

A review on pharmacological relevance of common weed plant *Cynodon Dactylon*

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Abstract

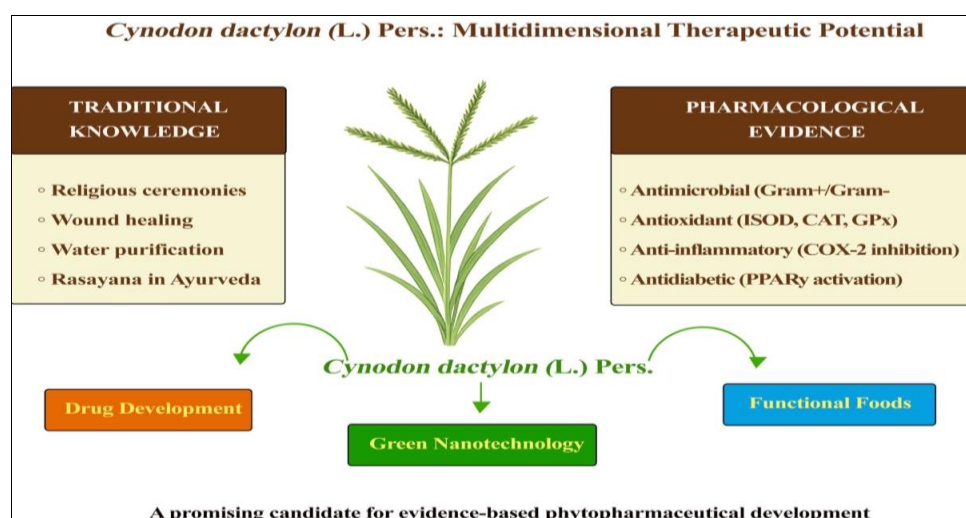
Cynodon dactylon (L.) is extensively distributed across the world as a weed with potent ethnomedical relevance. Despite its invasive character, *Cynodon dactylon* (L.) has been widely used for a plethora of therapeutic benefits in traditional medicine, while its pharmacological potential persists unexplored in recent research. This review integrates and critically analyze the existing available scientific information concerning the phytochemical composition, and pharmacological potential, followed by the ecological adaptability of *Cynodon dactylon* (L.), spotlighting its antimicrobial, antioxidant, anti-diabetic, anti-inflammatory, anti-tumor, immunomodulatory and diuretic potentials. Furthermore, this study highlights the role of *Cynodon dactylon* (L.) in green synthesized nanoparticles for biomedical benefits. By bridging the traditional available knowledge concerning the potential exploitation of *Cynodon dactylon* (L.) with contemporary scientific research, this review underpins the intact potential of *Cynodon dactylon* (L.) as a prominent source of phytochemical constituents for biomedical advancements and clinical sectors, advocating for further toward pharmacological research for better health.

Keywords: *Cynodon dactylon*, Compound, Anti-oxidant, Anti-bacterial, Anti-diabetic

Introduction

The growing research interest concerning medical ethnobotany has been always allied to the perception of tropical rainforests as a prominent source of medicinal herbs. This link has been reinforced earlier by a plethora of research articles and books across the globe. Researchers across the globe have highlighted the potential of such medicinal plants to yield treatments for various critical diseases. However, the aforesaid assumption persists extensively and is untested as reported by (Stepp & Moerman, 2001) [36]. Only a few studies have quantified this

link, finding that the majority of the drugs of botanical origin are from tropical rainforests. Globally, wild edible plants including weeds play a prominent role in food security followed by traditional medicine, specifically in rural populations where admittance to nutrition and primary health care is limited as mentioned by (Ulian *et al.*, 2020) [40]. According to the World Health Organization, about 80% of the world's population primarily relies on traditional medicine, specifically plant-based strategies for primary healthcare benefits.



Weeds are previously known to have the potential that made them to thrive in diverse environmental threats. While many of the weeds are usually recognized to be nuisances because of their invasive nature, many of them also possess

medicinal as well as nutritional values. Historical innovations also validated that certain specific weeds have been used as fodder and food supplements in traditional healing systems (Hwong *et al.*, 2022) [20]. Despite their

significance in ecology and ethnopharmacology, the weeds remain unexplored for scientific research compared to the plants from tropical rainforests. For this reason, the current study seeks to explore the ethnomedical potential of weed-containing bioactive compounds having a significant role in community health care.

Based on the earlier efforts, *Cynodon dactylon* (L.) has been recognized to be a significant candidate in this regard and it is believed to have originated from East African provinces. As a monocotyledonous weed, it later became a prominent invasive species and it spread across the various parts of India. Surviving in tropical and subtropical regions, the *Cynodon dactylon* (L.) has been traditionally exploited for various therapeutic benefits, with both aerial and rhizome of *Cynodon dactylon* (L.) being employed in herbal strategies and pharmacological research. However, despite its well-documented ethnomedical implications in traditional herbal formulations, it has been recognized to be underexplored in recent pharmacological research. From this point of view, here the review aims to consolidate and critically evaluate the existing inferences concerning its phytochemical composition, pharmacogenetic potential, and traditional strategies to encourage further scientific investigations. By bridging the traditional significant knowledge towards contemporary research, the present study seeks to unveil the untapped potential of the *Cynodon dactylon* (L.) for clinical and therapeutic benefits, ultimately contributing to advancements in human health.

