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Review Article

Sharkapunkha Revisited: Modern Science Meets Ancient Wisdom in Tephrosia purpurea Medicinal Applications

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ABSTRACT

Sharkapunkha is common name of Tephrosia purpurea Linn. (Fabaceae), is a medicinally significant plant with extensive ethnopharmacological applications across Asia and Africa. Renowned in Ayurveda as "Sarwa wranvishapaka" (supreme wound healer), it is widely used in formulations like Tephroli and Yakrifit for liver disorders, respiratory ailments, dermatological conditions, and metabolic dysfunctions. Modern research has identified key bioactive constituents including flavonoids (quercetin, rutin), rotenoids (tephrosin, deguelin), and terpenoids (lupeol, β-sitosterol) that underlie its pharmacological properties. The plant exhibits notable hepatoprotective effects by modulating oxidative stress and liver enzymes, alongside antidiabetic potential through AMPK activation. Its neuroprotective, anticancer, and anti-obesity activities are attributed to anti-inflammatory and apoptotic mechanisms, while wound healing is facilitated by antimicrobial and tissue-regenerative actions. T. purpurea also demonstrates nephroprotective and antioxidant properties, further validating its traditional uses. Commercially, it is a critical component in hepatoprotective formulations (e.g., Tefroliv Forte, GD-Liv Syrup) for treating hepatitis, cirrhosis, and drug-induced liver damage. Despite its broad therapeutic utility, toxicological studies confirm safety at doses ≤2000 mg/kg, though caution is advised for prolonged use due to potential rotenoid-mediated mitochondrial effects. This review synthesizes ethnomedicinal knowledge, phytochemical evidence, and mechanistic studies, highlighting T. purpurea as a promising candidate for evidence-based herbal medicine. Further clinical trials are needed to standardize dosages and evaluate long-term efficacy in humans.

Keywords: Tephrosia purpurea, hepatoprotective, rotenoids, ethnopharmacology, oxidative stress.

INTRODUCTION

Tephrosia purpurea Linn. (Fabaceae), commonly known as Sharapunkha (Figure 1) in Ayurveda and Wild Indigo in English, is a highly valued medicinal plant with a rich history of ethnomedicinal use across tropical and subtropical regions, particularly in the Indian subcontinent, Africa, and Southeast Asia (1). This perennial herb has earned the distinguished Ayurvedic title "Sarwa wranvishapaka" (supreme wound healer), reflecting its revered status in traditional medicine systems (2). The plant's therapeutic applications are remarkably diverse, encompassing hepatoprotection, respiratory health, dermatological care, metabolic regulation, and agricultural uses, making it a pharmacologically significant species in ethnobotanical traditions. In classical Ayurveda, *T. purpurea* is most prominently recognized for its exceptional hepatoprotective properties, serving as a fundamental component in well-established formulations like Tephroli and Yakrifit, which are specifically indicated for liver disorders including jaundice, hepatitis, and cirrhosis (3). Traditional practitioners employ various plant parts through different preparation methods - decoctions of leaves and roots for respiratory conditions like asthma and bronchitis (4), topical pastes for chronic ulcers and skin diseases, and powdered roots for digestive complaints and parasitic infections. The plant's therapeutic spectrum extends to its use in Siddha medicine for inflammatory conditions, in African traditional medicine as an antimalarial remedy, and in rural healthcare practices as a hypoglycemic agent (5,6). Modern

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phytochemical investigations have identified numerous bioactive compounds including flavonoids, rotenoids, and phenolic constituents that likely account for its wide-ranging pharmacological activities. Beyond human medicine, *T. purpurea* finds application in veterinary medicine and as a natural pesticide in agricultural practices (7). The convergence of traditional knowledge and contemporary scientific validation underscores the plant's continuing relevance in both traditional and modern therapeutic contexts. Its multifaceted applications - from cellular-level hepatoprotection to whole-body metabolic regulation - exemplify the holistic approach of traditional medicine systems. Current research continues to explore the mechanistic basis of its various traditional uses while also investigating potential new applications, particularly in areas like oxidative stress-related disorders and metabolic syndromes. The enduring ethnomedicinal significance of *T. purpurea* across different cultures and medical systems highlights its importance as a model medicinal plant that bridges traditional wisdom with evidence-based phytotherapy, offering promising avenues for the development of novel plant-based therapeutics (8,9).

