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Research Article

PHYTOCHEMISTRY AND PHARMACOLOGICAL INSIGHTS INTO *CYPERUS ROTUNDUS* L.: A MEDICINALLY IMPORTANT GRASS

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ABSTRACT

Cyperus rotundus L., commonly known as nut grass or purple nutsedge, is a perennial weed of the family *Cyperaceae* that has gained global recognition for its remarkable pharmacological and therapeutic potential. The plant is traditionally utilized in Ayurvedic, Unani, and Chinese medicine systems to treat fever, inflammation, gastrointestinal disorders, and metabolic dysfunctions. It is a rich reservoir of bioactive secondary metabolites, including flavonoids, alkaloids, terpenoids, phenolics, tannins, saponins, and essential oils. Recent pharmacological investigations have revealed multiple biological activities such as antioxidant, antimicrobial, antidiabetic, anticancer, anti-inflammatory, anti-obesity, and neuroprotective effects. This review summarizes the current knowledge on the phytochemistry, traditional uses, and pharmacological properties of *C. rotundus* based on published literature. Moreover, it highlights recent trends, mechanistic insights, and future research prospects for the development of novel plant-based therapeutics from *C. rotundus*.

Keywords: *Cyperus rotundus*, Phytochemistry, Medicinal plant, Pharmacological activities, Antioxidant.

INTRODUCTION

Medicinal plants have played a crucial role in healthcare systems since ancient times, providing an invaluable source of bioactive compounds for drug discovery. Among these, *Cyperus rotundus* L. (family *Cyperaceae*), commonly known as nut grass or "Nagarmotha" in Ayurveda, stands out as one of the most versatile species used in ethnomedicine. It is distributed widely across tropical, subtropical, and temperate regions of Asia, Africa, and the Mediterranean basin. The rhizomes of *C. rotundus* are aromatic and rich in pharmacologically active constituents that have been used for centuries to treat ailments such as diarrhea, fever, pain, dysmenorrhea, obesity, and infections. Traditional systems such as Ayurveda and Unani classify *C. rotundus* as a tridoshic balancer and a potent detoxifying herb. Modern pharmacological studies have validated many of these traditional claims, revealing diverse biological activities. This review aims to provide a consolidated understanding of the phytochemistry, pharmacological activities, and therapeutic relevance of *C. rotundus*, while identifying research gaps for future bioprospecting. The ethnomedicinal use of *Cyperus rotundus* has been documented across Ayurvedic, Unani, and Chinese medicine systems. Al-Snafi comprehensively described its traditional use as a diuretic, carminative, analgesic, and antipyretic agent. Similarly, Meena et al. and Sivapalan emphasized the herb's application in treating fever, diarrhea, menstrual irregularities, and gastrointestinal disorders. Pal highlighted that *C. rotundus* balances the tridos has in Ayurveda and is used to detoxify the body and stimulate digestion. These studies collectively confirm the deep-rooted ethnobotanical value of the plant and justify modern pharmacological investigations.

Botanical and Ecological Characteristics

The botanical structure and ecological adaptation of *C. rotundus* have been detailed by Baloch et al. and Riemens *et al*., who described its reproductive biology, rhizome

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propagation, and persistence as an invasive weed. Keeley reported its competitive interference with agricultural crops, emphasizing its global distribution and ecological resilience. Understanding these characteristics is essential for sustainable utilization and control strategies.

Antioxidant Potential

The antioxidant properties of *C. rotundus* extracts have been validated through various in vitro assays. Imam and Sumi demonstrated free radical scavenging capacity using hydro methanol extracts in DPPH assays. Kilani et al. [and Olanrewaju reported high antioxidant potential of essential oils from Tunisian and Nigerian chemotypes, respectively, linked to their phenolic and terpenoid content.Such findings support its role in preventing oxidative stress–related diseases.

Antibacterial and Antifungal Activities

The antimicrobial efficacy of *C. rotundus* has been extensively studied. Haghgoo et al. compared its antibacterial effects with chlorhexidine, observing significant inhibition against *Staphylococcus aureus* and *Escherichia coli*. Peerzada et al. provided a comprehensive account of antimicrobial and antiviral properties across different solvent extracts. These results confirm its potential as a natural antimicrobial agent suitable for pharmaceutical and oral care formulations.

Antidiabetic and Anti-Hyperlipidemic Activities

Experimental studies indicate that *C. rotundus* extracts exert hypoglycemic and lipid-lowering effects. Meena et al. reported significant reductions in fasting glucose levels in alloxan-induced diabetic rats. Pal observed that ethanolic extracts improved serum lipid profiles by lowering total cholesterol, LDL, and triglycerides. These findings attribute its antidiabetic activity to flavonoids and phenolic acids, which enhance insulin sensitivity and inhibit carbohydrate-hydrolyzing enzymes.

