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Review Article

Comparative Evaluation of Nanoparticles and Plant Extract of *Cynodon dactylon* for Gastric Acid Regulation

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Abstract

The common medicinal plant that has been used is *Cynodon dactylon* (Bermuda grass) which is used in gastrointestinal diseases. The plant has a number of bioactive phytochemicals such as flavonoids, glycosides, alkaloids and terpenoids which help in mucosal protection and neutralization of gastric acid. Widely used extracts of the plant have proven to have moderate anti ulcer and antacid effects. Innovations that have taken place in green nanotechnology have now facilitated the synthesis of plant mediated nanoparticles that increase stability, bioavailability and therapeutic efficacy of these phytoconstituents. The relative studies indicate that *Cynodon dactylon* derived nanoparticles have better antioxidant capacity and acid neutralizing and better gastroprotection than crude extracts. The enhanced effect is explained by the synergistic effect of the phytochemicals and nanoscale delivery systems. As such, plant extracts as well as nanoparticle formulations of *Cynodon dactylon* can be used as viable therapeutic options in the treatment of gastric acidity and ulcer related disorders.

Keywords: *Cynodon dactylon*; Durva; Traditional Uses; Gastric Acid Neutralization

Introduction

Gastric hyperacidity and related diseases including gastritis, acid reflux and peptic ulcer disease appeal a high percentage of the population in the world. These diseases are usually as a result of an imbalance between stimulatory factors that include hydrochloric acid, pepsin and reactive oxygen species and the defense mechanisms of the gastric mucosa. The traditional pharmacological treatment is based on the use of proton pump inhibitors, H2 receivers and synthetic antacids. Despite the good effect that these drugs have in inhibiting acid secretion and offering symptomatic relief, the long-term use of the drugs can cause a number of effects that are undesirable such as electrolyte imbalance, diarrhea, constipation and high-risk of getting infected [1].

Because of these limitations, interest has increased in plantbased therapeutic agents that provide gastroprotection with fewer side effects. *Cynodon dactylon* (L.) Pers., commonly known as Bermuda grass or Durva, is a perennial herb belonging to the Poaceae

family and is widely used in traditional systems of medicine such as Ayurveda, Siddha and Unani. The plant is rich in flavonoids, phenolic compounds, alkaloids and terpenoids that contribute to antioxidant, antiinflammatory and gastroprotective activities [2].

Experimental studies have demonstrated that aqueous and alcoholic extracts of the plant can reduce gastric acidity and ulcer index in experimental models. Recently, green synthesis of nanoparticles using plant extracts has emerged as a promising approach to improve the biological performance of herbal compounds. In this approach, phytochemicals present in the extract act as reducing and stabilizing agents, producing nanoparticles with improved bioavailability and surface reactivity. Comparative evaluation of plant extracts and nanoparticles may therefore provide new insight into improved therapeutic strategies for gastric acid neutralization [3,4].

Phytochemical profile of *Cynodon dactylon*

- Botanical description [5]
- Scientific name: *Cynodon dactylon* (L.) Pers.
- Common names: Durva (Hindi), Bermuda grass (English), Arugampillu (Tamil)
- Family: Poaceae (Gramineae)
- Habitat: Grows in warm climates; found in lawns, fields, and roadsides

Figure 1: *Cynodon dactylon* (Bermuda grass) and its powder.

Part	Key Features (Short)
Roots	Fibrous root system; strong anchorage; efficient nutrient & water absorption
Stems	Rhizomes & stolons for spreading; creeping habit; culms up to ~20 cm.
Leaves	Linear, narrow (2–15 cm × 1–5 mm); green/ gray-green; rough upper surface.
Inflorescence	3–7 spikes; spikes 2–5 cm; spikelets 2–3 mm with single flower.
Seeds	Tiny (1–2 mm), light brown; dispersed by wind, water, animals.
Growth Habit	Perennial; fast-spreading; highly drought-tolerant.

Table 1: Morphology of *Cynodon dactylon* (Durva grass) [6].

Flavonoids, alkaloids, glycosides, terpenoids, triterpenoids, steroids, saponins, tannins, resins, phytosterols, reducing sugars, carbohydrates, proteins, volatile oils, and fixed oils were all found in the plant, according to a variety of phytochemical investigations [7].

Glycosides	12.2%
Flavonoids	12.3%
Tannins	6.3%
Alkaloids	0.1%
Resins	1.0%
Free Reducing Sugar	10%
Total Reducing Sugar	12%

Table 2: Quantitative estimation of Phytoconstituents.

