IJEMD-BMCR, (3) 1 (2025)   *https://doi.org/*10.54938/ijemdbmcr.2025.03.2.543

International Journal of Emerging Multidisciplinaries:
Biomedical and Clinical Research

Research Paper
Journal Homepage: www.ojs.ijemd.com
ISSN (print): 2957-8620 ISSN (online): 2960-0731

Comprehensive Review of the Phytochemical Diversity and Pharmacological Multifunctionality of *Cynodon dactylon* (L.) Pers

Ajay Kumar Verma[1]

1. *Maharishi School of Pharmaceutical Sciences, Maharishi University of Information Technology, Lucknow, Uttar Pradesh, India.*

ABSTRACT

Background: *Cynodon dactylon* (L.) Pers. is also referred to as Bermuda grass, and its ethnomedical benefits in treating microbial infections, diabetes, and inflammation have long been acknowledged. Its varied therapeutic potential has been confirmed by recent pharmacognostic and phytochemical research, which has identified bioactive compounds and biological activities. **Methods:** A thorough review of the literature was carried out using the PubMed, Scopus, and Google Scholar databases, encompassing research from 2002 to 2024. We examined and contrasted pertinent reports on C. dactylon's phytochemical makeup, pharmacological activity, and toxicological features. The review places a strong emphasis on pharmacodynamic observations, extract types, and experimental design. **Results:** The presence of flavonoids (apigenin, luteolin, and vitexin), alkaloids, terpenoids, saponins, and phenolic acids as important metabolites was verified by phytochemical profiling. Strong antioxidant, antidiabetic, anti-inflammatory, hepatoprotective, and anticancer properties were shown by methanolic and aqueous extracts both in vitro and in vivo. Interestingly, in streptozotocin-induced diabetic rats, hydroalcoholic extracts markedly decreased blood glucose and lipid levels (Garg et al. 2023), whereas Hep-2 cancer cells were highly susceptible to the cytotoxicity of ethyl acetate fractions (Salahuddin et al. 2016). However, in certain ecological contexts, reports of alkaloid toxicity and allergenic potential have been made. **Conclusion:** The

Email Address: ajaykverma66@gmail.com ***(*Ajay Kumar Verma[1])**

phytochemical diversity of Cynodon dactylon supports its broad-spectrum pharmacological activity. Standardized extraction, mechanistic clarification, and clinical validation should be given top priority in future research to create secure and efficient therapeutic uses. These pharmacological activities indicate potential applications of C. dactylon in healthcare and rehabilitation, particularly for managing oxidative stress–related disorders, enhancing tissue recovery, and supporting metabolic rehabilitation.

Keywords: antioxidant; Cynodon dactylon; phytotherapy; wound healing; diabetic recovery.

1.0 INTRODUCTION

C. dactylon is commonly referred to as Bermuda grass [1], is a species of perennial grass included in the Poaceae family [2]. It is indigenous to Africa, Asia, and southern Europe, as well as other warm temperate to tropical parts of the Eastern Hemisphere. *C. dactylon* is widely recognized for its hardiness, adaptability, and rapid growth, making it a well-liked option for pasturelands, golf courses, sports fields, and lawns. Botanically, *C. dactylon* is characterized by its fine-textured leaves, deep green color, and ability to form a dense turf. It has a robust root system, which allows it to withstand drought conditions and recover quickly from damage. The grass spreads primarily through stolons and rhizomes, which contribute to its aggressive growth habit. *C. dactylon* thrives in full sunlight and well-drained soils (Figure 1). Its high-temperature tolerance property makes it ideal for regions with hot climates.

Traditionally, *C. dactylon's* practical, medicinal, and environmental uses have been utilized by many cultures [3-5]. The potential use of Cynodon dactylon in the treatment of chronic inflammatory and metabolic disorders, as well as in the promotion of wound healing and post-injury recovery, is supported by its pharmacological profile in the context of contemporary healthcare and rehabilitation. Its bioactive ingredients support cellular regeneration, enhanced metabolic balance, and antioxidant defense—all important facets of rehabilitation science.

Figure 1: *Cynodon dactylon*

1.1 Phytochemicals in *Cynodon dactylon*

The phytochemical study reported that the *C. dactylon* plant contained carbohydrates, proteins, minerals, alkaloids, terpenoids, and vitamin C [6]. It contained apigenin, luteolin, orientin, and vitexin flavonoids [7-9]. Carotenoids reported in *C. dactylon* are beta-carotene, violaxanthin, and neoxanthin [10], and it has also been reported to contain phenolics [11], phytosterols, glycosides, saponins [12], and terpenoids [13].

1.2 Biological activities of *Cynodon dactylon*

The aerial part and rhizomes of *C. dactylon* have been reported to contain antioxidant, antibacterial, cardioprotective, antimicrobial, diuretic, wound-healing, and antidiabetic properties [14, 15]. Reports on the *C. dactylon* (Table 1) plant also provided an account of analgesic, antibiotic, antiulcer, antiviral, antipyretic, antihypertensive, antihysteric, anti-kidney stone, antipsychotic, and gonorrheal and hypoglycemic effects [16, 17].

1.2.1 Flavonoids

It has flavonoids called tricin, luteolin, and apigenin. Their anti-inflammatory and antioxidant qualities are well-known.

1.2.2 Phenolic acids

The antioxidant-active phenolic acids ferulic acid and p-coumaric acid are noteworthy.

1.2.3 Alkaloids

Among the many physiological effects of alkaloids are analgesic and anti-inflammatory properties.

1.2.4 Terpenoids

The aromatic qualities of these are well-known. They may be used therapeutically because of their antibacterial and anti-inflammatory qualities.

1.2.5 Tannins

Medicinally, they have wound-healing and antimicrobial effects.

