabolic disorders. Contemporary pharmacological studies support these traditional claims, demonstrating that bioactive compounds isolated from *Justicia* species—such as flavonoids, alkaloids, terpenoids, and phenolic glycosides—exhibit significant antidiabetic activity. Mechanistic investigations reveal their potential in inhibiting α-amylase and α-glucosidase, modulating oxidative stress, improving insulin sensitivity, and regulating glucose and lipid metabolism in preclinical models [12]. In addition, molecular docking and in-silico studies provide insights into interactions between these phytochemicals and key diabetic targets, further validating their therapeutic relevance.

Despite promising evidence, current research is disproportionately focused on a few well-studied *Justicia* species, leaving many lesser-known plants underexplored. *Justicia tranquebarensis*, a species endemic to certain regions of India, has been reported in ethnomedicinal records for the management of metabolic disorders, yet scientific studies investigating its antidiabetic potential remain limited [13]. Preliminary phytochemical analyses suggest that *J. tranquebarensis* contains bioactive flavonoids, alkaloids, and terpenoids, indicating possible mechanisms relevant to glucose homeostasis and insulin modulation. However, comprehensive in-vitro, in-vivo, and in-silico studies, as well as pharmacokinetic and toxicological evaluations, are lacking, representing a significant knowledge gap and an opportunity for novel drug discovery.

The present review critically examines the phytochemistry, pharmacological evidence, and mechanistic insights of *Justicia* species with respect to

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their antidiabetic potential. Special emphasis is placed on *J. tranquebarensis* as an underexplored yet promising candidate. By integrating traditional knowledge, preclinical studies, and molecular modeling data, this review aims to provide a systematic overview of the genus *Justicia* as a source of potential antidiabetic agents and to outline future research directions for phytopharmaceutical development.

BOTANICAL AND ETHNOPHARMACOLOGICAL OVERVIEW OF JUSTICIA SPECIES

Taxonomy and Botanical Description:

The genus *Justicia* belongs to the family Acanthaceae, which comprises approximately 250 genera and over 2500 species worldwide. *Justicia* is one of the largest genera in the family, with more than 600 recognized species distributed across tropical and subtropical regions of Asia, Africa, Central, and South America [11,14]. Members of the genus are predominantly perennial herbs, shrubs, or small trees, characterized by opposite leaves, zygomorphic flowers, and a capsule fruit containing small seeds. The flowers are often brightly coloured (white, yellow, pink, or purple) and tubular, adapted to pollination by insects or birds [14,15].

Key taxonomic features of *Justicia* species include:

- **Leaves:** Opposite, simple, entire or serrate, often pubescent.
- **Stems:** erect, branched, sometimes succulent.
- **Inflorescence:** Terminal or axillary spikes or racemes.
- **Flowers:** Bilaterally symmetrical, with a two-lipped corolla and four stamens.
- **Fruits:** Capsule dehiscent along two valves, containing small, triquetrous seeds [14].

Several species such as *J. adhatoda* (Vasaka), *J. gendarussa*, *J. spicigera*, and *J. procumbens* have been well studied in floristic surveys and pharmacognostic studies due to their medicinal importance [13,15,16].

Geographical Distribution:

Justicia species thrive in tropical and subtropical climates, often found in:

- India and Sri Lanka: ~150 species
- Southeast Asia (Thailand, Malaysia, Indonesia)
- Africa (tropical and subtropical regions)
- Central and South America

Several species have adapted to diverse ecological conditions, ranging from moist forest to semi-arid open lands. Distribution patterns often influence phytochemical diversity, as environmental stress, altitude, and soil type modulate secondary metabolite synthesis.

Ethnopharmacological Uses:

The genus *Justicia* is widely recognized in traditional medicine for a broad spectrum of therapeutic applications. Historically, different parts of the plants such as leaves, roots, stems, flowers, and seeds have been used for the treatment of respiratory ailments, fever, wounds, inflammation, gastrointestinal disorders, liver diseases, and metabolic disturbances [13,15,16].

Specific ethnopharmacological records related to diabetes and metabolic disorders include:

- ***J. adhatoda:*** Leaves and roots used in Indian traditional medicine for blood sugar regulation and treatment of diabetic complications [16].
- ***J. gendarussa:*** Employed in Indonesian and Indian folk medicine for hyperglycemia and inflammation [15,16].
- ***J. spicigera:*** Used in Ayurvedic and Mesoamerican practices for wound healing and sugar control [15].
- ***J. procumbens:*** Leaves and aerial parts used in folk remedies for diabetes and oxidative stress [15].
- ***J. tranquebarensis:*** Reported in regional ethnomedicinal surveys in southern India for treatment of metabolic disorders, fatigue, and general debility, although scientific validation is limited [13].

Ethnobotanical evidence in Diabetes Management:

Ethnobotanical studies suggest that *Justicia* species have been traditionally used not only for the management hyperglycemia but also associated complications such as

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oxidative stress, dyslipidemia, and inflammation. The use of decoctions, infusions, and powdered leaves in combination with other medicinal plants has been reported in several indigenous healthcare practices [27,28]. These traditional applications provide a scientific rationale for modern investigations into the antidiabetic potential of *Justicia* species [13,15,16].

PHYTOCHEMICAL CONSTITUENTS OF JUSTICIA SPECIES

Phytochemical investigation of the genus *Justicia* reveals a diverse array of bioactive secondary metabolites, which underpin the observed pharmacological activities, including antidiabetic potential. The chemical diversity is largely influenced by species, geographical origin, plant part, developmental stage, and extraction methodology. Major classes of bioactive compounds reported from *Justicia* species include alkaloids, flavonoids, terpenoids, phenolics, glycosides, saponins, and essential oils [12,15,17]. These metabolites exhibit multi-target mechanisms relevant to glucose regulation, oxidative stress attenuation, and metabolic homeostasis.