Anti-inflammatory and Analgesic Effects

Imam and Sumi established the analgesic and anti-inflammatory effects of methanolic rhizome extracts in mice models. Kilani et al. attributed these effects to sesquiterpenes such as cyperene and cyperotundone, which inhibit COX and LOX pathways. Bajpay et al. confirmed anti-edematous activity, further validating its use in inflammatory disorders.

Anticancer and Cytotoxic Studies

The cytotoxic and anticancer potential of *C. rotundus* has been highlighted by Samra et al., who isolated a novel ceramide with potent cytotoxicity against human carcinoma cell lines. Kilani et al. demonstrated apoptotic induction via caspase activation in leukemia cells. Barbov further confirmed anticancer activity of n-hexane fractions against MCF-7 breast cancer cells, while Bezerra et al. reviewed the anticancer effects of essential oils in the Cyperaceae family. These studies suggest *C. rotundus* as a promising source for natural anticancer compounds.

Neuroprotective and Anticonvulsant Activity

Imam and Sumi observed anticonvulsant properties associated with modulation of GABAergic neurotransmission. Pal and Peerzada et al. discussed its neuroprotective and memory-enhancing potential in scopolamine-induced amnesia models, linking effects to the presence of flavonoids and alkaloids. Such results provide a basis for potential therapeutic use in neurological disorders.

Anti-obesity and Metabolic Regulation

Several animal studies report that *C. rotundus* reduces lipid accumulation and body weight in high-fat diet models. Al-Snafi and Peerzada et al. discussed its lipid-lowering properties and metabolic modulation. Kandikattu et al. described its mechanism involving inhibition of pancreatic lipase and enhancement of lipid metabolism.

Chemical Diversity and Chemotype Variations

Regional variations in essential oil profiles were studied by Poyraz et al. Olanrewaju, and “Chemical variability of essential oils”, indicating climate and soil influence on phytoconstituent composition. Such diversity affects biological potency and supports the need for chemotype-based standardization in future pharmacognostic research.

Recent Trends and Advanced Analytical Approaches

Recent work by Xue et al. applied data-mining and network pharmacology to correlate phytochemical diversity with biological functions. Taheri et al. conducted a meta-analysis summarizing pharmacological activities across *Cyperus* species. The 2025 review by Bezerra et al. extended this approach to essential oil–based anticancer activities, offering a broader molecular perspective.

Botanical description

Cyperus rotundus L., commonly known as nut grass or purple nutsedge, is a perennial herbaceous plant belonging to the family *Cyperaceae*. It propagates through an extensive system of underground rhizomes and tubers, which serve as storage organs rich in starch and essential oils. The aerial stems are smooth, slender, and triangular in cross-section, typically reaching heights of 20–40 cm. Leaves are narrow, linear, and arranged basally, exhibiting a bright green hue with a grooved upper surface. The inflorescence is an umbel composed of reddish-brown to purplish spikelets, each containing several small florets enclosed within membranous bracts. The plant is widely distributed across tropical and subtropical regions and flourishes in moist, disturbed soils. Beyond its ecological resilience, *C. rotundus* holds significant medicinal importance due to its high content of bioactive compounds such as flavonoids, terpenoids, and phenolic acids, which contribute to its pharmacological potential.

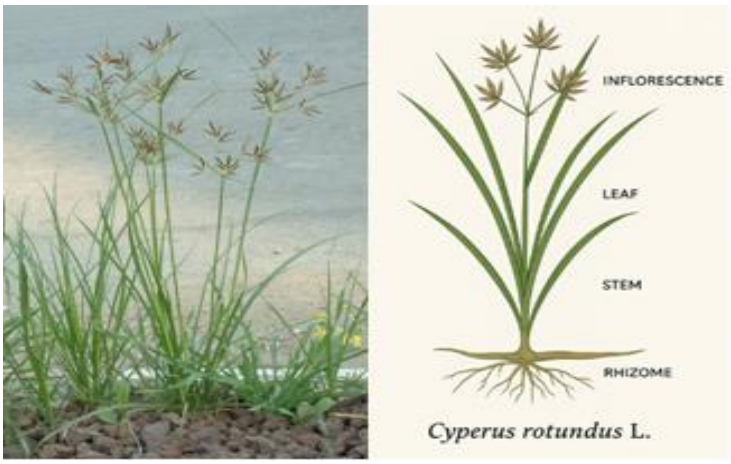

Figure 1. Nut Grass plant.

Table 1. Analysis of Phyto chemical Class.