Taxonomic classification

Kingdom-Plantae
 Division-Magnoliophyta
 Class-Liliopsida
 Order-Cyperales
 Family-Poaceae
 Genus-Cynodon
 Species-*Cynodon dactylon*

The common name of the *Cynodon dactylon* is as in the following manner; Africa (Kweekgras), India (Karuka-Oulli, Talla, Kabbar, Doob, and Haryali), Indonesia (Rumput Grinding, Jukut Kakawatan and Rumput) and Spain (Chepica Brave, Gramilla Blanca, Pate De and Perdiz).

Geographical Distribution and Ecological adaptability

The genus *Cynodon* (Poaceae) constituting nine warm-season grasses typically exhibits an extensive distribution over the tropical, subtropical and temperate provinces across the globe. The *Cynodon dactylon* has been recognized to be the most ecologically and economically prominent species belonging to the *Cynodon* genus, which is indigenous to the areas spanning Southern Europe, Asia, East Africa and Australia (Figure 1). Recognized for its potential of adaptability to threatening conditions, the *Cynodon dactylon* has become extensively spread across the world nonnative to its habitat, where it often assumes invasive characteristic features. Its ecological versatility made *Cynodon dactylon* for multifaceted applications including erosion control. As per the observations by (Mangathayaru, Umadevi, & Reddy, 2009) [22], the *Cynodon dactylon* is one of the most prevalent weeds in India, a hardy perennial known as Bermuda grass. An essential component of religious ceremonies, this "Rasayana" substance is also an extensively useful herbal

remedy used as the first treatment for minor wounds (Oudhia, 1999) [24]. According to the inferences concerning the folklore, it purifies water as reported by (Artizzu, Bonsignore, Cottiglia, & Loy, 1996) [7]. The wide distribution of *Cynodon dactylon* (L.) Pers. across the various provinces over the globe in all environmental conditions were reported in earlier studies (Tufail *et al.*, 2023) [39]. However, recent evidence indicates that its distribution has been principally affected by low-freezing temperatures. The ability of *Cynodon dactylon* (L.) Pers. to tolerate potent environmental stress has been extensively documented in earlier investigations with special reference to the aridity, high altitudes, freezing, waterlogging, salinity and extreme temperature settings (Tufail *et al.*, 2023) [39]. The ecotypic variability of *Cynodon dactylon* (L.) Pers. found very high and that might be the reason why this plant inhabits the majority of areas and habitats including wastelands, canal beds, grasslands, prairies, and savannas river as an invasive species (Shumail, Khalid, Ghaffar, Akhtar, & Haq, 2022) [34].

Among the many attempts to unveil the degree of tolerance towards *Cynodon dactylon*, a study by (Shumail *et al.*, 2022) [34] investigated and verified the intensity of variation according to various parameters. They assessed the degree of tolerance to altitudinal stress for three ecotypes of the Bermuda grass *Cynodon dactylon*: foothill (700 m), mid-hill (1571 m), and top hill (2804 m). They hypothesize that plants occupying different altitudes exhibit variation in structure and strategy due to the heterogeneity in environmental gradients. The top hill site's soil was reported to be more acidic and showed a prominent rise in both total nitrogen and ionic content. Morphoanatomical and physiological characteristics were significantly impacted by high altitude. The top hill ecotype showed a notable decrease in both shoot fresh weight and total leaf area. The content of other ions and chlorophyll decreased dramatically, except for Ca²⁺ and carotenoid when elevation increased. Promising anatomical adaptations in the top hill ecotype included increased leaf thickness, intense clarification around the vascular bundle and pith area, reduced metaxylem vessel area, a high number of silica bodies, and high pubescence. These changes were crucial in the grass's high level of tolerance to altitudinal stresses. Higher trichome density may be involved in preventing the transpiration of water and internal heat, whereas increased leaf thickness may be a reaction to a lower temperature that protects mesophyll cells. The continuous change pattern indicates that the air temperature, and rainfall patterns followed by the nutrient availability constitute a significant impact on the various responses of these ecotypes.

Earlier research by (Wang *et al.*, 2020) [41] has demonstrated that geographic locations have a substantial impact on morphological variations of *Cynodon dactylon*. It frequently exhibits variation in morphological characteristic features according to the environmental changes at various geographic locations. In their study, they also mentioned that an earlier investigation analyzed 260 accessions of bermudagrass germplasm and revealed that it exhibits prominent morphological diversity over longitudinal gradients. The correlation analysis then unveiled that there was rarely a substantial link between the breadth and diameter parameters against the climate, nutrition, or longitude. These characteristics are reported to be less sensitive to environmental changes, which implies that