Cynodon dactylon's traditional function

Cynodon dactylon (Linn.) Pers., a perennial creeping herb in the Poaceae family, is also referred to as Durva or Bermuda grass. It is found in many tropical and subtropical areas, is revered in Indian culture, and is frequently utilized in religious rites honoring Lord Ganesha. Beyond its cultural value, *C. dactylon* has long been used medicinally in Unani, Siddha, and Ayurvedic medical systems [8].

The herb has long been used for its anti-inflammatory, antipyretic, diuretic, and wound-healing qualities. Grass decoctions are used to treat bleeding disorders, kidney stones, and urinary tract infections. While the juice is ingested to stop excessive bleeding in

menorrhagia and piles, leaf paste is applied externally to cuts and skin eruptions. Because it has been used to treat peptic ulcers, acid reflux, and indigestion, its significance in gastrointestinal health is especially significant. Modern pharmacological research into its bioactive components and therapeutic potential has been spurred by these ethnomedical assertions [9].

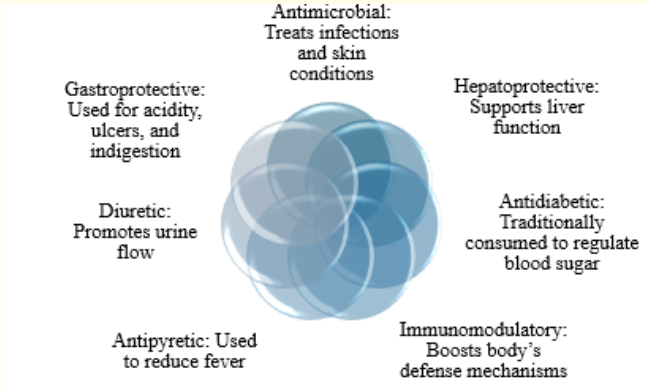

Figure 2: Traditional uses of *C. dactylon*.

Pharmacological actions [10-13]

Cynodon dactylon has bioactive compounds like flavonoids, alkaloids, glycosides, carotenoids, proteins and minerals. These components lead to several pharmacological effects:

- Antimicrobial effect -Efficient against fungal and bacterial infections.
- Anti-inflammatory effects → Swelling and pain-reducing, could be used in wound-healing.
- Antidiabetic effects → Aids in normalizing the levels of glucose in the blood.
- Antioxidant activity→Disarms free radicals, and cells become resistant to oxidative stress.
- Hepatoprotective effect - Protects liver functions, helps to prevent the effects of toxins.
- Protective effect on the heart concepts - Enhances blood flow and lessens cholesterol.
- Diuretic effect → Stimulates the flow of urine, which helps in detoxification.

Gastric acid neutralization property [14]

Mechanisms of action

- Phytochemicals combine with gastric proteins, suppressing acid secretion and increasing mucosal defense.
- The gastro protectional action of extracts and nanoparticles of C. dactylon is agreeable to various mechanisms.
- **Acid Neutralization**: Buffering of gastric acid directly, making acidic.
- **Antioxidant Defense**: ROS Scavenging, upregulation of endogenous antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase).
- **Anti inflammatory Effect**: Suppression of pro inflammatory cytokine(s), including TNF 6 and IL 6.
- **Mucosal Protection:** Stimulation of mucus and bicarbonate secretion, strengthening the gastric barrier.
- **Pepsin Inhibition:** Reduction of proteolytic activity that contributes to mucosal injury.
- **Nanoparticlemediated delivery:** Improved penetration and sustained release of phytochemicals at the gastric mucosa.

The gastro-protective properties of *C. dactylon* were tested against alcohol and indomethacin-induced damage to the stomach mucosa. They were divided into two sections: the alcohol-induced rat section and the indomethacin-induced rat section. Before being exposed to ulcerogens, the reference group, standard group, and test group of both induced sections were given 25 mg/kg of ranitidine and 300 mg/kg of *C. dactylon* juice triturate, respectively. After four hours of ulcerogenic exposure, the rats were dissected. The number of ulcers discovered, together with their diameters and indices, were recorded during the dissection process. In contrast to the reference and standard groups, the test group, which received the juice triturate of *C. dactylon*, showed the strongest anti-ulcer properties in the section of rats induced with alcohol. However, the standard group pre-treated with ranitidine performed better in the section of rats stimulated with indomethacin [15].

Experimental evidence for gastroprotection

Several preclinical studies have validated the traditional claims of *C. dactylon* in gastric protection. Aqueous and ethanolic extracts have been tested in animal models of gastric ulcer induced by ethanol, indomethacin, or pyloric ligation. Results consistently demonstrate:

- Decreased gastric acidity and gastric secretions volume.
- Reduction in ulcer index and severity of the lesions.
- Mucosal defensive factors such as mucus secretion and antioxidant enzyme activity are improved.
- Inhibition of lipid peroxidation and reactive oxygen species.