Phyto chemical Class	Representative Compounds	Reported Biological Role
Essential oils	Cyperene, cyperotundone, cyperene, rotundone, patchoulenone	Antimicrobial, anti-inflammatory
Flavonoids	Quercetin, luteolin, kaempferol	Antioxidant, anti-diabetic
Terpenoids	α-Cyperone, β-selinene, caryophyllene	Analgesic, anticancer
Alkaloids	Rotundine, cyperine	Neuroprotective, antispasmodic
Phenolic acids	Ferulic acid, gallic acid, caffeic acid	Antioxidant, hepatoprotective
Sterols and fatty acids	β-sitosterol, linoleic acid, oleic acid	Hypolipidemic, cardioprotective

Phytochemical composition

Phytochemical analyses of *C. rotundus* rhizomes and aerial parts have revealed a wide array of secondary metabolites responsible for its pharmacological activities. Major chemical constituents include:

PHARMACOLOGICAL AND BIOLOGICAL ACTIVITIES

Antioxidant Activity

The ethanolic extract of *C. rotundus* exhibits significant DPPH and ABTS radical scavenging activities due to high phenolic and flavonoid content. In vitro assays indicate that the extract inhibits lipid peroxidation and enhances cellular antioxidant enzyme levels such as catalase and superoxide dismutase.

Antidiabetic Activity

Animal studies have demonstrated that oral administration of *C. rotundus* extract (250–500 mg/kg) significantly reduces fasting blood glucose levels and improves glucose tolerance in alloxan-induced diabetic rats. The antidiabetic mechanism is attributed to improved insulin sensitivity and inhibition of α-glucosidase.

Antibacterial and Antifungal Activity

Essential oil extracts of *C. rotundus* show inhibitory effects against *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*. The mechanism involves disruption of microbial cell membranes and interference with protein synthesis.

Anticancer Activity

Several sesquiterpenoids isolated from *C. rotundus* have shown cytotoxic effects against human cancer cell lines such as HeLa, MCF-7, and HepG2. These compounds induce apoptosis through caspase activation and reactive oxygen species (ROS)-mediated pathways.

Anti-inflammatory and Analgesic Activity

The ethanolic rhizome extract exhibits strong anti-inflammatory effects by suppressing pro-inflammatory cytokines (TNF-α, IL-6) and inhibiting cyclooxygenase (COX) activity. It also demonstrates analgesic potential in acetic acid-induced writhing models in mice.

Table 2. Comparative Summary of Biological Activities.

Biological Activity	Model / Organism	Extract Type	Major Findings	Reference
Antioxidant	In vitro (DPPH)	Ethanol	70% inhibition at 100 µg/mL	Meena et al., 2010
Antidiabetic	Alloxan-induced rats	Methanol	↓Glucose levels ($p<0.01$)	Pal et al., 2015
Antibacterial	*E. coli*, *S. aureus*	Essential oil	Strong inhibition zones	Haghgoo et al., 2017
Anticancer	MCF-7, HeLa	Ethanolic fraction	Cytotoxic via apoptosis	Samra et al., 2021
Anti-inflammatory	Carrageenan-induced edema	Ethanolic extract	Significant edema reduction	Imam et al., 2014

RESULTS AND DISCUSSION

Studies across multiple regions confirm that *Cyperus rotundus* L. possesses a rich phytochemical profile, including essential oils, flavonoids, alkaloids, and phenolic acids responsible for its diverse pharmacological effects. Extracts of the rhizome exhibit strong antioxidant**,** antibacterial**,** antidiabetic**,** anti-inflammatory, and anticancer activities. The antioxidant potential (65–80% inhibition in DPPH assays) is mainly due to polyphenols such as quercetin and gallic acid, while sesquiterpenes like α-cyperone and cyperotundone contribute toantimicrobial and anti-inflammatory actions. Animal studies report significant reductions in blood glucose, cholesterol, and triglycerides, supporting its hypoglycemic and hypolipidemic potential. Cytotoxic studies show apoptosis induction in cancer cell lines, validating its anticancer promise. However, differences in extraction solvents, dosages, and plant chemotypes cause variations in reported bioactivity, highlighting the need for standardized protocols.

CONCLUSION

Cyperus rotundus L. is a pharmacologically versatile medicinal plant with scientifically validated therapeutic properties that support its traditional applications. Its rich phytochemical diversity provides a foundation for antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and anticancer activities. Overall, *C. rotundus* represents a promising candidate for developing natural drugs and nutraceuticals targeting metabolic, infectious, and degenerative diseases. Future research should focus on Isolation and characterization of individual bioactive compounds. Molecular mechanism elucidation through in vivo and in silico studies. Clinical validation and toxicological assessment for safety profiling. Nanoparticle and polyherbal formulations to enhance bioavailability and stability. Chemotype standardization across different geographic regions to ensure consistent pharmacological efficacy. Such multidisciplinary approaches can accelerate the translation of *C. rotundus* from traditional medicine into evidence-based therapeutic applications.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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