Alkaloids*:* Alkaloids represent a significant class of nitrogen-containing compounds in *Justicia* species. In *J. adhatoda*, the major alkaloid vasicine has been reported to exhibit antioxidant, anti-inflammatory, and enzyme-modulating properties relevant to diabetes management [18,19]. Similarly, *J. gendarussa* contains gendarussine and related indole alkaloids, which have shown potential in in-vitro α-glucosidase inhibition and in-silico binding to diabetic targets [20]. Alkaloids in *J. tranquebarensis* are less explored; preliminary phytochemical screening indicates the presence of alkaloid fractions that may contribute to insulinotropic and glucose-lowering activity [13].

Flavonoids*:* Flavonoids are polyphenolic compounds known for their antioxidant, anti-inflammatory, and enzyme inhibitory activities. Flavonoids such as quercetin, kaempferol, apigenin, and luteolin have been isolated from *Justicia* species, contributing to α-amylase and α-glucosidase inhibition, enhancement of insulin secretion, and protection of pancreatic β-cells against oxidative stress [12,15,17]. Notably, *J. spicigera* and *J. procumbens* are rich in flavonoid glycosides, which have been associated with reduced blood glucose and improved lipid profiles in experimental diabetic models [17].

Terpenoids*:* Terpenoids, including mono-, sesqui-, and diterpenes, are abundantly reported in *Justicia* species. For example, diterpenoids isolated from *J. gendarussa* exhibit significant free radical scavenging and enzyme inhibitory activity, while triterpenoids from *J. adhatoda* have demonstrated anti-inflammatory and hepatoprotective effects [13,17]. Terpenoids are particularly relevant in diabetes management due to their ability to modulate glucose metabolism, oxidative stress, and inflammatory pathways that contribute to insulin resistance [17].

Phenolics*:* Phenolic compounds, including simple phenols, phenolic acids, and polyphenols, are widely present in leaves, stems, and roots of *Justicia* species. Compounds such as caffeic acid, ferulic acid, gallic acid, and chlorogenic acid exhibit potent antioxidant and antiglycation activity, mitigating oxidative stress–induced pancreatic β-cell damage. These compounds also play a role in inhibiting carbohydrate-digesting enzymes and improving insulin sensitivity in experimental models [17].

Glycosides*:* Cardiac glycosides and flavonoid glycosides have been isolated from several *Justicia* species. Flavonoid glycosides enhance solubility and bioavailability of flavonoid aglycones, contributing to enzyme inhibitory activity and improved glucose utilization. Limited studies suggest that *J. tranquebarensis* contains glycosidic fractions that may be responsible for preliminary antidiabetic effects reported in ethnomedicine [17].

Saponins and Other Compounds*:* Saponins, known for their amphiphilic structure and biological activity, are reported in *Justicia procumbens* and *J. gendarussa*, exhibiting hypoglycemic and lipid-lowering effects in animal models [17,18]. Additionally, essential oils and sterols isolated from selected species contribute to antioxidant, anti-inflammatory, and insulin-sensitizing properties [17].

Analytical Tools and Phytochemical Characterization:

The chemical profiling of *Justicia* species has employed a variety of analytical techniques such as Chromatographic methods involving HPLC, LC-MS, GC-MS, and TLC for identification and quantification of bioactives, Spectroscopic methods involving UV-Vis,

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FTIR, NMR, and mass spectrometry for structural elucidation. Phytochemical screening involving Qualitative tests for alkaloids, flavonoids, terpenoids, saponins, glycosides, and phenolics [12,15].

These approaches have been critical in correlating chemical constituents with antidiabetic activity and in guiding further in-vitro, in-vivo, and in-silico investigations.

Table 1: Major Phytochemical Classes and Bioactive Compounds of Selected Justicia Species

Species	Major Phytochemicals	Reported Bioactivity (Antidiabetic/Relevance)
J. adhatoda	Alkaloids (vasicine), flavonoids	α-glucosidase inhibition, antioxidant
J. gendarussa	Alkaloids (gendarussine), terpenoids	α-amylase inhibition, free radical scavenging
J. spicigera	Flavonoid glycosides, phenolics	Blood glucose reduction, lipid modulation
J. procumbens	Saponins, flavonoids	Antioxidant, anti-inflammatory
J. tranquebarensis	Alkaloids, glycosides, flavonoids (preliminary)	Potential insulinotropic, glucose-lowering

PHARMACOLOGICAL EVIDENCE OF ANTIDIABETIC POTENTIAL

The antidiabetic potential of *Justicia* species has been investigated using a combination of *in-vitro* assays, *in-vivo* animal models, and *in-silico* molecular docking studies. These approaches collectively provide mechanistic insights into glucose-lowering effects, enzyme inhibition, insulin sensitization, and oxidative stress modulation.

***In-Vitro* Studies:** In-vitro investigations primarily focus on enzyme inhibition assays, antioxidant capacity, antiglycation activity, and insulinomimetic effects.

Enzyme Inhibition Assays: Carbohydrate-hydrolysing enzymes, including α-amylase and α-glucosidase, are critical in postprandial glucose regulation. Extracts and isolated compounds from *Justicia* species have shown significant inhibition of these enzymes in concentration-dependent manners.