Cynodon dactylon comprises stress tolerance mechanisms that diminish the likelihood of irrevocably reacting to varying environmental settings. Furthermore, the majority of other characteristic features showed sturdy correlations toward other environmental factors. However, their major findings imply that longitude variation was one of the major environmental factors that had a substantial impact. While these findings highlight the morphological adaptability of *Cynodon dactylon* over environmental attributes, certain studies have raised significant questions concerning the underlying molecular mechanisms triggering such plasticity. To get deeper insights into the aforesaid inferences, it is vital to explore the molecular basis that governs the reviewed adaptive characteristic features. A study by (Sun *et al.*, 2024) ^[37] investigated the molecular driving mechanism of stress tolerance in *Cynodon dactylon* with special reference to the identification and expression of drought-resistance genes. According to their observations, the ability of *Cynodon dactylon* to withstand drought is controlled by several important genes and the expression patterns differ

according to the organ. Remarkably, the DEGs encoding enzymes primarily involved in starch production showed the maximum expression level and were prominently linked with drought resistance. Moreover, there exists a plethora of pathways allied to the regulation of genes and the advanced approaches including transcriptome analysis assisted the researchers in identifying the signal transduction, which aids *Cynodon dactylon* in preserving typical physiological mechanisms in the face of drought stress. Potential genes allied with the drought have been found through additional research with the mitochondrial genome sequencing of bermudagrass hybrids. To increase the resistance to drought, CdDHN4 antioxidant genes Cu/ZnSOD and APX within the *Cynodon dactylon* produce increased antioxidant activity. The reported results establish a strong basis for molecular techniques for the investigation of drought tolerance genes in bermudagrass. In addition to the genetic resilience, *Cynodon dactylon* constitutes the efficient phyto-constituents with potent medical benefits.

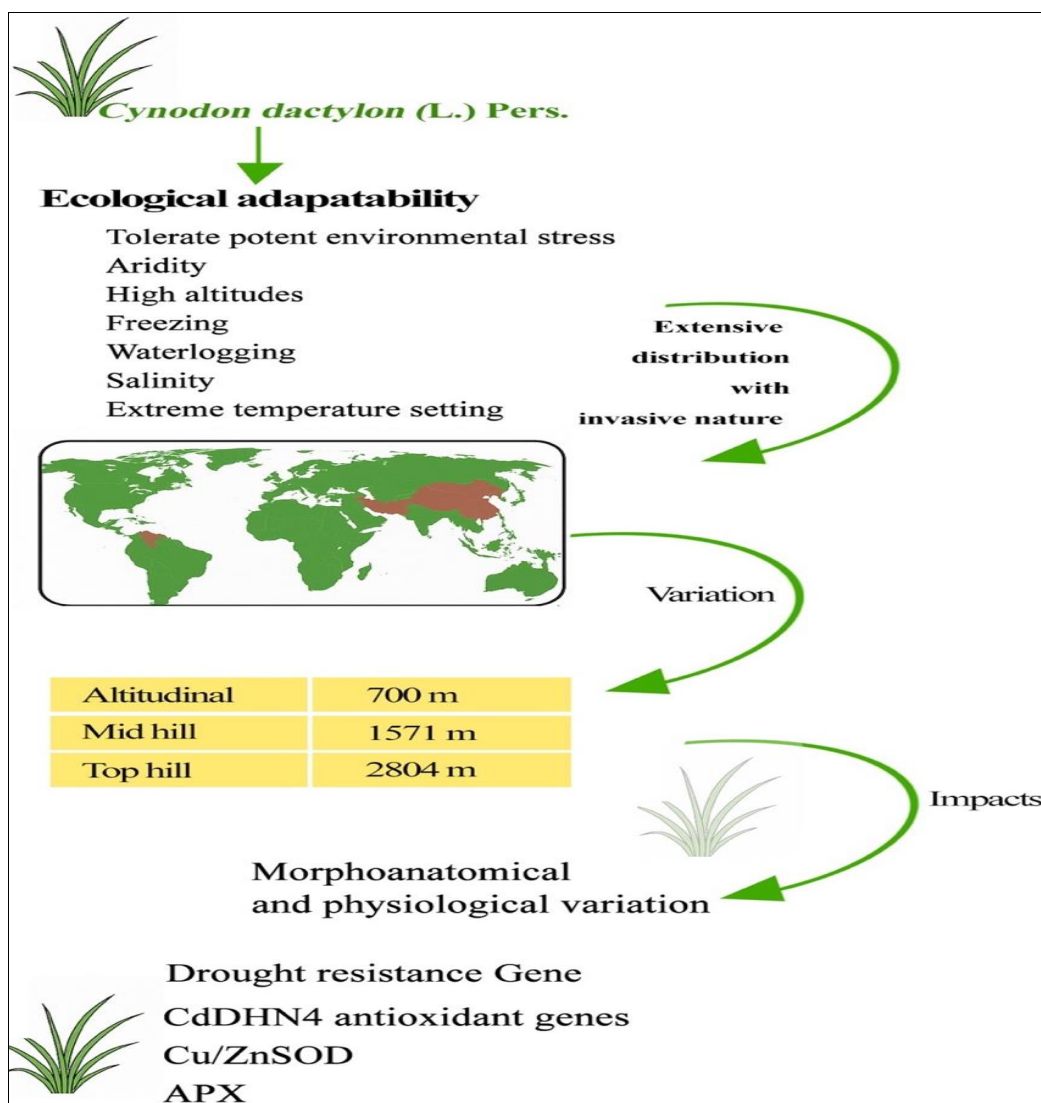


Fig 1: Ecological adaptation made it invasive

Major phytochemical constituents

The phytochemical profile of *Cynodon dactylon* (L.) along with the isolation and characterization of bioactive compounds were done by (Allahresani, Ghorbanian, Kazemnejadi, & Nasser, 2021) ^[4]. They reported the