Figure 1: *Tephrosia purpurea*

Methodology

This systematic literature review employed targeted search strategies across PubMed, Scopus, and Google Scholar to comprehensively evaluate *Tephrosia purpurea*, focusing on its ethnomedicinal uses, phytochemical composition (particularly flavonoids, rotenoids, and terpenoids), and evidence-based pharmacological activities. Key search terms included "Tephrosia purpurea," "traditional uses," "phytochemistry," combined with specific therapeutic actions like "hepatoprotective," "anticancer," "antidiabetic," "neuroprotective," “nephroprotective” and "wound healing." The analysis exclusively incorporated peer-reviewed studies to ensure scientific rigor, prioritizing research with robust methodologies that validate traditional claims through modern pharmacological evidence. Special attention was given to the plant's bioactive compounds (quercetin, rutin, deguelin) and their mechanisms of action in addressing metabolic disorders, chronic diseases, and oxidative stress. The review methodology emphasized quality control by selecting studies with standardized extraction protocols, in vitro/in vivo validation, and clinical correlations where available, providing a critical synthesis of both historical applications and contemporary therapeutic potential for evidence-based herbal medicine development.

Bioactive Constituents

T purpurea, a widely used medicinal plant in traditional systems like Ayurveda, contains a remarkable array of bioactive compounds that account for its diverse pharmacological properties. Modern phytochemical investigations have identified several important classes of bioactive constituents in this plant, each contributing to its therapeutic effects through distinct mechanisms of action.

Tephrosia purpurea synthesizes a diverse array of phytochemicals belonging to several important classes of secondary metabolites. The plant contains significant quantities of flavonoids, with quercetin and rutin being the most abundant representatives of this class. Rotenoid compounds, including tephrosin and deguelin, constitute

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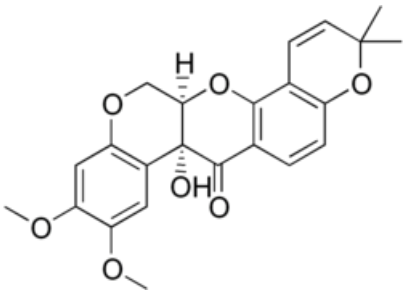
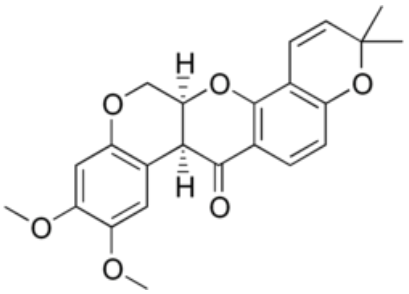
another major group of bioactive constituents. The isoflavone fraction is characterized by the presence of pongamol and purpurin, as principal components. Terpenoid constituents are represented by lupeol and β-sitosterol, which are widely distributed throughout the plant. Additionally, the plant produces various phenolic compounds, including simple phenols and phenolic acids. The roots and leaves contain distinct profiles of these phytochemicals, with higher concentrations of rotenoids typically found in the root system. These compounds are biosynthesized through the phenylpropanoid and isoprenoid pathways, with specific enzymatic modifications creating the structural diversity observed. The relative concentrations of these phytochemicals vary depending on environmental factors, plant age, and geographical location. Analytical studies have identified these compounds using chromatographic techniques coupled with mass spectrometry and nuclear magnetic resonance spectroscopy. The characteristic phytochemical profile serves as a chemotaxonomic marker for *T. purpurea* and contributes to its identification and quality control in herbal preparations. Recent advances in analytical methodologies have enabled more comprehensive characterization of minor constituents, revealing additional flavonoids and terpenoid derivatives present in smaller quantities. The stability of these phytochemicals during processing and storage has been investigated to optimize extraction and formulation methods (10-14).