1.2.6 Saponins

Saponins exhibit immune-boosting, anti-inflammatory, and anticancer activities [18-20].

Table 1: *Biological activities reported in C. dactylon [21]*

S. No.	Solvent extract	Plant part	Biological activity
1	Aqueous	Entire plant	Antipyretic
2	Aqueous	Entire plant	Analgesic
3	Aqueous	Leaflets	Antimicrobial
4	Methanolic	Rootstock	Anticancer
5	Phenolic	Entire plant	Vasodilatory
6	Aqueous	Rhizomatous stem	Antidiuretic
7	Aqueous and non-polysaccharide fraction	Entire plant	Antidiabetic
8	Aqueous and ethanolic	Aerial parts	Anti-diabetic
9	Ethanolic	Aerial parts	Central nervous system
10	50% aqueous- 50%ethanolic	Aerial parts	Nephrolithiasis
11	Ethyl acetate fraction	Leaflets	Antioxidant
12	Hydro-alcoholic	Aerial parts	Antioxidant
13	Ethyl-acetate fraction	Aerial parts	Antioxidant
14	Ethyl-acetate fraction	Leaflets	Immuno-modulatory
15	Ethanol, butanoic, and methanolic	Leaflets	Anti-bacterial
16	Hydroalcoholic	Entire plant	Anti-bacterial
17	Aqueous	Entire plant	Anti-inflammatory
18	50% ethanolic	Entire plant	Anti-inflammatory
19	Chloroform-methanolic	Entire plant	Anti-inflammatory

2.0 LITERATURE REVIEW

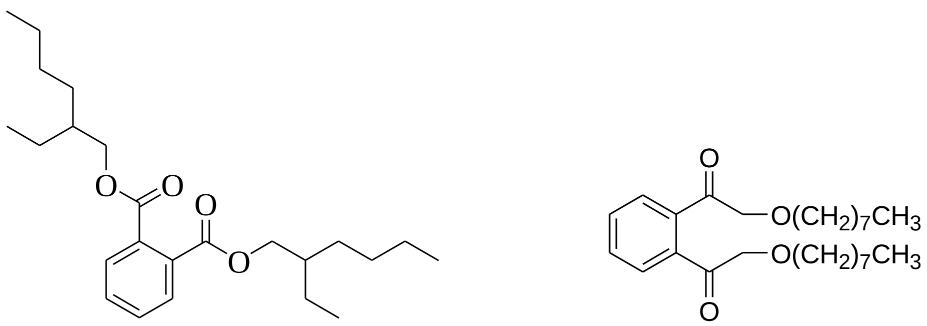
The literature review makes it abundantly evident that Cynodon dactylon's varied phytoconstituents, which include flavonoids, terpenoids, alkaloids, saponins, and phenolic acids, exhibit a remarkable array of pharmacological activities. Through the use of various experimental models and extraction methods, each study investigated various biological potentials, offering a comprehensive understanding of the plant's potential medical value.

2.1 Phytochemical Studies

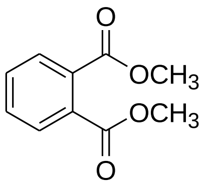
Nurminskaya *et al.* (**2017**) investigated the process of automating morphological analyses of plant leaves, such as those of C. dactylon. The project's objective was to develop automated systems for the detailed analysis of leaf morphology in order to facilitate extensive botanical research [22].

Shendye *et al.* (**2014**) examined its pharmacological properties, chemical constituents, ethnomedicinal significance, pharmacognostic traits, and traditional uses. The study also attempts to compile a list of patents related to C. dactylon. A comprehensive literature review was part of the research methodology in order to compile data on C. dactylon from different origins. Proteins, carbohydrates, minerals, flavonoids, carotenoids, alkaloids, and glycosides are among the many metabolites found in the herb [20].

Ingole *et al.* (**2017**) studied C. dactylon, a grass in the Poaceae family, in terms of morphotaxonomic analysis and phytochemical analysis. The intricate floral structures of grasses often cause them to be disregarded, despite their vital ecological and economic importance. To gain a better understanding of C. dactylon's traditional medicinal uses, its phytochemical components were examined. The proper identification of C. dactylon and its classification within its respective tribe were made easier by the morphotaxonomic investigation. GC-MS analysis was used to identify three antimicrobial and antifouling compounds: bis (2-ethylhexyl) phthalate, di-octyl phthalate, and phthalic acid diester (Figure 2) [23].



bis (2-ethylhexyl) phthalate di-octyl phthalate

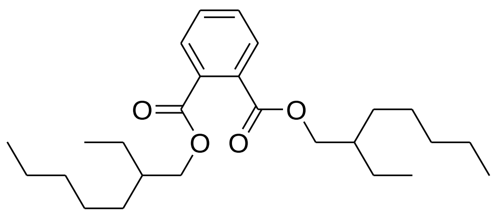


phthalic acid diester

Figure 2: *Structure of bis (2-ethylhexyl) phthalate, di-octyl phthalate, and phthalic acid diester.*

Geetha (**2015**) emphasizes how important it is to examine medicinal plants from a range of perspectives, such as pharmacology, genetics, commerce, and quality control. Pharmacists play a crucial role in carrying out chromatographic and other analytical procedures in the framework of Indian traditional medicine systems, such as Ayurveda, for the identification and purity evaluation of medicinal plants. The study also describes how phytoconstituents were extracted from the C. dactylon crude methanolic extract using column chromatography [24].