Phenol, flavonol and flavonoid content of *Cynodon dactylon* (L.). They obtained the maximum yield in 80% ethanol extract. The presence of high phenolic compounds has been recognized as the principal reason behind the potent antioxidant activity and they also validated the direct link

between the antioxidant potential and the corresponding amount of phenolic compounds. Among the various compounds listed, linoleic acid, oleic acid and palmitic acid are the predominant phytochemicals present in *Cynodon dactylon* (L.). Likewise, (Al-Snafi, 2016) [21] has reviewed the major phytochemical constituents along with their pharmacological effects. (Al-Snafi, 2016) [22] enlisted the following compounds from the plant having potent medicinal benefits; 1. Hexadecanoic acid, ethyl ester, 2. Linolenic acid, ethyl ester, 3. D-mannose, 4. Phytol, 5. Ar-tumerone, 6. Curlone, 7. 9,12-Octadecadienoic acid, ethyl ester, 8. Octadecanoic acid, ethyl ester, 9. 2-Methoxy-4-vinylphenol, 10. 2-Furancarboxaldehyde, 5-(hydroxymethyl)-, 11. Hydroquinone, 12. Furfural, 13. Levoglucosenone, 14. Vanillic acid, 15. Syringic acid, 16. Glycerin, 17. Thymol, 18. Ethyl α -D-glucopyranoside, 19. Squalene, and 20. Diazprogesterone. Similar to these findings, (Mishra, Lu, & Mohanty, 2020) [23] implemented Py-FTIR and Py-GC/MS to study the kinetics and thermal behavior of *Cynodon dactylon* (L.). In addition to the major elements, they also analyzed and reported the following attributes in a significant range; Lignin, H/C ratio, Ash content, Hemicellulose, Carbon, Calorific value, Fixed carbon, Oxygen, Sulphur, VM/FC ratio, Moisture, Cellulose, Hydrogen, Bulk density, O/C ratio, Nitrogen, Volatile matter. Furthermore, The GC-MS analysis validated that the following predominant elements from *Cynodon dactylon* (L.); Aromatic hydrocarbons, phenolic compounds, furan derivatives, cyclopentanones, ketones, acids, esters, nitrogen-rich compounds, carboxylic acids, 1,2-cyclooctadiene, and various light hydrocarbons. (Ashokkumar, Selvaraj, & Muthukrishnan, 2013) [8] mentioned the presence of following compounds from the *Cynodon dactylon* (L.); Hexadecanoic acid ethyl ester, linoleic acid ethyl ester, d-mannose, 3H-pyrazol-3-one (2,4,5-trimethyl), 4H-pyran-4-one (2,3-dihydro-3,5-dihydroxy-6-methyl), methanol, benzoic acid 2-hydroxy-methyl ester, benzofuran (2,3-dihydro), 2-furancarboxaldehyde (5-hydroxymethyl), 2-methoxy-4-vinylphenol, decanoic acid ethyl ester, 3-tert-butyl-4-hydroxyanisole, α -tumerone, tumerone, curlone, tricyclo[6.3.0.0(1,5)]undec-2-en-4-one (2,3,5,9-tetramethyl), tetramethyl-2-hexadecen-1-ol, phytol, octadecadienoic acid ethyl ester, propanoic acid, 2-oxo-furfural, 2H-pyran-2-one (5,6-dihydro), pantolactone, pentanoic acid, 4-oxo-furfural, levoglucosenone, hexanediamide N,N'-dibenzoyloxy, 3-hydroxy-1-methylpyridinium hydroxide, 2-furancarboxaldehyde (5-methyl), propanedioic acid phenyl, hydroquinone, phthalic acid, 1,3-benzenediol, 5-chlorobenzaldehyde, 3-(chloroacetoxy)-4-methoxy, ethenone (1-(4-hydroxy-3-methoxyphenyl)), 1,6-anhydro- α -D-glucopyranose, vanillic acid, 1-(2-hydroxy-4,5-dimethoxyphenyl)ethenone, syringic acid, pyrrolidine-2-one N-(2,4-dimethylcyclopent-3-enoyl), cinnamic acid (4-hydroxy-3-methoxy), dimethoxybicyclo[3.3.1]nona-2,4-dione, glycerine, thymol, conhydrin, 1,2-cyclopentanediol (3-methyl), benzenepropanol (4-hydroxy- α -methyl-R-ethyl), α -D-glucopyranoside, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, n-hexadecanoic acid ethyl ester, linolic acid ethyl ester, 9,12-octadecadienoyl chloride, octadecanoic acid ethyl ester, pentanal (2-methyl), hexadecanoic acid, 1-(cyclopropyl-nitro-methyl)cyclopentanol, 2-propenamide N-[2-(dimethylamino)ethyl], hexadecanoic acid 2-hydroxy-1-(hydroxymethyl)ethyl ester, didodecyl phthalate, 13-