For example, *J. adhatoda* leaf extracts demonstrated 65–78% inhibition of α-glucosidase at 200 µg/mL, comparable to acarbose, a standard antidiabetic drug [21,22]. Flavonoid-rich fractions of *J. gendarussa* inhibited α-amylase by 55–70%, suggesting potential for controlling postprandial hyperglycemia [23]. Preliminary in-vitro studies of *J. tranquebarensis* indicate modest α-glucosidase and DPP-IV inhibition, warranting further isolation of active constituents [24,25].

Antioxidant and Antiglycation Activity: Oxidative stress and glycation are key contributors to β-cell dysfunction and diabetic complications. *Justicia* species exhibit robust antioxidant activity in DPPH, ABTS, and FRAP assays. *J. procumbens* flavonoid fractions scavenged >80% DPPH radicals at 100 µg/mL [26]. Phenolic extracts of *J. spicigera* inhibited advanced glycation end-product (AGE) formation, suggesting protection against protein glycation–mediated complications [27].

Insulinomimetic and cellular effects: Certain compounds demonstrate insulinomimetic activity by enhancing glucose uptake in cultured adipocytes or hepatocytes. Methanolic extracts of *J. gendarussa* increased glucose uptake in 3T3-L1 adipocytes via AMPK activation [28]. Preliminary in-vitro studies of *J. tranquebarensis* suggest moderate insulin-sensitizing effects, though mechanistic elucidation is still lacking [25].

***In-Vivo* studies:** In-vivo studies using animal models provide critical validation of glucose-lowering effects and safety profiles. Common models include streptozotocin (STZ)-induced diabetes, alloxan-induced diabetes, and high-fat diet (HFD)-induced insulin resistance.

Streptozotocin (STZ) and Alloxan Models: STZ and alloxan selectively destroy pancreatic β-cells, simulating Type 1 diabetes. Oral administration of *J. adhatoda* leaf extract (200 mg/kg) in STZ-induced rats reduced fasting blood glucose by 35–40% over 14 days [21]. *J.*

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gendarussa ethanol extract significantly restored plasma insulin levels and improved pancreatic histology in alloxan-induced diabetic mice [29].

High-Fat Diet (HFD) and Insulin Resistance Models*:* HFD-induced insulin resistance models mimic Type 2 diabetes. Flavonoid-rich fractions of *J. spicigera* administered to HFD-fed rats improved insulin sensitivity (HOMA-IR reduction) and normalized lipid profiles [27]. Preliminary studies of *J. tranquebarensis* in HFD-fed mice demonstrated a trend toward lowered fasting glucose and improved glucose tolerance, though statistical significance was limited due to small sample sizes [24,25].

Additional Outcomes*:* Other beneficial effects observed in-vivo include, Antioxidant effects: reduction in malondialdehyde (MDA) and increased superoxide dismutase (SOD) activity. Anti-inflammatory effects: reduction in TNF-α and IL-6 levels and Lipid modulation: decreased triglycerides, LDL-C, and total cholesterol; increased HDL-C [29].

In-Silico* Studies*: Molecular docking and computational analyses provide mechanistic insights and support structure activity relationships. Bioactive compounds from *Justicia* species (e.g., flavonoids, alkaloids, terpenoids) have been docked against key diabetic targets such as α-amylase, α-glucosidase, DPP-IV, PPARγ, and insulin receptor tyrosine kinase. Docking studies indicate strong binding affinities of *J. adhatoda* alkaloids to α-glucosidase, comparable to acarbose, with hydrogen bonding and π-π stacking interactions stabilizing ligand–enzyme complexes. Terpenoids from *J. gendarussa* and flavonoid glycosides from *J. spicigera* showed favorable docking scores with PPARγ, suggesting potential for insulin sensitization [30]. In-silico analysis of *J. tranquebarensis* compounds indicates moderate binding to α-glucosidase and DPP-IV, supporting preliminary antidiabetic potential [24,25].

These computational findings complement in-vitro and in-vivo data, guiding targeted isolation of active compounds and future mechanistic studies.

Table 2: Summary of Antidiabetic Pharmacological Studies of Selected Justicia Species

Species	Model/Assay	Major Findings
J. adhatoda	STZ-diabetic rats, α-glucosidase inhibition	Decreased fasting glucose, enzyme inhibition
J. gendarussa	Alloxan-diabetic mice, 3T3-L1 cells	Increased Insulin, glucose uptake, α-amylase inhibition
J. spicigera	HFD rats, DPPH assay	Increased Insulin sensitivity, antioxidant activity
J. procumbens	DPPH, AGE inhibition	Antioxidant, antiglycation effects
J. tranquebarensis	HFD mice, α-glucosidase assay, docking	Preliminary glucose-lowering, moderate enzyme inhibition

CASE SECTION: JUSTICIA TRANQUEBARENSIS

Botanical Profile:

Justicia tranquebarensis (L.) Vahl, belonging to the family Acanthaceae, is a perennial shrub native to the coastal and tropical regions of southern India. It is locally known by several vernacular names, including "Vellaikodi" and "Thottukodi" in Tamil Nadu. Morphologically, it exhibits opposite leaves, small white to pale violet tubular flowers, and dehiscent capsules containing triquetrous seeds [13,31].

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Traditional and Ethnomedicinal Uses:

J. tranquebarensis has been documented in several ethnobotanical surveys for its traditional use in managing metabolic and general health disorders. Diabetes and metabolic disorders: Leaf decoctions and powdered leaves have been used in southern India to regulate blood sugar and treat fatigue associated with chronic illness [13,32]. Hepatic and gastrointestinal disorders: Traditional preparations are employed for liver tonics, jaundice, and dyspepsia [33]. Anti-inflammatory and wound healing: Leaf poultices and extracts are applied topically for swelling and minor wounds [34]. While ethnomedicinal records suggest potential antidiabetic effects, the plant remains underexplored scientifically, with only preliminary pharmacological reports available.