Allahresani *et al.* (**2021**) conducted thorough phytochemical examinations on C. dactylon (L.), a plant with a long history of use in traditional medicine. Finding and characterizing the bioactive compounds in this plant was the primary objective of their investigation. Their efforts led to the discovery of bis(2-ethylheptyl) phthalate as a significant phytochemical constituent. The compounds were extracted from the plant extracts using a variety of chromatographic techniques, such as TLC and column chromatography. These advanced analytical techniques verified the accurate identification of bis (2-ethylheptyl) phthalate (Figure) [25].



bis (2-ethylheptyl) phthalate

Figure 3: Structure of bis (2-ethylheptyl) phthalate

Amritkar *et al.* (**2024**) investigated the phytochemical composition of C. dactylon and found that it contained reducing sugars, proteins, carbohydrates, volatile and fixed oils, alkaloids, glycosides, terpenoids, triterpenoids, steroids, saponins, tannins, resins, and phytosterols. C. dactylon has been shown to possess anti-inflammatory, antipyretic, analgesic, immunological, antiallergic, gastrointestinal, antioxidant, antimicrobial, antiparasitic, insecticidal, dermatological, diuretic, and immune system-related properties in previous investigations [26].

2.2 Antioxidant Studies

Savadi *et al.* (**2020**) examined the chemical composition, antimicrobial qualities, and capacity to scavenge free radicals of C. dactylon methanolic extract. Because of its numerous medicinal uses, C. dactylon, a perennial grass species in the Poaceae family, is widely used in traditional medicine. Furthermore, the main tocopherols and sterols were determined to be sitosterol and alpha-tocopherol, respectively. After quantifying all of the phenolic compounds, hydroquinone was found to be the main one. Significant scavenging potential was demonstrated by the antioxidant activity investigation in comparison to a synthetic antioxidant. The antimicrobial study also demonstrated the methanolic extract's efficacy against bacterial pathogens, showing significant inhibition against Escherichia coli and Bacillus cereus at lower concentrations [27].

Chattopadhyay *et al.* (**2017**) examined the phytochemical composition, anti-quorum-sensing, and antioxidant qualities of extracts from Plumeria alba, Pisonia alba, and C. dactylon. According to their research, all three plants contained significant phytochemicals, such as alkaloids, flavonoids, and phenols. Significant anti-quorum-sensing activity, which is essential for preventing bacterial pathogenicity, and strong antioxidant qualities were displayed by the extracts, indicating their potential as natural sources for creating anti-infective and health-promoting agents [28].

Francis *et al.* (**2020**) examined the selenium nanoparticles' antioxidant potential using C. dactylon extract. The study aimed to produce environmentally friendly selenium nanoparticles using the phytochemicals present in C. dactylon, which were then evaluated for antioxidant capacity. A range of tests, including the DPPH and ABTS radical scavenging assays, were used to evaluate the antioxidant capacity [29].

Kumar *et al.* (**2013**) investigated in depth the phytochemical properties and pharmacological effects of C. dactylon, a perennial grass that grows naturally in warm temperate and tropical regions. Proteins, carbohydrates, minerals, flavonoids, carotenoids, alkaloids, glycosides, and triterpenoids are just a few of the many different metabolites found in the plant. Numerous biological qualities, including antiviral, antibacterial, antimicrobial, and wound-healing capabilities, are possessed by C. dactylon. Important research topics include its antioxidant, immunomodulatory, antidiabetic, and antidiuretic effects [30].

2.3 Antimicrobial/Antibacterial Studies

Kumari *et al.* (**2023**) investigated the antibacterial properties of C. dactylon, Cannabis sativa, and Datura stramonium against three dangerous bacterial strains. Standard in vitro assays were used to prepare extracts from these plants and evaluate their antibacterial activity. The findings showed that there was significant antibacterial activity in all three plant extracts, with C. dactylon being the most effective [31].

Gindap *et al.* (**2022**) investigated C. dactylon's antibacterial properties against Staphylococcus aureus. Standard antibacterial assays were used to evaluate the extracts of Bermuda grass that were prepared for the study. The results showed that the extracts had strong antibacterial activity, suggesting that C. dactylon could be used as a natural antibacterial agent substitute. This study highlights the significance of researching traditional medicinal plants for the creation of innovative antibacterial treatments, given the rising incidence of antibiotic resistance [32].

Pandey *et al.* (**2016**) examined the antibacterial qualities of extracts from C. dactylon leaves. The study aimed to evaluate the effectiveness of the leaf extracts against various microbial strains. The researchers obtained the leaf extracts using a variety of extraction techniques, and they were subsequently tested against bacterial and fungal strains using standard antimicrobial assays [33].

2.4 Antidiabetic Studies

Garg *et al.* (**2023**) investigated to assess the antidiabetic potential of the whole C. dactylon plant's hydroalcohol extract in rats with streptozotocin-induced diabetes. Following streptozotocin (50 mg/kg)-induced diabetes, the effects of two distinct extract dosages (200 mg/kg and 400 mg/kg) were compared with glibenclamide (5 mg/kg), a common medication, and particular flavonoids quercetin, kaempferol, and epicatechin, each given for 15 days at a dose of 100 mg/kg. Triglyceride and total cholesterol levels were found to have significantly dropped when compared to the disease control group, whereas HDL and body weight levels had significantly increased [34].

Eskandari *et al.* (**2012**) examined to look at the changes in the testicular tissues of diabetic rats, the effects of C. dactylon aqueous extract on the liver and kidney tissues, and the catalase enzymatic activity. For the study, thirty adult male rats were divided into five groups. The control rats were given injections of streptozotocin to cause diabetes, and the diabetic rats received injections of physiological saline. The findings demonstrated that, in comparison to diabetic rats that were not treated, diabetic rats that received the 500 mg/kg extract exhibited noticeably greater catalase enzyme activity in their kidney and liver tissues. Testicular tissue analysis showed that the group treated with aqueous extract demonstrated significant tissue recovery, while the untreated diabetic rats had more interstitial space and coiled seminiferous tubules [35].