tetradec-11-yn-1-ol, 10-undecyn-1-ol, squalene. From this point of view, (Ashokkumar *et al.*, 2013) [8] reviewed the presence of the following phytoconstituents; Flavonoids such as luteolin, vitexin, orientin, and apigenin, together with phytosterols, glycosides, volatile oils, and saponins, are among the major bioactive constituents of *Cynodon dactylon*. The plant also comprises proteins, carbohydrates, crude protein, minerals, fiber, and total ash. Significant components include vitamin C, alkaloids, palmitic acid, and terpenoids. Additionally, it contains carotenoids like neoxanthin, violaxanthin, and beta-carotene. GC-MS analysis has revealed the presence of compounds such as tricosane, phytol, glycerin, linoleic acid ethyl ester, ethyl α -D-glucopyranoside, and 9,12-octadecadienoyl chloride (Z, Z). Other notable substances include 1,2-propanediol, 3-benzyloxy-1,2-diacetyl, hexadecanoic acid ethyl ester, D-mannose, linolenic acid ethyl ester, hydroquinone, furfural, and levoglucosenone. The use of GC-MS to unveil the presence of predominant elements with potent pharmacological benefits was reported by (Bagewadi, Siddanagouda, & Baligar, 2014) [10]. They identified the following major elements from the *Cynodon dactylon* (L.) and suggested that the antimicrobial and antipyretic properties of the plant might be due to the presence of these elements; Flavonoids, anthraquinones, reducing sugars, catechol, resins, glycosides, proteins, sterols, tannins, amino acids, acidic compounds, phlobatannins, quinones, triterpenoids, carbohydrates, alkaloids, saponins, phenols, coumarins. Based on the presence of various phytochemical compounds reviewed, it was inferred that the *Cynodon dactylon* (L.) appears to be rich in bioactive compounds, that can be extensively exploited for pharmacological benefits to cure a plethora of anomalies and diseases.

Pharmacological Activities

Previous research conducted on the *Cynodon dactylon* (L.) validated the following pharmacological potential of *Cynodon dactylon* (L.); Antidiabetic activity, antihyperlipidemic activity, antibacterial activity, antifungal activity, anti-inflammatory activity, chondroprotective activity, diuretic activity, chemopreventive activity, antiproliferative activity, anti-ulcer activity, antioxidant activity, bronchodilatory activity, hepatoprotective activity, immunomodulatory activity, wound healing activity, anticonvulsant activity, antiemetic activity, anti-nephrolithiatic activity, hypotensive activity, antiparkinsonian activity, angiogenic modulatory activity, alpha-amylase inhibitory activity, antipyretic activity, anticancer activity (Annapurna *et al.*, 2013; Parihar & Sharma, 2021) [6, 25].

Antimicrobial Activity

The ability of *Cynodon dactylon* to produce strong toxic potential against microbial consortia has been witnessed in earlier studies. (Abdullah, Gobilik, & Chong, 2013) [1] employed disc diffusion method and thin-layer chromatographic (TLC) bioassay to examine the potential of various extracts (acetone, chloroform, diethyl ether, ethanol, ethyl acetate, methanol, and n-pentane) prepared from *Cynodon dactylon* against *Streptococcus pneumonia*, *Streptococcus pyogenes*, *Escherichia coli*, *Klebsiella spp.*, *Pseudomonas aeruginosa*, *Streptococcus pneumonia*, *Streptococcus pyogenes*, *Aspergillus niger*, *Bacillus cereus*, *Bacillus subtilis*, and *Staphylococcus aureus*. According to

crude extraction, the maximum yield (7.065%) was attained from ethanolic extraction, which was followed by methanolic (5.420%) and chloroform (3.550%) extraction. The extraction of n-pentane had the lowest yield of 0.500%. The antimicrobial examination revealed that extracts prepared using ethanol (7.0–10.0 ± 0.0–1.0 mm) and ethyl acetate (7.0–12.0 ± 0.0–1.0 mm) had an extensive range of antibacterial activity toward the examined bacterial pathogen. Similar to the aforementioned study, (Savadi, Vazifedoost, Didar, Nematshahi, & Jahed, 2020) [32] used the disk-diffusion method to examine the chemical makeup and antibacterial potential of the methanolic extract of *Cynodon dactylon*. The findings showed that palmitic acid (36.40%), oleic acid (28.26%), and linoleic acid (17.01%) were the main fatty acid structures while sterols were sitosterol (3199.62 mg·kg⁻¹) and alpha-tocopherol (151.39 mg·kg⁻¹) are the major tocopherols and sterols. Furthermore, the maximum zone of inhibition was produced against *Escherichia coli* (16.8 ± 0.5 mm) and *Bacillus cereus* (18.3 ± 0.4 mm) by the methanolic extract of *Cynodon dactylon* while the *Pseudomonas aeruginosa* exhibited the maximum resistance followed by an inhibition zone of 12.8 ± 0.15 mm since the *Cynodon dactylon* possesses antibacterial potential, a recent article by (Bristi, Rahman, Malitha, Rahman, & Shoukat, 2024) [12] coated the *Cynodon dactylon* in a woven cloth called “Cotton gauze” which is always used for wound cushioning and wound dressing and various experiments were conducted including Energy-dispersive X-ray (EDX), Scanning Electron Microscopy (SEM), gram-positive and gram-negative bacterial tests, color fastness, Fourier Transform Infrared Spectroscopy (FTIR) and anti-bacterial test. Their primary objective was to create herbal cotton bandages and they finally won with their attempt since the treatment performed well in all the performed analysis. The reviewed findings highlight the utmost antibacterial potential, and durability followed by the safety of *Cynodon dactylon*-based products, positioning it as a natural and competitive alternative to synthetic antibacterial elements.