Phytochemical Profile:

Phytochemical investigations of *J. tranquebarensis* are limited but indicate the presence of alkaloids, flavonoids, terpenoids, phenolic compounds, and glycosides, which are known to contribute to antidiabetic activity:

- **Alkaloids:** Preliminary screening confirms the presence of nitrogen-containing compounds, potentially responsible for enzyme inhibition and insulinotropic effects [24].
- **Flavonoids:** Leaf extracts contain quercetin and kaempferol derivatives, which may contribute to antioxidant and α-glucosidase inhibitory activity [25,27].
- **Terpenoids and glycosides:** Detected in methanolic extracts, these compounds may mediate insulin sensitization and lipid-lowering effects [36].

Further isolation and characterization of bioactive molecules are necessary to establish clear structure–activity relationships.

Preliminary Antidiabetic Evidence:

Although scientific studies on *J. tranquebarensis* are scarce, early reports indicate potential antidiabetic activity. Methanolic leaf extracts show moderate inhibition of α-glucosidase and DPP-IV, suggesting control of postprandial hyperglycemia [24,25]. Small-scale experiments in high-fat diet–induced diabetic mice demonstrate a trend toward lowered fasting blood glucose and improved glucose tolerance, though statistical significance has not yet been robustly established [35,36]. Docking of flavonoid and alkaloid fractions against α-glucosidase and DPP-IV reveal moderate binding affinities, supporting the rationale for future mechanistic exploration [30].

Knowledge Gaps and Research Potential:

Despite promising preliminary evidence, several knowledge gaps exist for *J. tranquebarensis*:

1. **Limited phytochemical characterization:** Only a few secondary metabolites have been reported; comprehensive profiling using HPLC, LC-MS/MS, and NMR is lacking.
2. **Mechanistic studies:** No detailed studies on insulin secretion modulation, glucose transporter activation, or anti-inflammatory signaling pathways have been performed.
3. **Pharmacokinetics and toxicity:** Safety, bioavailability, and dosage optimization remain unexplored.
4. **Translational studies:** No clinical or preclinical studies have validated its efficacy in humans or large animal models.

These gaps present significant opportunities for systematic research, including isolation of bioactive compounds, mechanistic studies using modern molecular techniques, and pharmacological evaluation to develop *J. tranquebarensis* as a lead antidiabetic candidate.

Table 3: Ethnobotanical Uses and Preliminary Antidiabetic Evidence of Justicia tranquebarensis

Aspect	Details
Traditional use	Leaf decoctions/powders for diabetes, fatigue, liver disorders
Phytochemicals	Alkaloids, flavonoids (quercetin, kaempferol), terpenoids, glycosides
In-vitro evidence	α-glucosidase and DPP-IV inhibition
In-vivo evidence	Trend in lowering fasting glucose in HFD-induced mice

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Knowledge gaps	Lack of detailed phytochemistry, mechanisms, toxicity, clinical validation

COMPARATIVE INSIGHTS ACROSS JUSTICIA SPECIES

The genus *Justicia* exhibits considerable diversity in chemical composition and pharmacological activity, with several species showing validated antidiabetic potential. Comparative analysis across species helps identify the most promising candidates, elucidate structure–activity relationships, and highlight underexplored species such as *J. tranquebarensis*.

Species with Strong Evidence of Antidiabetic Activity:

Among the over 600 species of *Justicia*, only a few have been systematically investigated for their antidiabetic potential:

- ***J. adhatoda:*** Extensive in-vitro and in-vivo studies demonstrate robust α-glucosidase inhibition, antioxidant activity, and glucose-lowering effects in STZ-induced diabetic models. Alkaloids such as vasicine, together with flavonoids and terpenoids, mediate enzyme inhibition and β-cell protection [18,19,21,22].
- ***J. gendarussa:*** Ethnopharmacological and preclinical studies highlight enzyme inhibitory effects, insulin sensitization, and antioxidant activity. Terpenoids and indole alkaloids show favorable molecular docking scores with α-amylase, DPP-IV, and PPARγ, supporting their therapeutic potential [12,20,23,28,29].
- ***J. spicigera:*** Flavonoid glycosides and phenolic compounds contribute to improved insulin sensitivity, lipid regulation, and free radical scavenging, validated in HFD-induced diabetic rat models [6,7,27].

These species form the core evidence base for the genus, as multiple studies consistently demonstrate significant pharmacological activity and mechanistic support.

Species with Moderate or Limited Evidence:

Several other *Justicia* species, including *J. procumbens* and *J. gendarussa var.*, exhibit moderate antidiabetic activity, primarily through antioxidant, antiglycation, and enzyme inhibition assays. However, these species lack comprehensive in-vivo validation or mechanistic studies, limiting translational potential [26,27].

Positioning of Justicia tranquebarensis:

J. tranquebarensis represents a comparatively underexplored species within the genus:

- **Preliminary evidence:** In-vitro studies indicate α-glucosidase and DPP-IV inhibition, while small-scale in-vivo studies suggest trends toward glucose-lowering and improved glucose tolerance [35,36].
- **Phytochemical potential:** Alkaloids, flavonoids, terpenoids, and glycosides detected in initial screenings indicate a mechanistic basis similar to well-studied species, yet the full spectrum of bioactive molecules remains unidentified [24,25].
- **Research gaps:** Absence of robust in-vivo, pharmacokinetic, toxicological, and clinical studies contrast sharply with extensively studied species like *J. adhatoda* and *J. gendarussa*, highlighting an opportunity for future exploration.

Thus, *J. tranquebarensis* can be considered an underutilized antidiabetic candidate that may yield novel bioactive compounds for drug development.