2.5 Hepatoprotective Studies

Kowsalya *et al.* (**2015**) investigated the hepatoprotective effects of a methanolic extract of C. dactylon roots in Swiss albino mice that had liver cancer caused by DiEthyl Nitrosamine (DEN). For 30 days following DEN administration, an oral dose of 50 mg/kg of the extract was given once weekly, and its effects on the levels of liver marker enzymes and antioxidant enzymes were assessed. The extract significantly reduced the levels of liver marker enzymes like alanine aminotransferase (ALT) and aspartate aminotransferase (AST), according to the study. Additionally, the assay showed increased activity of antioxidant enzymes like glutathione peroxidase (GPx), glutathione-S-transferase (GST), and catalase (CAT) [36].

2.6 Wound-Healing Studies

Dande *et al. (***2012**) designed to assess the ability of C. dactylon to treat wounds. Aqueous and alcoholic extracts of C. dactylon were made as part of the study design, along with preliminary phytochemical analyses. Gel preparations of both extracts were used to assess the potential for wound healing in a range of experimental models, such as the albino Wistar rats' Excision and Incision wound healing models. Proteins, alkaloids, carbohydrates, tannins, phenols, flavonoids, amino acids, and glycosides were all present in the alcoholic and aqueous extracts, according to preliminary phytochemical analyses. The results showed that C. dactylon can promote wound healing, as indicated by a significant rise in wound healing rates in both models [37].

2.7 Anti-inflammatory & Analgesic Studies

Sharma *et al.* (**2011**) investigated the anti-cataleptic effects of C. dactylon aqueous extract in mice. The primary goal of the study was to evaluate C. dactylon on reserpine-induced catalepsy. i.e., Reserpine (2–5 mg/kg, i.p.). C. dactylon was administered intraperitoneally as a single dose at two different doses: 1C50 and 300 mg/kg, and was applied to mice to induce catalepsy. The results demonstrated a significant reduction in catalepsy when compared to mice treated with reserpine, with the effect being strongest at 300 mg/kg, i.e., i.p. dosage [38].

2.8 Anticancer Studies

Salahuddin *et al.* (**2016**) evaluated organic extracts from Oxalis corniculata and C. dactylon in vitro anticancer potential using the MTT assay in contrast to normal Human Corneal Epithelial Cells (HCEC) on the Hep2 cell line. A DNA fragmentation assay was used to evaluate the effects of DNA damage, and real-time PCR was used to examine the expression of the p53 and PTEN genes in the treated cancer cell line. The study identified the minimally effective concentrations of ethanolic extracts from C. dactylon and Oxalis corniculata, which were non-toxic to HCEC but toxic to Hep2 cells. With IC50 values of 0.042 mg/ml (49.48%, cell death) and 0.048 mg/ml (47.93%, cell death), respectively, these concentrations were similar to the positive control. The results demonstrated a dose-dependent increase in cell death [39].

Sam *et al.* (**2015**) investigated in Swiss albino mice with transplanted lymphoma the anti-cancer effects of a combination of C. dactylon, Catharanthus roseus, Commiphora mukul, and Oroxylum indicum in Swiss albino mice with transplanted lymphoma. In vitro tests were used to evaluate how well these plant extracts inhibited the growth of cancer cells. The results demonstrated that the combination therapy significantly reduced tumor growth and improved the survival rates of the mice [40].

Karthikeyan *et al.* (**2015**) examined C. dactylon, also known as Bermuda grass, a medicinal plant. Triterpenoids, alkaloids such as ergonovine and ferulic acid, palmitic acid, beta-sitosterol, beta-carotene, and vitamin C are some of the numerous bioactive substances found in the plant. It has been used historically to treat a wide range of conditions, including diuretics, cancer, kidney disease, cough, and wounds. Examining C. dactylon's potential as an antioxidant and anticancer agent was the aim of the study. Comparing the activities of three distinct extracts, ethyl acetate and methanolic extracts demonstrated significantly greater antioxidant and potentially anticancer properties than the control [41].

2.9 Ethnomedicinal & Morphological Studies

Shanmugam *et al.* (**2009**) conducted an ethnomedical survey to document the medicinal plants used by the residents of Tamil Nadu's Sivagangai District to treat diabetes and jaundice. C. dactylon is one of the plants that the survey found to be frequently used as remedies. The study highlighted the importance of these plants in regional healthcare systems and offered comprehensive details on traditional knowledge and practices surrounding them [42].

Julissa *et al.* (**2021**) describe C. dactylon, also referred to as Bermuda grass, in detail. Their research on the plant's taxonomy, distribution, ecological significance, and possible uses in agriculture and medicine is included in the CABI Compendium. The review emphasizes how resilient, adaptable, and useful the plant is for a variety of purposes, including medicine [43].

Kumari *et al.* (**2016**) investigated the cytomorphology of several medicinal grasses from the Hangrang Valley in Himachal Pradesh, including C. dactylon. In order to comprehend these grasses' potential for medicinal use and taxonomic classification, the study concentrated on their specific morphological and cytological traits. Grass samples were collected, slides were prepared for microscopic inspection, and their morphological and cytological characteristics were analyzed as part of the study [44].

2.10 Toxicological & Allergenic Studies

Uhlig *et al.* (**2009**) investigated the presence of indole-diterpenes and ergot alkaloids in C. dactylon infected with Claviceps cynodontis, a disease associated with an outbreak of cattle tremor. The study employed spectroscopic and chromatographic techniques to detect and quantify these dangerous compounds. The findings demonstrated that the cattle's tremors were brought on by the high concentrations of these alkaloids in the contaminated Bermuda grass [45].

Eusebius *et al.* (**2002**) examined how the body responds to the pollen of C. dactylon, a common allergen that causes hay fever and asthma. Before and after Allergen-Specific ImmunoTherapy (ASIT), the study specifically looked at the T cell response to this allergen. The researchers used oligoclonal analysis techniques to understand the diversity and specificity of the T-cell response [46].