Antioxidant Activity

Commercially available synthetic antioxidants such as butylated hydroxyanisole and butylated hydroxytoluene are harmful to both humans and animals in many instances as reported by (Roy, Pawar, & Chowdhary, 2016) [29]. Moreover, plant-based natural products have been suggested as a possible source of effective natural antioxidants. As mentioned earlier, the presence of phenolic chemicals, including proanthocyanidins, flavonoids, phenols, and flavonols is primarily responsible for this activity. From this point of view, (Roy *et al.*, 2016) [29] verified the antioxidant potential of *Cynodon dactylon*. They found a strong correlation between phenolic content and antioxidant activity, justifying the possible role of phenolic compounds to contribute to the antioxidant potential. (Rai, Jaiswal, Rai, Sharma, & Watal, 2010) [27] Done extension study and evaluated the antioxidant potential of water extracts prepared from *Cynodon dactylon* in diabetic rats. They administered the rats with 500 mg/kg of water extract for 30 days and analyzed the different oxidative stress parameters across the various tissues. Significant variation has been reported in their studies along with increased activities of antioxidant enzymes such as CAT, GST, SOD, and GPx. As reported earlier, the presence of flavonoids

in *Cynodon dactylon* may probably be responsible for the reported antioxidant potential in STZ-induced diabetic rats. Since it impacts the STZ-induced diabetic rats, then could be able to have anti-diabetic activity.

Anti-diabetic Activity

The prevalence of type 2 diabetes mellitus (T2DM), an emerging epidemic, is predicted to rise to 69% in developing nations and 29% in industrialized ones (Shaw, Sicree, & Zimmet, 2010) [33]. According to a recent survey on the population with type 2 diabetes, India has more than 60 million diabetic patients (7.8% of the adult population), which is more than the global estimates for 2030 (Anjana *et al.*, 2011) [5]. Peripheral insulin resistance, visceral obesity, poor glucose utilization in muscle and adipose tissues, and a gradual decline in beta cell activity leading to β -cell failure are the main causes of type 2 diabetes, a progressive disease. Patients with diabetes who had the disease for more than ten years must need insulin therapy and various oral hypoglycemic medications due to inadequate blood sugar control. To prevent consequences like diabetic neuropathy and nephropathy, diabetologists' arsenal of medications focuses on controlling HbA1C levels. However, long-term usage of some medications to manage diabetes can lead to negative side effects including hypoglycemia and weight gain. Reducing postprandial glucose is a key strategy for diabetic patients, and new, risk-free medications are needed to treat hyperglycemia. These new targets address these problems by reducing glucose reabsorption from the kidney and inhibiting glucose transport in the small intestine. Because of these reasons, recent years have witnessed the use of natural products to treat diabetes mellitus. In this regard, (Annapurna *et al.*, 2013) [6] isolated and identified the potent following compounds from *Cynodon dactylon* using HPLC–ESI MS with Anti-diabetic activity; luteolin, 6-C-hexosyl-8-C-pentosyl luteolin, apigenin, 6-C-pentosyl-8-C-hexosyl apigenin. With the aid of the Schrödinger suite, PDB, UniProt, Lig, Prep and ligands whose interactions with PPAR γ , GLUT-4, and SGLT-2 receptors, they proved the Anti-diabetic Activity of *Cynodon dactylon*. Precisely, since C-glycosyl flavones are more resistant to being hydrolyzed by intestinal beta glucosidases than their O-glycoside counterparts, C-aryl glycosides, including dapagliflozin, have demonstrated efficacy as anti-diabetic agents. Additionally, the disaccharides 6-C-pentosyl-8-C-hexosyl apigenin and 6-C-hexosyl-8-C-pentosyl luteolin were docked to the aforementioned receptors to ascertain their binding affinities since they have not been assessed as diabetes targets, particularly for SGLT-2. To determine whether the glide scores are equivalent, the same receptors were additionally docked with test drugs that have been shown to have inhibitory actions, such as dapagliflozin, sergliflozin, fascentin, rosiglitazone, and genistin.