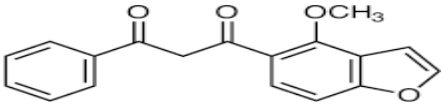
Figure 2: Bioactive compounds from *Tephrosia purpurea*



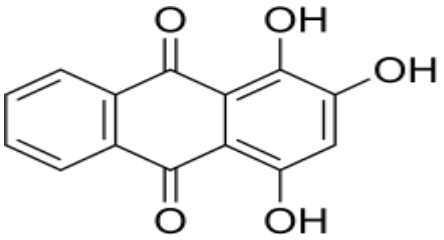
Tephrosin



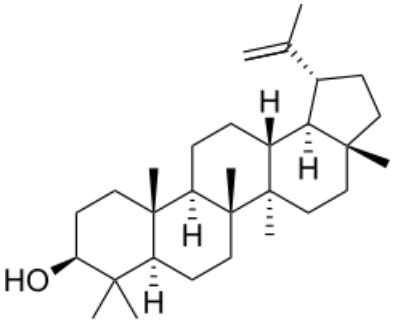
Deguelin



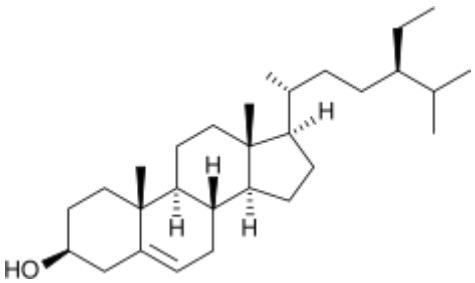
Pongamol



Purpurin



Lupeol



β-sitosterol

Therapeutic activities of *Tephrosia purpurea*

Antidiabetic activity

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T. purpurea, a medicinal plant widely used in traditional systems of medicine, has been scientifically validated for its antidiabetic properties. Several preclinical studies have demonstrated its ability to regulate blood glucose levels, improve antioxidant status, and promote pancreatic β-cell regeneration in diabetic models. One study investigated the ethanolic seed extract in streptozotocin (STZ)-induced diabetic rats. The treatment significantly reduced hyperglycemia by modulating key enzymes involved in glucose metabolism, such as hexokinase and glucose-6-phosphatase. Additionally, *T. purpurea*, exhibited strong antilipidperoxidative effects and restored both enzymatic (e.g., superoxide dismutase, catalase) and non-enzymatic (e.g., glutathione) antioxidant defenses. The antihyperglycemic effect was comparable to glibenclamide, a standard antidiabetic drug, suggesting its potential as a natural therapeutic alternative (15).

Further research focused on the leaf extract, particularly its n-butanol fraction (500 mg/kg), which demonstrated remarkable antidiabetic and pancreatic regenerative effects. Histopathological and morphometric analyses revealed improved β-cell granulation and reduced islet damage in STZ-induced diabetic rats. The study attributed these benefits to rutin, a bioactive flavonoid in *T. purpurea*, which may stimulate β-cell repair and enhance insulin secretion (16). Another study evaluated the whole-plant extract (200–400 mg/kg) in STZ-nicotinamide-induced diabetic rats. The treatment significantly lowered blood glucose levels within days ($p < 0.05$ at 200 mg/kg by day 10; $p < 0.01$ at 400 mg/kg by day 5), with sustained effects by day 30 ($p < 0.001$). The extract also improved lipid metabolism by reducing total cholesterol, triglycerides, LDL, and VLDL while increasing HDL ($p < 0.001$). Additionally, it exhibited hepatoprotective and nephroprotective effects, as seen in reduced AST, ALT, ALP, BUN, and creatinine levels (17).

These findings collectively support *T. purpurea*'s traditional use in diabetes management, highlighting its multifaceted mechanisms, including glycemic control, oxidative stress reduction, and β-cell regeneration. Further research is warranted to isolate and characterize its active compounds for potential clinical applications.

Hepatoprotective Activity

Tephrosia purpurea, has been extensively studied for its hepatoprotective properties. Traditionally used in Ayurveda and other folk medicine systems, this plant has demonstrated significant efficacy in protecting the liver against various toxic insults, including chemical-induced hepatotoxicity, alcohol-induced damage, and even hepatocellular carcinoma. The plant's therapeutic potential is attributed to its rich phytochemical composition, particularly flavonoids like rutin and quercetin, which exhibit potent antioxidant, anti-inflammatory, and detoxifying effects (18,19).