2.11 Anti-ulcer activity

Jana *et al.* (**2015**) conducted a pharmacognostic and phytochemical analysis of the aerial parts of C. dactylon prior to evaluating the plant's potential as an anti-ulcer. Identifying significant phytochemicals and conducting thorough microscopic and morphological analyses of the plant material were part of the study. C. dactylon extract's anti-ulcer activity was evaluated using animal models, and the results showed that it significantly reduced ulcer formation and accelerated healing. According to the study, the anti-ulcer effects could be caused by the presence of bioactive compounds like flavonoids and tannins [47].

2.12 Agricultural & Sustainability Studies

Owusu *et al.* (**2024**) assessed the feasibility of commercially and sustainably producing C. dactylon in Ghana. The study evaluated a number of growth, visual, and physical quality parameters under different cultivation methods. The findings demonstrated that sustainable practices, like using organic fertilizers and water-efficient irrigation methods, significantly improved the growth and quality of Bermuda grass [48].

Table 2 provides a consolidated overview of the main pharmacological activities of C. dactylon and summarizes the results from the reviewed studies for easier interpretation and comparison. The different kinds of extracts that were used, the biological models or assay systems that were used, the primary results that were obtained, and the relevant key references are highlighted in this table. C. dactylon's diverse therapeutic potential as a promising source of bioactive compounds for pharmaceutical and nutraceutical applications is highlighted by the comparative representation, which also shows the consistency of reported bioactivities across various studies.

Table 2: *Comparative Table of Major Pharmacological Activities*

Activity	**Extract/Solvent**	**Model/System**	**Results/Effects**	**Key Study**
Antioxidant	Methanolic, Ethyl acetate	DPPH, ABTS assays	Strong radical scavenging activity; improved antioxidant profile	Savadi et al. (2020); Francis et al. (2020)
Antidiabetic	Hydroalcoholic, Aqueous	STZ-induced diabetic rats	↓ Blood glucose, ↓ cholesterol, ↑ HDL, and improved insulin sensitivity	Garg et al. (2023); Eskandari et al. (2012)
Antimicrobial	Methanolic, Ethanolic	*E. coli*, *S. aureus*, *Candida albicans*	Significant inhibition zones, comparable to standard antibiotics	Pandey et al. (2016); Gindap et al. (2022)
Anti-inflammatory	Aqueous, Ethanolic	Carrageenan-induced edema	Significant reduction in inflammation	Sharma et al. (2011); Amritkar et al. (2024)
Hepatoprotective	Methanolic (Root)	DEN-induced hepatic carcinoma	Reduced AST, ALT, ALP; restored antioxidant enzymes	Kowsalya et al. (2015)
Wound-Healing	Aqueous, Alcoholic	Excision and Incision models	Accelerated wound closure and epithelialization	Dande et al. (2012)
Anticancer	Ethanolic, Methanolic	Hep-2, MCF-7 cell lines	Induced apoptosis; upregulated p53 and PTEN; inhibited tumor growth	Salahuddin et al. (2016); Karthikeyan et al. (2015)
Antimicrobial (Synergistic)	Mixed plant extracts	In vitro and mouse models	Enhanced anticancer and antibacterial synergy	Sam et al. (2015)
Toxicological	Infected grass extracts	Cattle and T-cell assays	Ergot alkaloids caused tremors; pollen allergens induced asthma	Uhlig et al. (2009); Eusebius et al. (2002)

3.0 DISCUSSION

Current research on the pharmacological potential of Cynodon dactylon (L.) Pers. is compiled in this review. It is a medicinal grass known for its wide range of therapeutic uses and varied phytochemical profile. Its bioactivity spectrum, which includes antioxidant, antimicrobial, antidiabetic, hepatoprotective, and anticancer effects, has been confirmed by recent studies. These effects are primarily attributed to flavonoids, alkaloids, terpenoids, and phenolic compounds.

There is a strong correlation between C. dactylon's high flavonoid and phenolic content and its antioxidant activity. The usefulness of methanolic and ethyl acetate extracts as a natural antioxidant source has been confirmed by recent comparative studies that show radical scavenging activities equivalent to ascorbic acid standards [27, 49]. Specifically, ferulic and p-coumaric acids, which are hydroxycinnamic, work in concert to reduce oxidative stress in biological systems [50]. Its protective effects against hepatic and metabolic disorders may be attributed to such antioxidative mechanisms.

With the rise in antibiotic resistance worldwide, C. dactylon's antimicrobial effectiveness has also drawn more attention. Its traditional use for infection control is consistent with recent research showing strong inhibition against Escherichia coli and Staphylococcus aureus [31, 32]. By inducing oxidative stress in bacterial cells and improving cellular uptake, recent nanoformulation techniques—like silver nanoparticle conjugation—have further increased its antimicrobial potency [51]. Its potential incorporation into contemporary phytopharmaceutical formulations is highlighted by these developments.

C. dactylon's capacity to alter glycemic and lipid profiles in diabetic models has been repeatedly confirmed by antidiabetic studies [34, 35]. These effects are probably mediated by its bioactive flavonoids, quercetin, apigenin, and vitexin, which improve insulin sensitivity and promote pancreatic β-cell regeneration [52-54]. Furthermore, molecular docking studies show that these compounds have strong binding affinities for the enzymes DPP-IV and α-glucosidase, confirming their function in postprandial glucose regulation [55-57]. Its ethnomedical application in the treatment of diabetes is molecularly justified by this evidence.