Anti-inflammatory Activity

Traditional knowledge indicated that the entire *Cynodon dactylon* plant has long been used to combat inflammatory and painful ailments in earlier epochs (Garg & Paliwal, 2011) [17]. Since there was no comprehensive scientific investigation on the anti-inflammatory potential of *Cynodon dactylon*, (Garg & Paliwal, 2011) [17] used the cotton pellet method and carrageenan, serotonin, histamine, and dextran-induced rat paw edema to examine the anti-inflammatory potential of aqueous extract of *Cynodon dactylon* at varying

dosages. Three distinct dosage levels of 200, 400, and 600 mg kg⁻¹ were administered orally and determined to be safe at all dosages, and when taken orally, there was no mortality up to a dose of 4000 mg kg⁻¹ of extract. In every model examined, *Cynodon dactylon* showed notable anti-inflammatory potential. Another study by (Ghumre *et al.*, 2017) [18] examined the anti-inflammatory potential of *Cynodon dactylon* methanolic extract through two different methods such as the Albumin denaturation assay and Membrane stabilization assay. Dose-dependent Anti-inflammatory potential was observed in their study. The protein denaturation method at a concentration of 1000ppm extract revealed maximum protection. From the results obtained, they concluded that *Cynodon dactylon* methanolic extract offered maximum potential. In addition, As mentioned in earlier strands, phytochemical analysis of *Cynodon dactylon* methanolic extract produced the presence of alkaloids, glycosides, proteins, carbohydrates, flavonoids and phytosterol and the presence of these phytochemical constituents may be responsible for the Anti-inflammatory potential.

Antidiuretic Activity

The Diuretic potential of *Cynodon dactylon* was observed by (Sohgaura, Bigoniya, & Shrivastava, 2018) [35] with strong statistical significance. The extracts prepared from *Cynodon dactylon* have shown elevated levels of sodium (Na⁺) and potassium (K⁺) excretion. Precisely, the *Cynodon dactylon* showed a remarkable increase in sodium (Na⁺) and potassium (K⁺) excretion elimination at 300 and 500 mg/kg dose respectively with strong statistical significance. Diuretics augment the amount of water and intensity of ion excretion in urine to preserve the composition and balance of bodily fluids. Internal organ failure, cirrhosis, nephritic syndrome, premenstrual tension, and high blood pressure are among the life-threatening anomalies for which drug-induced diuresis is accommodative. Diuretics of botanical origin have been shown by science to be highly efficient in treating mild to moderate hypertension. Furthermore, diuretics also assist individuals with cardiovascular problems by reducing congestion followed by peripheral puffiness. Additionally, these medicines help alleviate dyspnea and reduce volume overload. Primarily, the condition diuresis augments the volume of urine excreted and causes a net loss of electrolytes in the urine, which are its two main consequences. Based on the findings from (Sohgaura *et al.*, 2018) [35], the various *Cynodon dactylon* extracts can be exploited to combat the complications that can be solved by antidiuretic activity.

Anti-tumor and Cytotoxic Effects

Cancer and allied complications in the Indian region rank second in terms of causes of death, after heart disease. The four major prevalent malignancies across the world are those of the stomach, colon, breast, and lung (Bingham & Riboli, 2004) [11]. Traditional treatment strategies primarily employ diverse medicinal plants to combat an extensive range of conditions and symptoms including cancer and allied complications. As per the WHO, over 80% of the world's population receives their primary healthcare from these traditional plant-based medical systems. Such point directs the researchers to exploit the various extracts of *Cynodon dactylon* to treat the cancerous cell lines. For

instance, (Albert-Baskar & Ignacimuthu, 2010) [3] examined and verified the anticancer potential of *Cynodon dactylon* against COLO 320 DM cells and induced colon carcinogenesis in rats. Although the capacity of *Cynodon dactylon* to trigger and carry out apoptosis in various cancerous cells, the MTT assay directs to the mitochondrial role. Altogether, the methanolic extract prepared from *Cynodon dactylon* protects experimental mice in their study from the harm that DMH causes, recommending that it is a safe approach for colon cancer. Similar to this observation, (Kowsalya, Kaliaperumal, Vaishnavi, & Namasivayam, 2015) [21] examined the anticancer activity of *Cynodon dactylon* toward diethyl nitrosamine-induced hepatic carcinoma.

Over the past few years, phytochemical constituents of botanical origin have garnered a lot of attention as mentioned in the former strands. Also, a growing body of research was primarily focusing on the potential of bioactive compounds to suppress tumors in animal carcinogenesis models that are produced chemically as well as genetically. From this direction, (Salahuddin *et al.*, 2016) [30] used the MTT assay to examine and compare the *in vitro* anticancer activity of extracts prepared using *Cynodon dactylon* with normal human corneal epithelial cells (HCEC) on the Hep2 cell line. The p53 and PTEN genes in a treated cancer cell line were analyzed using real-time PCR. To unveil the detrimental effects of the extracts prepared on DNA, a DNA fragmentation experiment was also performed by them. As observed in earlier studies, the ethanolic extracts of *Cynodon dactylon* were toxic to Hep2 but nontoxic to HCEC and were found to have minimally effective concentrations (IC₅₀) of 0.042 mg/ml (49.48 percent cell death). The reported concentration was comparable to the positive control and their findings showed that cell death increased in a dose-dependent manner, suggesting the potential exploitation of *Cynodon dactylon* for pharmacological benefits.