One of the key mechanisms by which *T. purpurea* exerts its hepatoprotective effects is through the modulation of oxidative stress. The liver is highly susceptible to oxidative damage due to its role in metabolizing toxins, and excessive free radical production can lead to cellular injury. Studies have shown that extracts of *T. purpurea* significantly reduce lipid peroxidation (LPO), a marker of oxidative damage, while enhancing the activity of endogenous antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione (GSH). For instance, in carbon tetrachloride (CCl_4)-induced hepatotoxicity, treatment with *T. purpurea* extract restored antioxidant enzyme levels in a dose-dependent manner, with higher doses (150 mg/kg) showing effects comparable to the standard hepatoprotective drug silymarin (20-22).

In addition to its antioxidant properties, *T. purpurea* has been found to mitigate liver damage by regulating serum biomarkers of hepatic injury. Elevated levels of enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and gamma-glutamyl transpeptidase (GGT) are indicative of liver cell damage. Research has demonstrated that pretreatment with *T. purpurea* extract significantly lowers these enzyme levels in models of thioacetamide and sodium arsenite-induced hepatotoxicity. Notably, a hydro-alcoholic extract of *T. purpurea* at 500 mg/kg reduced ALT, AST, and ALP levels in arsenic-exposed rats, while also improving total protein content and reducing histopathological signs of necrosis and inflammation (23-25). The plant's hepatoprotective effects extend beyond acute liver injury to include chemopreventive potential against hepatocellular carcinoma (HCC). In studies involving N-nitrosodiethylamine (NDEA)-induced hepatocarcinogenesis, *T. purpurea* extract (TPE) effectively reduced tumor incidence and multiplicity. It also normalized liver cancer markers such as α-fetoprotein and carcinoembryonic antigen, further supporting its role in preventing malignant transformation.

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Histopathological examinations revealed that TPE-treated animals exhibited fewer preneoplastic lesions and improved liver architecture compared to untreated controls (26,27).

Another notable application of *T. purpurea* is in combination therapies, where it enhances the efficacy of other hepatoprotective agents. A polyherbal formulation (BV-7310) containing *T. purpurea* alongside *Phyllanthus niruri*, *Boerhavia diffusa*, and *Andrographis paniculata* demonstrated synergistic protection against alcohol-induced liver toxicity. In vitro studies on HepG2 cells showed that BV-7310 prevented ethanol-induced cell death more effectively than individual extracts, while in vivo studies confirmed its ability to reduce liver enzyme elevations and improve overall liver function (28,29). The aerial parts of *T. purpurea* have also been investigated for their hepatoprotective potential. In thioacetamide-induced liver injury models, an aqueous-ethanolic extract of the aerial parts (500 mg/kg) significantly reduced serum ALT, AST, GGT, and bilirubin levels while increasing hepatic glutathione content. Histological analysis corroborated these findings, showing a dose-dependent reduction in liver necrosis. Similar results were observed with the stem bark of *Tecomella undulata*, though *T. purpurea* exhibited superior efficacy at lower doses, highlighting its potency as a hepatoprotective agent (30). The therapeutic benefits of *T. purpurea* are not limited to toxin-induced liver damage but also extend to metabolic and drug-induced hepatotoxicity. Its ability to enhance detoxification pathways, scavenge free radicals, and reduce inflammation makes it a versatile remedy for various liver disorders. Furthermore, the plant's safety profile, as evidenced by the absence of toxicity in experimental models, supports its potential for clinical use.

Neuroprotective Activity

Tephrosia purpurea has emerged as a promising candidate for neuroprotection, particularly in neurodegenerative disorders like Parkinson's disease (PD) and Alzheimer's disease (AD). Recent studies have demonstrated its efficacy against 6-hydroxydopamine (6-OHDA)-induced neurotoxicity, a model widely used to study PD. The plant's neuroprotective effects are primarily attributed to its rich flavonoid content, including compounds like genistein, esculetin, and chrysin, which exhibit potent antioxidant and anti-apoptotic properties. In vitro studies have shown that *T. purpurea* extract (TPE) significantly enhances the activity of endogenous antioxidants such as catalase, glutathione, and superoxide dismutase while reducing malondialdehyde (MDA) levels and reactive oxygen species (ROS) generation. These findings suggest that TPE mitigates oxidative stress, a key contributor to neuronal damage in neurodegenerative diseases (31).