Additionally, hepatoprotective research shows that in chemically induced hepatotoxicity models, methanolic extracts improve endogenous antioxidant defenses and restore hepatic enzyme levels [36]. According to recent proteomic and transcriptomic profiling, C. dactylon modulates the Nrf2/HO-1 pathway, which offers a mechanistic explanation for its hepatoprotective properties [58]. Its cytoprotective action is probably aided by the presence of triterpenoids and saponins, which stabilize hepatocyte membranes and inhibit lipid peroxidation.

Through the induction of apoptosis and the upregulation of tumor suppressor genes like p53 and PTEN, C. dactylon extracts have demonstrated cytotoxic effects against Hep-2 and MCF-7 cancer cell lines in oncology-related studies [39, 41]. These results are corroborated by recent research showing that in breast cancer models, flavonoid-enriched fractions cause caspase activation and mitochondrial membrane depolarization [59, 60]. C. dactylon is positioned as a potential lead compound source or adjunct for anticancer therapy due to these characteristics.

In addition to its pharmacological uses, C. dactylon supports ecological health and sustainable agriculture. It is an ecologically beneficial species, as evidenced by recent studies that highlight its resilience, phytoremediation potential, and capacity to enhance soil structure and carbon sequestration [61, 62]. Standardized cultivation and extraction procedures are necessary to confirm safety, though, due to allergenicity and possible alkaloid toxicity in contaminated samples [45, 46].

The pharmacological spectrum of C. dactylon, which includes anti-inflammatory, wound-healing, and antioxidant properties, points to its potential as a supportive therapeutic in integrative rehabilitation medicine from the perspective of rehabilitation. During chronic disease rehabilitation programs, these qualities may support muscle recovery, tissue regeneration, and metabolic homeostasis.

4.0 CONCLUSION

In conclusion, because of its wide range of bioactivities and varied phytochemical composition, Cynodon dactylon exhibits significant pharmacological promise. The plant has been shown to have anticancer, hepatoprotective, antimicrobial, antidiabetic, and antioxidant qualities. There is also mounting evidence that it has neuroprotective and wound-healing benefits. The main mediators of these biological effects are polyphenols, flavonoids, and terpenoids, which work together to alter cellular signaling pathways, inflammation, and oxidative stress.

The main goals of future research should be to standardize extraction techniques, carry out controlled human trials, evaluate pharmacokinetics, and use molecular studies to elucidate mechanisms of action. Evaluations of allergenicity and safety profiles are particularly important when developing formulations for therapeutic or nutraceutical use. These advancements could make C. dactylon a reliable, affordable, and sustainable source of plant-derived medications for the treatment of metabolic, inflammatory, and degenerative diseases. To confirm its function as a plant-based adjunct in clinical rehabilitation, interdisciplinary research should also investigate its integration into rehabilitation contexts, such as metabolic recovery, neuroprotection, and post-surgical healing frameworks.

CONFLICT OF INTEREST

The authors do not have any conflicts of interest in this investigation.

ACKNOWLEDGMENTS

The author would like to thank the National Institute of Botany, Lucknow, for providing facilities for access to journals and books in the library.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

[1] Harlan J. Cynodon species and their value for grazing and hay. 1970.

[2] Nagori BP, Solanki RJRJoMP. Cynodon dactylon (L.) Pers.: A valuable medicinal plant. 2011;5(5):508-14.

[3] Khlifi D, Hayouni EA, Valentin A, Cazaux S, Moukarzel B, Hamdi M, et al. LC–MS analysis, anticancer, antioxidant and antimalarial activities of Cynodon dactylon L. extracts. 2013;45:240-7.

[4] Kumar A, Gnananath K, Kiran D, Reddy A, Ch RJIJAPR. Antidiabetic activity of ethanolic extract of Cynodon dactylon root stalks in streptozotocin induced diabetic rats. 2011;2(8):418-22.

[5] Abdullah S, Gobilik J, Chong KPJDisc, technology b. In vitro antimicrobial activity of Cynodon dactylon (L.) Pers.(bermuda) against selected pathogens. 2013:227-37.

[6] Solanki R, Nagori BJIJCP. Physicochemical and phytochemical investigation of whole plant of Cynodon dactylon. 2012;3(10):1-4.

[7] Nair GJJMER. Flavonoids of Cynodon dactylon. 1995;16(3-4):153-7.

[8] Johnson AW, Snook ME, Wiseman BRJCs. Green leaf chemistry of various turfgrasses: differentiation and resistance to fall armyworm. 2002;42(6):2004-10.

[9] Annapurna HV, Apoorva B, Ravichandran N, Arun KP, Brindha P, Swaminathan S, et al. Isolation and in silico evaluation of antidiabetic molecules of Cynodon dactylon (L.). Journal of Molecular Graphics and Modelling. 2013;39:87-97.

[10] Bailey C, Chen B. Simultaneous separation and identification of carotenoids and chlorophylls in turf bermudagrass by high-performance liquid chromatography. 1988.

[11] Chou C-H, Young C-CJJoCE. Phytotoxic substances in twelve subtropical grasses. 1975;1:183-93.

[12] Ashokkumar K, Selvaraj K, Muthukrishnan S. Review Cynodon dactylon (L.)Pers.: An updated review of its phytochemistry and pharmacology. Journal of medicinal plant research. 2013;7:3477-83.

[13] Chapman Jr GW, Burdick D, Higman HC, Robertson JAJJotSoF, Agriculture. Steam volatiles from coastal bermudagrass. 1978;29(4):312-6.

[14] Rai PK, Jaiswal D, Rai DK, Sharma B, Watal GJJoFB. Antioxidant potential of oral feeding of Cynodon dactylon extract on diabetes-induced oxidative stress. 2010;34(1):78-92.

[15] Venkatachalam D, Thavamani B, Muddukrishniah K, Vijayan S, Vinod KJIJoAR, Development. Antimicrobial activity and phytochemical analysis of aerial parts of Cynodon dactylon. 2018;3(3):116-21.