Comparative Mechanistic Insights:

Table 4: The antidiabetic effects of *Justicia* species arise from multiple, sometimes overlapping mechanisms

Mechanism	Strong Evidence	Moderate/Preliminary Evidence
α-Glucosidase inhibition	*J. adhatoda*, *J. gendarussa*	*J. tranquebarensis, J. procumbens*

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α-Amylase inhibition	*J. adhatoda*, *J. gendarussa*	*J. spicigera*
DPP-IV inhibition	*J. gendarussa*	*J. tranquebarensis*
Antioxidant/antiglycation	*J. spicigera*, *J. procumbens*	*J. tranquebarensis*
Insulin sensitization	*J. gendarussa, J. spicigera*	*J. tranquebarensis*
Lipid regulation	*J. spicigera*	*J. tranquebarensis*

This comparative framework highlights species-specific strengths, emphasizes the multi-targeted potential of the genus, and positions *J. tranquebarensis* as a candidate requiring deeper investigation.

Strategic Insights for Research and Development:

1. **Targeted isolation of bioactive compounds:** Leveraging similarities in phytochemistry with well-studied species may streamline identification of active molecules from *J. tranquebarensis*.
2. **Mechanistic validation:** Functional assays, molecular docking, and omics approaches should be integrated to uncover molecular pathways.
3. **Bridging ethnomedicine and modern pharmacology:** The preliminary ethnobotanical use of *J. tranquebarensis* for metabolic disorders provides a rational foundation for structured pharmacological studies.
4. **Species prioritization for translational research:** Well-studied species can serve as benchmarks, whereas underexplored species like *J. tranquebarensis* may yield novel scaffolds for antidiabetic drug discovery.

Table 5: Summary of comparative pharmacological evidence and research gaps.

Species	Evidence Strength	Key Mechanisms	Research Gaps
J. adhatoda	Strong	α-Glucosidase inhibition, antioxidant, β-cell protection	Limited clinical data
J. gendarussa	Strong	α-Amylase, DPP-IV inhibition, insulin sensitization	Pharmacokinetics lacking
J. spicigera	Moderate	Antioxidant, lipid regulation	Limited in-vivo studies
J. procumbens	Moderate	Antiglycation, antioxidant	Few mechanistic studies
J. tranquebarensis	Preliminary	α-Glucosidase, DPP-IV inhibition, antioxidant	Full phytochemistry, in-vivo, PK, clinical validation

CRITICAL DISCUSSION

The genus *Justicia* represents a rich repository of ethnomedicinally relevant species, many of which exhibit promising antidiabetic potential. Despite considerable preliminary evidence, a critical

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examination reveals several methodological, mechanistic, and translational gaps that must be addressed to fully harness this genus for phytopharmaceutical development.

Strengths of Existing Studies:

1. **Diverse pharmacological evidences:**

   Multiple studies across *J. adhatoda, J. gendarussa, J. spicigera,* and *J. procumbens* demonstrate consistent enzyme inhibition (α-amylase, α-glucosidase, DPP-IV), antioxidant, and insulin-sensitizing activities, validated in both in-vitro and in-vivo models.

2. **Correlation between phytochemistry and bioactivity:**
   The identification of alkaloids, flavonoids, terpenoids, and phenolics provides mechanistic rationales for antidiabetic effects. Structural elucidation and molecular docking studies support the observed enzyme inhibitory and insulinotropic actions.

3. **Ethnopharmacological justification:**
   Traditional use of *Justicia* species for metabolic disorders aligns with experimental findings, reinforcing the relevance of ethnobotanical knowledge for drug discovery.

4. **Multi-targeted potential:**
   Several species exhibit polypharmacology, targeting hyperglycemia, oxidative stress, lipid dysregulation, and inflammation, making them attractive candidates for complex metabolic disorders like Type 2 diabetes.

Weaknesses and Limitations:

1. **Lack of standardization:**
   Most studies employ **crude extracts**, with limited standardization regarding plant part, extraction solvent, and concentration. This variability compromises reproducibility and comparability of results across laboratories.

2. **Incomplete mechanistic studies:**
   While enzyme inhibition and antioxidant effects are frequently assessed, detailed pathways involving insulin signaling, glucose transporters, PPARγ activation, and inflammatory cytokines are rarely explored. Consequently, the precise cellular and molecular mechanisms remain unclear.

3. **Limited in-vivo validation:**
   Although some species are tested in STZ, alloxan, or HFD models, sample sizes are often small, study durations are short, and endpoints are limited to blood glucose or lipid levels. Long-term efficacy and safety remain largely unknown.

4. **Species bias:**
   Research is disproportionately concentrated on *J. adhatoda, J. gendarussa,* and *J. spicigera*, leaving most Justicia species, including *J. tranquebarensis*, underexplored. This bias may obscure potential novel bioactives in lesser-studied species.

5. **Limited clinical translation:**
   Despite promising preclinical data, no clinical studies validate the antidiabetic efficacy, pharmacokinetics, or safety of any *Justicia* species. This represents a critical barrier to therapeutic development.

6. **Variability in phytochemical composition:**
   Environmental factors, geographic origin, plant age, and harvest season can significantly influence the concentration of bioactive metabolites. Few studies have systematically investigated these variations, which may explain inconsistent pharmacological outcomes.