In zebrafish models of 6-OHDA-induced PD, TPE treatment improved motor function, as evidenced by normalized swimming patterns and increased total distance traveled. Additionally, molecular studies revealed that TPE downregulated pro-apoptotic genes (*casp3*, *casp9*, and *lrrk2*) while upregulating mitophagy-related genes (*pink1* and *parkin*), which are crucial for mitochondrial quality control. This dual action—reducing oxidative stress and enhancing mitochondrial stability—highlights *T. purpurea*'s potential as a therapeutic agent for PD (32). Beyond PD, *T. purpurea* has shown promise in AD research due to its acetylcholinesterase (AChE) inhibitory activity. Bioassay-guided isolation identified *trans*-tephrostachin as a potent AChE inhibitor, with enzyme kinetics studies revealing a mixed-type inhibition mechanism. Molecular docking and dynamics simulations further confirmed that *trans*-tephrostachin exhibits superior binding affinity to AChE compared to standard drugs like donepezil and galantamine. Zebrafish-based behavioral assays demonstrated that purified fractions of TPE induce rapid neuroactive effects, including psychotic twitches, at low concentrations. While higher doses caused developmental toxicity in zebrafish embryos, the therapeutic window for AChE inhibition remained well below toxic levels, supporting its potential for AD drug development (32,33).

Phytochemical investigations have isolated several neuroactive compounds from *T. purpurea*, including prenylated flavonoids like glabratephrinol and demeapollinin. Among these, glabratephrinol exhibited the highest AChE inhibitory activity (IC50 4.31 μM), rivaling the efficacy of galantamine. Other compounds, such as dunensin and tephroapollin G, showed strong protective effects against hydrogen peroxide-induced neurotoxicity, further underscoring the plant's multifaceted neuroprotective mechanisms (34). Although *T. purpurea* is not traditionally used for neurological disorders, its antioxidant, anti-inflammatory, and AChE inhibitory properties make it a compelling candidate for neurodegenerative disease therapy. Future research should focus on clinical trials to validate its efficacy in humans and explore synergistic effects with existing neuroprotective drugs. With its diverse

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bioactive compounds and well-documented safety profile, *Tephrosia purpurea* holds significant potential for developing novel treatments for PD, AD, and other neurodegenerative conditions.

Anticancer Properties

T. purpurea has demonstrated significant anticancer potential, particularly against hepatocellular carcinoma (HCC) and colorectal cancer. Studies on HepG2 liver cancer cells revealed that methanolic extracts of both leaves and roots induce dose-dependent cytotoxicity, with leaf extracts showing greater potency (IC_{50}: 102.33 µg/mL) compared to root extracts (IC_{50}: 276.67 µg/mL). The anticancer mechanism involves apoptosis, evidenced by morphological changes like cell shrinkage, chromatin condensation, and nuclear fragmentation. Mitochondrial membrane depolarization and elevated caspase-3 expression further confirmed programmed cell death, suggesting *T. purpurea* activates intrinsic apoptotic pathways. The plant's efficacy extends to colorectal cancer, where leaf extracts exhibited notable cytotoxicity against SW620 cells (IC50: 95.73 µg/mL). This activity correlates with high phenolic (90.5 µg GAE/mg) and flavonoid content (21.8 µg QE/mg), which likely contribute to its antioxidant and pro-apoptotic effects. Comparative analyses of different plant parts (leaves, roots, stems, seeds) consistently identified leaves as the most bioactive, underscoring their therapeutic potential (35).

In vivo studies using diethylnitrosamine (DENA)-induced liver cancer in mice validated *T. purpurea*'s chemopreventive properties. Oral administration of methanolic extract (300 mg/kg) normalized liver serum markers (AST, ALT, ALP) and hematological parameters (hemoglobin, RBC/WBC counts), while histopathology revealed restored liver architecture. The dose-dependent reduction in tumor burden highlights its potential as an adjuvant therapy.