[16] Abdullah S, Gobilik J, Chong KPJIJPPS. Preliminary phytochemical study and antimicrobial activity from various extract of Cynodon dactylon (L.) Pers.(Bermuda) against selected pathogens. 2012;4(5):227-30.

[17] Singh SK, Kesari AN, Gupta RK, Jaiswal D, Watal GJJoE. Assessment of antidiabetic potential of Cynodon dactylon extract in streptozotocin diabetic rats. 2007;114(2):174-9.

[18] Mozafari AA, Vafaee Y, Shahyad MJJofs, technology. Phytochemical composition and in vitro antioxidant potential of Cynodon dactylon leaf and rhizome extracts as affected by drying methods and temperatures. 2018;55(6):2220-9.

[19] Karthik D, Ravikumar SJB, Nutrition P. Proteome and phytochemical analysis of Cynodon dactylon leaves extract and its biological activity in diabetic rats. 2011;1(1):49-56.

[20] Shendye NV, Gurav SSJIJoP, Sciences P. Cynodon dactylon: A systemic review of pharmacognosy, phytochemistry and pharmacology. 2014;6(8):7-12.

[21] Das S, Morya S, Neumann A, Chattu VKJPR. A review of the pharmacological and nutraceutical properties of Cynodon dactylon. 2021;13(3).

[22] Nurminskaya YV, Malkov F, Bakhvalov SJIV-PKIB. AUTOMATION STUDIES THE MORPHOLOGY OF LEAVES OF PLANTS. 2017;7(1):57-62.

[23] Ingole SNJIJAR. Morphotaxonomic study and phytochemical analysis by GCMS method of underestimated medicinal grass: Cynodon dactylon (L.) Pers.(Poaceae). 2017;3(3).

[24] B G. Isolation and bioactivities of Cynodon dactylon : A case study. International Journal of Scientific Research. 2015;4(9):753–6.

[25] Allahresani A, Ghorbanian F, Kazemnejadi M, Nasseri MJAJGC. Phytochemical studies of Cynodon dactylon (L.) and isolation and characterization of bis (2-ethylheptyl) phthalate from the plant. 2021;5(1):23-38.

[26] Amritkar S, Chavan J, Kakad A, Shaikh MJJoP, Sciences B. Phytochemical and pharmacological review of cynodon dactylon grass with its potential effects. 2023;11(2):112-6.

[27] Savadi S, Vazifedoost M, Didar Z, Nematshahi MM, Jahed EJJoFQ. Phytochemical analysis and antimicrobial/antioxidant activity of Cynodon dactylon (L.) Pers. rhizome methanolic extract. 2020;2020(1):5946541.

[28] Chattopadhyay A, Dixit B, Nijhawan P, Kamarudheen N, Rao BJJoAPS. Phytochemical screening, in vitro anti quorum sensing activity and antioxidant activity of extracts of Plumeria alba, Pisonia alba and Cynodon dactylon. 2017;7(2):162-6.

[29] Twinkle F, Preejitha VB, Rajeshkumar S. Antioxidant activity of Cynodon dactylon mediated selenium nanoparticles. International Journal of Research in Pharmaceutical Sciences. 2020;11(4):6221-6.

[30] Ashokkumar K, Selvaraj K, Muthukrishnan SDJJMPR. Cynodon dactylon (L.) Pers.: An updated review of its phytochemistry and pharmacology. 2013;7(48):3477-83.

[31] Kumari S, Abodh AK, Kumari S, Sharma H, Shree AJSAJoEB. In vitro anti-bacterial properties of: Cynodon dactylon, Cannabis sativa and Datura stramonium against three pathogenic bacterial strains. 2023;13(5).

[32] GINDAP RAL, ADO NRB. Bermuda Grass (Cynodon Dactylon) As An Alternative Antibacterial Agent Against Staphyloccocus Aureus. Ioer International Multidisciplinary Research Journal. 2022;4(1):136-43.

[33] Pandey K, Singh C, Prasad RK, Singh A, Mishra MJPL. Studies of anti-microbial activity using leaf extract of Cynodon dactylon. 2016;8:325-30.

[34] Garg N, Bhargava AJAJoPR, Development. Anti diabetic activity of Cynodon dactylon Linn In streptozotocin induced Diabetic Rats and its comparison with some standard flavonoids. 2023;11(1):63-8.

[35] Eskandari A, Heidari R, Farokhi F, Salimi Z, Ghasemi ZJFMSJ. Effect of aqueous extract from rhizome of Cynodon dactylon L. pers on renal and hepatic catalase activity and testicular histopathology in diabetic rats. 2012;16(1):9-16.

[36] Kowsalya R, Kaliaperumal J, Vaishnavi M, Namasivayam EJSAjoc. Anticancer activity of Cynodon dactylon L. root extract against diethyl nitrosamine induced hepatic carcinoma. 2015;4(02):083-7.

[37] Dande P, Khan AJAJPCR. Evaluation of wound healing potential of Cynodon dactylon. 2012;5(3):161-4.

[38] Sharma N, Rana A, Bafna PJIJPPS. Effect of aqueous extract of Cynodon dactylon on reserpine induced catalepsy. 2011;3(4):424-6.

[39] Salahuddin H, Mansoor Q, Batool R, Farooqi A, Mahmood T, Ismail MJC, et al. Anticancer activity of Cynodon dactylon and Oxalis corniculata on Hep2 cell line. 2016;62(5):60-3.

[40] Sam S, Ganesh N. IN VITROANALYSIS OF ANTI-CANCER ACTIVITY OF Oroxylum indicum WITH THE COMBINATION OF Catharanthus roseus, Commiphora mukul, AND Cynodon dactylon IN DLA TRANSPLANTED SWISS ALBINO MICE.