Immunomodulatory Activity

For several illnesses, immunomodulation with plant materials can offer an alternative to traditional chemotherapy, specifically when the host defense mechanism needs to be triggered in the event of an immune response impairment. The *Cynodon dactylon* extract has a significant use in treating dropsy and secondary syphilis, according to earlier evidence. In India, *Cynodon dactylon* has long been utilized as a diabetes treatment, while the research concerning the Immunomodulatory potential of *Cynodon dactylon* found scanty. However, the following studies have detailed the exploitation of *Cynodon dactylon* for immunomodulatory potential; (Devi, Annapoorani, & Ashokkumar, 2011; Farook *et al.*, 2016; Santhi & Annapoorani, 2010) [8, 14, 16, 31]. From the aforesaid studies, it was observed that since it may be used to treat immunocompromised situations, the xenobiotic regulation of immune response has presently gained significant scientific interest. Major drawbacks of the immune stimulating and immunosuppressive medications now on the market consist of the higher risk of infection followed by the suppression of bone marrow-derived cells. A plethora of medicinal herbs used in Ayurveda have prominent immunomodulatory properties as reported by (Devasagayam & Sainis, 2002) [13]. Their significant antioxidant potential has been linked in recent studies to their therapeutic benefits

and only a few of them have been thoroughly examined, despite their therapeutic significance. Given that *Cynodon dactylon* is used to treat immunological and neurological diseases, (Mangathayaru *et al.*, 2009) ^[22] assessed the DNA-protective and immunomodulatory effects of a standardized fresh juice of the *Cynodon dactylon* and verified the dose dependant potential with strong statistical significance. Likewise, (Devi *et al.*, 2011) ^[14] verified the immunomodulatory potential of *Cynodon dactylon* in experimental animal Balb/c mic. Their finding implied that the mechanism by which pyrogallol triggered immunosuppression might be used to screen for the immunomodulatory impact of the ethyl acetate fraction of *Cynodon dactylon*. Hence, they anticipate that the ethyl acetate fraction of *Cynodon dactylon* aqueous extracts can be recognized to be a powerful immunostimulant in clinical practice in the future.

Green Synthesized Nanoparticles and Their Applications

Green chemistry has an extensive range of applications in numerous study domains and is used in sustainability projects today to conserve or enhance the environment. There exist many uses for nanotechnology in daily life as well as in the medical, space, and related industries. The toxic potential of nanomaterials is mostly determined by their intrinsic characteristics, including their size, shape, and content, followed by their surface chemistry. There are several ways to create nanomaterials, including physical, chemical, and biological methods. The physical and chemical approaches to nanoparticle synthesis are recognized to be more costly, and need more preparation time, and may have the chance to generate environmentally hazardous by-products as reported by (Prakash *et al.*, 2020) ^[26]. Since plant extracts appear to be the most effective biological method for developing nanoparticles with a variety of uses, the recent research trends (Dharmarajan, Sathishkumar, Juliana, Ramanathan, & Durai, 2024; Hariharan, Srinivasan, & Nehru, 2017; Renitta, Jebaseeli, Dhanaraj, & Paul, 2022; Supraja & Arumugam, 2015) ^[15, 19, 28, 38] consider *Cynodon dactylon* based nanoparticle synthesis for pharmacological benefits. Based on the aforesaid inferences, (Babu, Yugandhar, & Savithramma, 2018) ^[9]

Reported a green synthesis strategy for silica nanoparticles (SiNPs) generation from *Cynodon dactylon* and the formed silica nanoparticles were characterized using Fourier-transform infrared (FT-IR), ultraviolet-visible (UV-Vis) spectrophotometer, X-ray diffractometer (XRD), transmission electron microscopy (TEM) and scanning electron microscope (SEM). Along with the strong purity of the synthesized nanoparticles, they reported the inhibitory activity of synthesized nanoparticles against different microbial consortia. From the various findings reviewed, the present study concluded that the various phytochemical constituents and major elements present in the *Cynodon dactylon* can be used as a reliable green source for the production of potential products for pharmacological benefits.

Conclusion

Cynodon dactylon is reported as a most promising weed with rich phytochemical constituents and diverse pharmacological benefits. The widespread availability followed by ecological resilience further augments its

potential as a prominent source of bioactive compounds. Despite its extensive use in traditional herbal medicine strategies, recent scientific validation persists limited and it necessitates further research to unveil the molecular mechanisms and optimize its therapeutic benefits. The integration of traditional knowledge concerning the potential exploitation of *Cynodon dactylon* into green nanotechnology and advanced scientific sectors also presents novel insights and opportunities for the development of drugs. By advancing the recent research in this direction, future studies can explore the potential of unexplored *Cynodon dactylon* to get its entire potential as a multifaceted candidate to contribute the global healthcare needs.

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Declarations

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication

Not required

Availability of data and material

The data analysed during the present investigation are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no conflict of interest.

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