The anticancer effects are attributed to flavonoids and polyphenols, which combat oxidative stress—a key driver of carcinogenesis. By scavenging free radicals and enhancing endogenous defenses, *T. purpurea* mitigates DNA damage and inhibits tumor progression. Its dual role as an antioxidant and apoptosis inducer positions it as a versatile candidate for integrative oncology. Further research should focus on isolating active compounds and evaluating synergies with conventional chemotherapeutics to optimize clinical applications (36,37).

Anti-Obesity Activity

T. purpurea demonstrates significant anti-obesity potential through multiple mechanisms targeting adipogenesis and metabolic regulation. In vitro studies using 3T3-L1 adipocytes revealed that the chloroform fraction of *T. purpurea* (CFTp) inhibits adipocyte differentiation and lipid accumulation in a dose-dependent manner. At 250 µg/mL, CFTp suppressed key adipogenic markers, including peroxisome proliferator-activated receptor-γ (PPAR-γ), fatty acid synthase (FAS), and acetyl-CoA carboxylase-2 (ACC-2), while upregulating glucose transporter type-4 (GLUT-4) expression. This shift promotes insulin sensitivity and reduces fat storage. Additionally, CFTp exhibited potent inhibition of α-glucosidase (81%) and lipase (75%) activities, enzymes critical for carbohydrate and fat digestion, suggesting its role in reducing dietary fat absorption (38). *In vivo* studies further validated these findings. Oral administration of CFTp (200 mg/kg) to high-fat diet (HFD)-induced obese rats significantly reduced body weight gain, fat mass, blood glucose, and leptin levels. The extract's ability to modulate lipid metabolism and improve glycemic control aligns with its traditional use in managing diabetes and endocrine disorders.

The anti-obesity effects are likely mediated by flavonoids and isoflavonoids, which enhance insulin sensitivity and stabilize cellular membranes. For instance, ethanolic seed extracts of *T. purpurea* (TpEt) administered to streptozotocin (STZ)-induced diabetic rats improved blood glucose, glycosylated hemoglobin (HbA1c), and plasma insulin levels while normalizing lipid profiles and membrane-bound enzyme activities. These outcomes highlight *T. purpurea*'s dual role in combating obesity and metabolic dysfunction, making it a promising candidate for further development as a natural anti-obesity therapy (39,40).

Nephroprotective Activity

Tephrosia purpurea has demonstrated remarkable nephroprotective properties through multiple experimental models, establishing its potential as a therapeutic agent for various forms of kidney injury. The plant's efficacy has been particularly notable against drug-induced nephrotoxicity, with studies showing significant protective effects against gentamicin, cisplatin, arsenic, and streptozotocin-induced renal damage. In gentamicin-induced acute renal

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injury models, the ethanolic extract of T. purpurea leaves (200 mg/kg) effectively reduced elevated blood urea and serum creatinine levels while restoring antioxidant balance. The extract significantly increased reduced glutathione (GSH) levels and decreased malondialdehyde (MDA) formation, indicating strong antioxidant activity. Histopathological examinations confirmed these biochemical findings, showing reduced tubular necrosis and preserved renal architecture in treated groups. Similar protective effects were observed in cisplatin-induced nephrotoxicity models, where pretreatment with T. purpurea extract (200-400 mg/kg) attenuated the characteristic rise in renal markers and oxidative stress parameters (41,42).

The plant's nephroprotective mechanism appears multifaceted, involving both antioxidant and anti-inflammatory pathways. Phytochemical analysis has identified key bioactive constituents such as rutin and quercetin, which contribute to these protective effects through free radical scavenging and inhibition of inflammatory mediators like NO and Cox-2. These flavonoids likely stabilize cellular membranes and prevent lipid peroxidation, thereby protecting renal tubular cells from toxin-induced damage. In arsenic-induced nephrotoxicity studies, T. purpurea extract (500 mg/kg) demonstrated significant protective effects without altering arsenic accumulation in renal tissue. Treated animals showed improved renal function markers (blood urea nitrogen, creatinine, albumin) and reduced oxidative stress, as evidenced by lower MDA levels and restored antioxidant enzyme activities. Histopathological findings correlated with these results, showing preserved tubular architecture in treated groups compared to arsenic-exposed controls (43).