Comparative Gaps Between *In-Vitro, In-Vivo*, and *In-Silico* Data:

- ***In-vitro* studies:** Provide preliminary mechanistic insights (enzyme inhibition, antioxidant effects) but often lack cellular context, limiting predictive validity for in-vivo efficacy.
- ***In-vivo* studies:** Validate glucose-lowering and lipid-modulatory effects but rarely elucidate molecular targets, leaving mechanistic gaps.
- ***In-silico* studies:** Offer binding and interaction predictions for bioactive compounds but remain

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uncorroborated with experimental bioavailability, metabolism, or toxicity data.

Integration of these approaches is limited, which hampers the development of a coherent translational pipeline from bench to clinical application.

Specific Challenges Pertaining to *Justicia tranquebarensis:*

1. **Preliminary evidence only:** Existing data on *J. tranquebarensis* are confined to basic phytochemical screening, small-scale enzyme inhibition assays, and limited HFD mouse models.
2. **Lack of standardized extract:** The absence of standardized extracts or quantified bioactive fractions limits reproducibility and pharmacological validation.
3. **No toxicological evaluation:** Safety, maximum tolerated dose, and long-term adverse effects remain uninvestigated.
4. **Underexplored molecular mechanisms:** Cellular and molecular pathways mediating antidiabetic effects, such as insulin receptor signalling, GLUT4 translocation, or modulation of inflammatory pathways, remain unknown.

These limitations underscore the critical need for systematic, multidisciplinary research to unlock the therapeutic potential of *J. tranquebarensis*.

Research Bias and Under reporting:

A clear research bias is evident in the genus:

- Only a few species have comprehensive studies, while many others, including *J. tranquebarensis*, *J. leptostachya*, and *J. flava*, remain ethnobotanically reported but pharmacologically uncharacterized.
- Geographic and cultural biases also exist, with most studies conducted in India, Southeast Asia, and Africa, potentially neglecting species used in Central and South American traditional medicine.

Addressing these biases is critical to identify novel bioactive compounds and expand the therapeutic repertoire of the genus.

Synthesis of Critical Insights:

In summary:

- *Justicia* species collectively demonstrate significant antidiabetic potential, mediated by enzyme inhibition, antioxidant activity, insulin sensitization, and lipid regulation.
- Strengths include ethnopharmacological validation, multi-target mechanisms, and rich phytochemical diversity.
- Weaknesses encompass lack of standardization, limited mechanistic studies, insufficient in-vivo validation, species bias, and absence of clinical translation.
- *J. tranquebarensis* represents a promising but underexplored candidate, with preliminary evidence supporting its potential yet requiring robust phytochemical, mechanistic, pharmacokinetic, and clinical studies.

Addressing these gaps through integrative, multidisciplinary approaches is essential for the development of Justicia species, particularly *J. tranquebarensis*, as credible antidiabetic phytopharmaceuticals.

Table 6: Strengths, weaknesses, and research gaps in pharmacological studies of Justicia species.

Aspect	Strengths	Weaknesses / Gaps
Phytochemistry	Diverse bioactives (alkaloids, flavonoids, terpenoids)	Incomplete profiling for most species
In-vitro activity	Enzyme inhibition, antioxidant, insulinomimetic effects	Lacks cellular context for some species
In-vivo efficacy	Glucose-lowering, lipid modulation	Small sample size, short duration

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In-silico studies	Mechanistic predictions	Not correlated with PK or toxicity
Species coverage	Strong for J. adhatoda, J. gendarussa	Underexplored: J. tranquebarensis and others
Clinical translation	Ethnomedical alignment	No clinical studies

FUTURE PERSPECTIVES

The genus *Justicia* represents a promising source of antidiabetic agents, yet the current evidence base remains fragmented and underdeveloped. Future research must adopt a multidisciplinary, systematic approach to translate preclinical findings into clinically relevant therapies, with special emphasis on underexplored species such as *J. tranquebarensis*.

Isolation and Characterization of Active Compounds*:*

1. **Comprehensive phytochemical profiling:**
   Advanced analytical techniques such as HPLC, LC-MS/MS, GC-MS, and NMR should be employed to systematically profile the full spectrum of secondary metabolites.
2. **Bioactivity-guided fractionation:**
   Targeted isolation of alkaloids, flavonoids, terpenoids, and glycosides can identify lead compounds with potent antidiabetic activity.
3. **Structure–activity relationship (SAR) studies:**
   Elucidating chemical features responsible for enzyme inhibition, antioxidant activity, and insulin sensitization can guide semi-synthetic modifications to improve efficacy and pharmacokinetics.

Mechanistic and Systems Pharmacology Studies*:*

1. **Molecular pathway elucidation:**
   Detailed investigations should focus on insulin signaling (IR/IRS/PI3K/Akt), glucose transporter activation (GLUT4), PPARγ modulation, and inflammatory cytokine suppression (TNF-α, IL-6).
2. **Omics-based approaches:**
   Transcriptomics, proteomics, and metabolomics can uncover network-level effects of *Justicia* extracts and isolated compounds, enabling identification of novel targets and polypharmacological profiles.
3. **Integrative in-vitro and in-silico validation:**
   Molecular docking, molecular dynamics, and QSAR studies should complement experimental mechanistic assays to streamline compound selection and optimization.

Pharmacokinetics, Toxicology, and Safety Assessment:

1. **Absorption, distribution, metabolism, and excretion (ADME):**
   Comprehensive pharmacokinetic profiling is critical to establish bioavailability, half-life, and metabolic stability of lead compounds.
2. **Acute and chronic toxicity studies:**
   Both rodent and non-rodent models are required to determine maximum tolerated dose, organ-specific toxicity, and potential drug–drug interactions.
3. **Safety in special populations:**
   Consideration of age, pregnancy, hepatic, and renal status is essential for future clinical translation.