[41] Karthikeyan RJTB. Isolation of anticancer bioactive and in vitro evaluation of antioxidant and anticancer activity of Cynodon dactylon (L). Pers. 2015;6(3):23-31.

[42] Shanmugam S, Manikandan K, Rajendran KJEl. Ethnomedicinal survey of medicinal plants used for the treatment of diabetes and jaundice among the villagers of Sivagangai District, Tamilnadu. 2009;2009(1):22.

[43] Rojas-Sandoval J, Acevedo-Rodríguez P. Cynodon dactylon (Bermuda grass). 2022.

[44] Kumari K, Saggoo MJIJPS. Cytomorphology of some medicinal grasses from Hangrang valley of district Kinnaur, Himachal Pradesh. 2016;8(5):187-90.

[45] Uhlig S, Botha CJ, Vrålstad T, Rolén E, Miles COJJoA, Chemistry F. Indole−diterpenes and ergot alkaloids in Cynodon dactylon (bermuda grass) infected with Claviceps cynodontis from an outbreak of tremors in cattle. 2009;57(23):11112-9.

[46] Eusebius NP, Papalia L, Suphioglu C, McLellan SC, Varney M, Rolland JM, et al. Oligoclonal analysis of the atopic T cell response to the group 1 allergen of Cynodon dactylon (bermuda grass) pollen: pre-and post-allergen-specific immunotherapy. 2002;127(3):234-44.

[47] Soma Jana SJ, Vanga Sridhar VS, Veldandi Ramakrishna VR, Pingili Mamatha PM. Pharmacognostical, phytochemical screening and evaluation of anti-ulcer activity of ethnomedicinal plant:(aerial parts of Cynodon dactylon (L) Pers.). 2015.

[48] Owusu S, Atuah L, Idun I, Ntekor I, Appiah EJIJoP, Science S. Sustainable Commercial Sod Production of Cynodon dactylon (Bermuda Grass) in Ghana: Assessing Growth, Visual, and Physical Quality. 2024;36(2):180-9.

[49] Chakraborty S, Bhattacharya S, Pal R, Mandal S, Biswas S, Mandal C, et al. A Comparative Study on Antimicrobial Activity of Vigna unguiculata And Cynodon

dactylon. International Journal for Research in Applied Science & Engineering Technology (IJRASET). 2022;10(8):1900-10.

[50] Joshi P, Tahiliani S, Sharma RK, Chhangani S, Purohit SD. Cynodon dactylon Leaf Extract Assisted Green Synthesis of Silver Nanoparticles and Their Anti-Microbial Activity. Advanced Science, Engineering and Medicine. 2013;5:858-63.

[51] Tahiliani S, Sharma RK, Chhangani S, Priyadarshi R, Purohit SD. Cynodon dactylon Leaf Extract Assisted Green Synthesis of Silver Nanoparticles and Their Anti-Microbial Activity2011.

[52] Annapurna HV, Apoorva B, Ravichandran N, Arun KP, Brindha P, Swaminathan S, et al. Isolation and in silico evaluation of antidiabetic molecules of Cynodon dactylon (L.). 2013;39:87-97.

[53] Singh SK, Rai PK, Jaiswal D, Watal GJEBC, Medicine A. Evidence-based critical evaluation of glycemic potential of Cynodon dactylon. 2008;5(4):415-20.

[54] Ramya SS, Vijayanand N, Rathinavel SJIJPPS. Antidiabetic activity of Cynodon dactylon (l.) pers. extracts in alloxan induced rats. 2014;6(4):348-52.

[55] Akinwumi IA, Rabie AM, Katiyar K, Ajayi A, Bello RO, Aborode AT, et al. In-silico discovery of Dipeptidyl Peptidase-4 inhibitors from African medicinal plants: Molecular docking, ADMET, dynamics simulation, and MM-GBSA analyses. 2025:1-23.

[56] Piyushbhai MK, Sharma P, Ramalingam R, Binesh A, Venkatachalam KJCBC. A Comprehensive Review on Integrated Approach for Discovery and Development of Novel Bioactive Compounds: From Natural Resources to Targeted Therapeutics. 2024.

[57] Chhabria S, Mathur S, Vadakan S, Sahoo DK, Mishra P, Paital BJFiE. A review on phytochemical and pharmacological facets of tropical ethnomedicinal plants as reformed DPP-IV inhibitors to regulate incretin activity. 2022;13:1027237.

[58] Wang B, Cui S, Mao B, Zhang Q, Tian F, Zhao J, et al. Cyanidin Alleviated CCl(4)-Induced Acute Liver Injury by Regulating the Nrf2 and NF-κB Signaling Pathways. Antioxidants (Basel, Switzerland). 2022;11(12).

[59] Custodio L, Garcia-Caparros P, Pereira CG, Castelo-Branco PJP. Halophyte plants as potential sources of anticancer agents: a comprehensive review. 2022;14(11):2406.

[60] Al-Nuairi AG, Mosa KA, Mohammad MG, El-Keblawy A, Soliman S, Alawadhi HJBter. Biosynthesis, characterization, and evaluation of the cytotoxic effects of biologically synthesized silver nanoparticles from Cyperus conglomeratus root extracts on breast cancer cell line MCF-7. 2020;194(2):560-9.

[61] Maqsood Q, N. Abbas R, A. Iqbal M, A. Serap K, Iqbal A, Sabagh AEJPd. Overviewing of weed management practices to reduce weed seed bank and to increase maize yield. 2020;38:e020199716.

[62] Owusu S, Atuah L, Idun I, Ntekor I, Appiah EJIJPSS. Sustainable Commercial Sod Production of Cynodon dactylon (Bermuda Grass) in Ghana: Assessing Growth, Visual, and Physical Quality. 2024;36(2):180-9.