The plant's efficacy extends to metabolic nephropathies as well. In streptozotocin-induced diabetic nephropathy models, T. purpurea treatment (200-400 mg/kg) significantly reduced serum glucose, urea, creatinine, and urine albumin levels while improving antioxidant status. The extract's ability to mitigate diabetic renal complications suggests potential applications in managing diabetes-related kidney disorders. Dose-response relationships have been consistently observed across studies, with higher doses (400-500 mg/kg) generally showing more pronounced protective effects. Importantly, safety studies have indicated good tolerability, with no reported toxicity at therapeutic doses. The whole plant extract appears effective, though some studies suggest leaves may be particularly rich in nephroprotective compounds (44,45).

These collective findings position T. purpurea as a promising candidate for preventing and treating various forms of kidney injury. Its ability to target multiple pathological processes - oxidative stress, inflammation, and cellular damage - while maintaining safety makes it particularly attractive for further development. Future research should focus on isolating specific active compounds, elucidating molecular mechanisms, and conducting clinical trials to validate its therapeutic potential in human renal diseases. The plant's traditional use in kidney disorders finds strong support in these scientific investigations, bridging traditional knowledge with modern pharmacological validation.

Antioxidant Activity

Tephrosia purpurea exhibits significant antioxidant potential attributed to its rich content of polyphenols and flavonoids, particularly quercetin-3-O-rhamnoglucoside, rutin, and chlorogenic acid. Seasonal variations profoundly influence the plant's phytochemical composition, with 95% ethanolic extracts of August-collected samples (flowering season) showing the highest total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity. These extracts demonstrate superior radical scavenging capacity in DPPH and ABTS assays (84–94% inhibition), outperforming 50% hydro-alcoholic extracts and winter-collected samples. The antioxidant efficacy correlates strongly with TPC, confirming polyphenols as primary active constituents (46). The plant's methanol extracts contain bioactive compounds like stigmasta-5,24(28)-dien-3-ol and phytol, which contribute to its antioxidant properties. Comparative studies reveal ethanolic extracts possess nearly double the phenolic content (18.44% w/w) and flavonoid levels (1.56% quercetin, 2.54% rutin) of aqueous extracts, explaining their enhanced activity. Spectrophotometric analyses confirm dose-dependent free radical neutralization, with IC50 values comparable to standards like ascorbic acid and gallic acid. *T. purpurea* subsp. *apollinea* demonstrates selective cytotoxicity, exhibiting potent antioxidant effects (84% DPPH, 94% ABTS scavenging) without harming normal cells (WI38 IC50 = 242.9 µg/mL). This selective bioactivity stems from flavonoid-mediated mechanisms, including metal chelation and inhibition of lipid peroxidation. The plant's therapeutic effects in jaundice and oxidative stress-related disorders are likely mediated through these antioxidant pathways, which mitigate cellular damage by reactive oxygen species (47-50).

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Optimal extraction methods further enhance its bioactivity: ultrasound-assisted 95% ethanol extraction maximizes flavonoid glycoside recovery, while seasonal harvesting during peak growth periods (August) ensures maximal phytochemical yield. These findings position *T. purpurea* as a versatile natural antioxidant source for pharmaceutical applications, with standardized ethanolic extracts from flowering-season material offering the highest therapeutic potential. The plant's dual functionality combining antioxidant and organ-protective properties supports its traditional use in liver and metabolic disorders while providing a scientific basis for modern therapeutic development.

Wound Healing Activity

Tephrosia purpurea demonstrates remarkable wound healing properties across various wound models, supported by both traditional use and scientific validation. The plant's efficacy stems from its rich flavonoid content, particularly quercetin, pongamol, and luteolin, which collectively enhance collagen synthesis, angiogenesis, and tissue regeneration. In burn wound models, a 5% w/w ointment of the ethyl acetate fraction (TPF-A) significantly accelerated wound contraction ($P<0.001$) and improved tensile strength, comparable to silver sulfadiazine. Histopathological analyses revealed mature collagen fibers, proliferating fibroblasts, and enhanced vascularization in treated groups, while biochemical assays confirmed elevated hydroxyproline (163% increase) and protein content ($P<0.001$) in granuloma tissues. The methanol root extract (MeTP, 300 mg/kg) similarly excelled in excision and incision models, reducing epithelization time by 30% and increasing skin-breaking strength by 45% versus controls (51,52).