Translational and Clinical Research:

1. **Pilot clinical trials:**
   Once standardized extracts or isolated compounds demonstrate preclinical efficacy and safety, early-phase clinical trials should assess glycemic control, insulin sensitivity, and lipid modulation in humans.
2. **Dose optimization and formulation:**
   Development of oral dosage forms, nanoparticles, or bioenhanced formulations may improve bioavailability and therapeutic outcomes.
3. **Combination therapies:**

   Exploration of synergistic interactions with existing antidiabetic drugs could enhance efficacy and reduce adverse effects.

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Integration of Ethnopharmacology with Modern Drug Discovery:

- Validation of traditional knowledge: Ethnobotanical reports, particularly for *J. tranquebarensis*, should guide targeted pharmacological studies, ensuring alignment with historical use.
- Geographic and genetic diversity studies: Variability in bioactive content across different populations and habitats should be evaluated to optimize plant sourcing and standardization.
- Sustainable harvesting and cultivation: Conservation strategies are critical to ensure long-term availability of high-quality plant material.

Strategic Development of *Justicia tranquebarensis*:

J. tranquebarensis represents an underexplored but promising antidiabetic candidate. Strategic research directions include:

1. Isolation of bioactive compounds with high α-glucosidase, DPP-IV, and antioxidant activity.
2. Comprehensive in-vivo validation in STZ, HFD, and combination models to assess glucose-lowering, insulin-sensitizing, and lipid-modulatory effects.
3. Elucidation of molecular mechanisms involving insulin signaling, glucose transport, and anti-inflammatory pathways.
4. Pharmacokinetic, toxicological, and dose-finding studies to support future clinical translation.
5. Integration into phytopharmaceutical development pipelines, potentially leading to standardized extracts, nutraceuticals, or lead compounds for novel drug discovery.

Broader Implications for the Genus:

- *Justicia* species offer a rich chemical diversity capable of addressing multifactorial aspects of diabetes.
- Systematic exploration of underreported species may uncover novel scaffolds for antidiabetic drugs.
- Collaborative research integrating ethnobotany, phytochemistry, pharmacology, molecular biology, and clinical studies is essential to harness the full therapeutic potential of the genus.

Table 7: Strategic research priorities for Justicia species in diabetes management.

Priority Area	Actions	Expected Outcome
Phytochemistry	Advanced analytical profiling, bioactivity-guided isolation	Identification of lead compounds
Mechanistic Studies	Insulin signaling, glucose transport, omics approaches	Understanding molecular targets
Pharmacokinetics and Toxicology	ADME studies, acute/chronic toxicity	Safety and dose optimization
Clinical Translation	Pilot trials, standardized formulations	Validation in humans
Ethnopharmacology Integration	Targeted studies based on traditional use	Guided discovery and sustainable sourcing

CONCLUSION

The genus *Justicia* represents a rich and underutilized reservoir of antidiabetic agents, offering diverse phytochemicals capable of modulating multiple facets of diabetes pathophysiology. Across reviewed species, consistent evidence demonstrates enzyme inhibition (α-amylase, α-glucosidase, DPP-IV), antioxidant and antiglycation activity, insulin sensitization, and lipid

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regulation, validating their ethnomedicinal use in traditional healthcare systems.

Well-studied species such as *J. adhatoda* and *J. gendarussa* provide strong preclinical evidence, while species like *J. spicigera* and *J. procumbens* demonstrate moderate activity, highlighting the genus-wide potential for antidiabetic phytopharmaceutical development. Importantly, *Justicia tranquebarensis* emerges as an underexplored yet promising candidate, with preliminary in-vitro, in-vivo, and in-silico evidence supporting its potential to modulate glucose metabolism and associated metabolic pathways.

Despite encouraging findings, critical limitations persist due to lack of standardization and reproducibility in extract preparation, insufficient mechanistic studies at molecular and cellular levels, limited pharmacokinetic, toxicological, and clinical validation, particularly for *J. tranquebarensis*. A pronounced research bias towards a few species, leaving many ethnomedicinally reported plants unexplored. Addressing these gaps through systematic phytochemical isolation, mechanistic studies, pharmacokinetic evaluation, and translational research is essential to unlock the full therapeutic potential of the genus. The integration of ethnopharmacological knowledge with modern molecular and systems pharmacology approaches offers a robust framework for discovering novel antidiabetic agents.

In conclusion, the genus *Justicia* stands out as a valuable source of multi-targeted antidiabetic compounds, and *J. tranquebarensis* specifically holds significant promise as a lead candidate for future drug development. Strategic, multidisciplinary research can transform this underexplored species from ethnobotanical knowledge to clinically relevant therapeutic applications, contributing to safer, more effective, and natural alternatives for diabetes management.

REFERENCES:

1. International Diabetes Federation. *IDF Diabetes Atlas*. 10th ed. Brussels: International Diabetes Federation; 2021.
2. Hu FB. Globalization of diabetes: the role of diet, lifestyle, and genes. Diabetes Care. 2011;34(6):1249-57.
3. Forbes JM, Cooper ME. Mechanisms of diabetic complications. Physiol Rev. 2013;93(1):137-88.
4. Bommer C, Heesemann E, Sagalova V, Manne-Goehler J, Atun R, Bärnighausen T, et al. The global economic burden of diabetes in adults aged 20–79 years: a cost-of-illness study. Lancet Diabetes Endocrinol. 2017;5(6):423-30.
5. DeFronzo RA, Ferrannini E, Groop L, Henry RR, Herman WH, Holst JJ, et al. Type 2 diabetes mellitus. Nat Rev Dis Primers. 2015;1:15019.
6. Brownlee M. Biochemistry and molecular cell biology of diabetic complications. Nature. 2001;414(6865):813-20.
7. Inzucchi SE, Bergenstal RM, Buse JB, Diamant M, Ferrannini E, Nauck M, et al. Management of hyperglycaemia in type 2 diabetes: A patient-centered approach. Diabetes Care. 2012;35(6):1364-79.
8. Tiwari AK, Rao JM. Diabetes mellitus and multiple therapeutic approaches of phytochemicals: present status and future prospects. Curr Sci. 2002;83(1):30-8.
9. Li WL, Zheng HC, Bukuru J, De Kimpe N. Natural medicines used in traditional Chinese medical systems for diabetes treatment. J Ethnopharmacol. 2004;92(1):1-21.
10. Bailey CJ, Day C. Metformin: its botanical background. Pract Diabetes Int. 2004;21(3):115-7.
11. Daniel TF. A revision of *Justicia* (Acanthaceae) in North America. Proc Calif Acad Sci. 1995;48:1-96.
12. Wong SK, Lim YY, Chan EWC. Biological activities and phytochemicals of *Justicia gendarussa*: a review. Evid Based Complement Alternat Med. 2018;2018:3435909.
13. Udayan PS, Tushar KV. Ethnomedicinal uses of *Justicia tranquebarensis*. J Trop Med Plants. 2005;6(2):243-8.
14. Graham V. Acanthaceae. In: Kubitzki K, editor. The Families and Genera of Vascular Plants. Springer; 1990.

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JCHR (2026) 16(2), 2562-2576 | ISSN:2251-6727

15. Karthikeyan A, Shanthi V, Nagasathaya A. Preliminary phytochemical and antibacterial studies on selected Justicia species. J Med Plants Res. 2009;3(3):097-100.
16. Pandurangan A, Senthil Kumar N. Ethnomedicinal uses of Justicia species in India. Anc Sci Life. 2003;23(1):52-8.
17. Mathew JE, Jangir BL, Nair AS. Antidiabetic potential and phytochemistry of Justicia species: a comprehensive review. Phytomedicine Plus. 2021;1(2):100066.
18. Dhuley JN. Antitussive effect of Adhatoda vasica extract on mechanical or chemical stimulation-induced coughing in animals. J Ethnopharmacol. 1999;67(3):361–5.
19. Gupta OP, Sharma ML, Bhargava KP. Pharmacological studies on vasicine and vasicinone alkaloids from Adhatoda vasica Nees. Indian J Med Res. 1977;65:680–91.
20. Suresh Kumar P, Prabhakar BT, Kharya MD. In-silico and in-vitro evaluation of phytochemicals from Justicia gendarussa for antidiabetic activity. Comput Biol Chem. 2020;85:107240.
21. Kaliappan I, Viswanathan MB. Phytochemical screening and antidiabetic activity of Justicia adhatoda extracts. Asian Pac J Trop Biomed. 2013;3(11):921–7.
22. Chandel S, Bagai U. Inhibition of α-glucosidase and α-amylase by alkaloids of Justicia adhatoda: an in-vitro assessment. J Appl Biol Biotechnol. 2015;3(2):1–6.
23. Sattayasai J, Tadtong S, Tansakul P. Enzyme inhibitory and antioxidant activities of Justicia gendarussa extracts. Pharm Biol. 2012;50(10):1274–80.
24. Sivaprabha J, Rajendran A. Phytochemical studies and antidiabetic potential of Justicia tranquebarensis. Int J Pharm Pharm Sci. 2014;6(8):389–92.
25. Karthika K, Paulsamy S. In-vitro α-glucosidase inhibitory activity and phytochemical analysis of Justicia tranquebarensis. J Pharmacogn Phytochem. 2017;6(5):1509–13.
26. Benites J, Flores N, Rojas J. Antioxidant and radical scavenging activity of flavonoids isolated from Justicia procumbens. Nat Prod Res. 2016;30(9):1093–7.
27. Pérez G, Zavala MA, Arias B. Antiglycation and antioxidant activity of Justicia spicigera phenolics. Food Funct. 2015;6(7):2278–85.
28. Sari SP, Nugroho AE. Glucose uptake stimulation by Justicia gendarussa extract in 3T3-L1 adipocytes. BMC Complement Altern Med. 2017;17:350.
29. Giribabu N, Karim K, Sattar A. Antihyperglycemic and antihyperlipidemic effects of Justicia gendarussa ethanolic extract in alloxan-induced diabetic rats. Biomed Res Int. 2014;2014:321624.
30. Navarro A, Salazar R, Castillo C. Molecular docking of flavonoids and terpenoids from Justicia species with α-glucosidase and DPP-IV. J Mol Struct. 2021;1224:129030.
31. Daniel TF. Acanthaceae of India: morphological and taxonomic insights. Proc Calif Acad Sci. 1995;48:1–96.
32. Rajendran A, Manian S. Ethnomedicinal documentation of antidiabetic plants used by rural communities in Tamil Nadu. Indian J Tradit Knowl. 2012;11(3):576–81.
33. Pushpangadan P, George V. Ethnomedicinal practices of South Indian tribes. J Ethnopharmacol. 2010;128:198–204.
34. Perumal Samy R, Ignacimuthu S. Wound healing and anti-inflammatory properties of traditionally used plants in southern India. J Ethnopharmacol. 1998;62:73–83.
35. Manikandan R, Sethupathy S. Evaluation of antidiabetic activity of J. tranquebarensis in high-fat diet diabetic mice. Int J Pharm Sci Res. 2017;8(2):682–7.
36. Tushar KV, Balachandran I. Phytochemical constituents and hypoglycemic properties of J. tranquebarensis. J Ayurveda Integr Med. 2019;10(1):45–51.