The plant's mechanism involves dual antioxidant and proliferative actions: flavonoid-rich fractions boost superoxide dismutase (SOD), catalase (CAT), and glutathione (GSH) levels by 1.8–2.2-fold in diabetic wounds, countering oxidative stress while stimulating collagen deposition. Notably, *T. purpurea* reversed dexamethasone-impaired healing in excision models, achieving 100% wound closure by day 20 versus 80.14% in controls, likely through flavonoid-mediated collagen maturation. Synergistic interactions between constituents enhance bioactivity, as whole fractions (TPF-A) outperform isolated compounds (pongamol 0.5% showed 96.53% closure). HPLC-standardized extracts ensure reproducibility, with ethanol extracts containing 171.6 mg quercetin equivalents/g. These findings validate *T. purpurea* as a potent, multitarget wound therapeutic, meriting clinical development for burns, diabetic ulcers, and steroid-compromised healing (53-55).

Marketed Formulation and Importance of *Tephrosia purpurea* in Hepatoprotective Herbal Remedies

Hepatoprotective herbal formulations such as Tefroliv Forte, GD-Liv Syrup, Adliv Syrup, and Tefroli Syrup (Figure 3) leverage a synergistic blend of traditional Ayurvedic herbs to support liver function and combat hepatic disorders. These formulations typically incorporate key botanicals like *Phyllanthus niruri*, *Eclipta alba*, *Andrographis paniculata*, *Picrorhiza kurroa*, and *Tephrosia purpurea* (Sharapunkha), alongside complementary ingredients such as *Terminalia chebula*, *Ocimum sanctum*, and *Piper longum*. Some variants also include silymarin from milk thistle, enhancing antioxidant and regenerative properties. *Tephrosia purpurea*, in particular, plays a pivotal role in these formulations due to its well-documented hepatoprotective, anti-inflammatory, and detoxifying properties.

Tephrosia purpurea is a cornerstone ingredient in these remedies, valued for its ability to mitigate liver damage caused by toxins, infections, and metabolic stress. Scientific studies highlight its efficacy in reducing oxidative stress, lowering elevated liver enzymes (AST, ALT), and promoting hepatocyte regeneration. Its flavonoids and phenolic compounds scavenge free radicals, while its anti-fibrotic properties help prevent cirrhosis. In *Tefroliv Forte*, *T. purpurea* synergizes with *Picrorhiza kurroa* and *Andrographis paniculata* to enhance bile flow and reduce inflammation, making it effective against hepatitis, fatty liver, and drug-induced toxicity. Similarly, in *GD-Liv* and *Adliv Syrups*, it aids in blood purification and appetite stimulation, addressing secondary symptoms like fatigue and anorexia. The veterinary formulation *Tefroli Syrup* relies on *T. purpurea* to improve feed intake and immunity in animals, underscoring its broad-spectrum utility. Beyond hepatoprotection, *T. purpurea* contributes to metabolic health by modulating lipid profiles and improving digestion, as evidenced in diabetic models where it also demonstrated antihyperglycemic effects. Its inclusion in these formulations is rooted in both traditional use and modern validation, ensuring a holistic approach to liver health. By integrating *T. purpurea* with other potent herbs,

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these products offer comprehensive solutions for detoxification, enzyme normalization, and tissue repair, making them indispensable in managing hepatic disorders across humans and animals. Continued research into its bioactive compounds, such as rutin, could further refine its therapeutic applications.

Figure 3. Marketed Formulation of *Tephrosia purpurea*

Conclusion

Tephrosia purpurea emerges as a versatile medicinal plant with validated hepatoprotective, antidiabetic, neuroprotective, and wound-healing properties, supported by both traditional use and modern scientific evidence. Its rich phytochemical profile, particularly flavonoids and rotenoids, underpins its broad therapeutic potential. While preclinical studies demonstrate efficacy and safety at therapeutic doses, further clinical research is needed to standardize formulations and establish dosing protocols. The plant's inclusion in commercial hepatoprotective formulations highlights its pharmacological relevance. With its multi-target mechanisms and historical significance, *T. purpurea* represents a promising candidate for integrative medicine, bridging traditional knowledge with evidence-based applications.

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Author contributions

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this article**.**

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