These findings suggest that this will be a dual action agent that impacts through cytoprotective and acid neutralizing effects. More importantly, its safety profile can be supported by the fact that it has not been reported to be toxic at therapeutic levels [16].

Green synthesis of nanoparticles from plant extracts

Preparation of plant extract

The *Cynodon dactylon* leaves are typically collected in the wild, washed with much care to remove the dust and other contaminants and shade dried to preserve the phytoconstituents. The dried leaves are cut into minute pieces and crushed against distilled water in order to prepare a crude aqueous extract. The mixture is cooled, centrifuged to remove debris and boiled to aid in liberating bioactive chemicals. Flavonoids, glycosides, tannins, and proteins are present in the ensuing clear supernatant and act as stabilizing and reducing agents during the formation of nanoparticles [17].

Phytochemical constituents

- Flavonoids (quercetin, luteolin) → antioxidant and gastroprotective activity
- Glycosides → contribute to anti-inflammatory effects
- Tannins → mucosal protection and astringent properties
- Proteins and carbohydrates → nutritional and stabilizing roles [17]

Extraction Method	Aqueous Extract	Alcoholic Extract
Solvent Used	Distilled water	Ethanol/Methanol
Key Phytoconstituents	Flavonoids, glycosides, tannins, proteins, carbohydrates	Alkaloids, sterols, phenolic compounds, flavonoids
Pharmacological Relevance	1. Mild acid neutralization effect 2. Antiulcer activity via mucosal protection 3. Safe, non-toxic, eco-friendly 4. Traditionally used in Ayurveda for digestive disorders	1. Stronger antiulcer activity (comparable to ranitidine) 2. Potent antioxidant and anti-inflammatory effects 3. Higher yield of non-polar compounds 4. Requires solvent handling and evaporation

Table 3: Comparative summary of aqueous vs alcoholic extracts [18].

Comparative efficacy: While aqueous extracts support traditional use and exhibit gastric acid neutralization, alcoholic extracts frequently exhibit higher antioxidant and antibacterial properties.

Silver nanoparticle green synthesis

Different quantities of silver nitrate solution are combined with the aqueous extract. The extract's phytochemicals degrade silver ions (Ag^+) to silver nanoparticles (AgNPs) when heated in a water bath. The color shift of AgNPs surface plasmon resonance results in visual confirmation of nanoparticles being made as the color changes significantly to dark brown instead of the pale yellow color. The approach to environmental-friendly synthesis shows the role of the plant metabolites in stability of nanoparticles without using harmful chemicals [19,20].

Characterization of nanoparticles [21,22]

The analysis of the synthesized nanoparticles is performed in terms of several analysis methods:

- **UV- Vis Spectroscopy:** UV-Vis spectroscopy results are used to verify nanoparticle formation, which is evident by the peaks in the 400-450 nm range.
- FTIR analysis determines functional groups (hydroxyl, carbonyl, amine) of reduction and capping.

- XRD (X ray diffraction) displays the crystalline character and distribution of particle size.
- TEM (Transmission Electron Microscopy) provides direct visualization of morphology, size, and dispersion of nanoparticles.
- Zeta Potential – Measures surface charge and stability

Pharmacological significance [23]

- Exhibits antiulcer and gastric acid neutralization activity by reducing acidity and protecting gastric mucosa
- Shows antioxidant and anti-inflammatory properties, helping in tissue repair
- Traditionally used in Ayurveda for digestive disorders, bleeding, and wound healing

The gastroprotective and stomach acid neutralization properties of the produced nanoparticles and the aqueous extract are assessed. Because of their larger surface area and better contact with the stomach mucosa, the nanoparticles frequently exhibit higher bioactivity than crude extracts [24,25].

Parameter	Plant Extract	Plant-Based Nanoparticles
Solubility	Limited aqueous solubility	Enhanced solubility and dispersion
Bioavailability	Low	Improved due to nanosize and permeability
Stability	Degraded by temperature, pH, and light	High stability due to nanoparticle protection
Pharmacological Activity	Moderate	Higher due to improved cellular uptake
Toxicity	Usually safe but may require high dose	Effective at lower concentrations
Target Specificity	Non-targeted	Potential for targeted delivery

Table 4: Comparative analysis: Plant extract vs. Nanoparticles [21-25].

Comparative efficacy: Extracts vs. Nanoparticles [23,25]

- Higher acid neutralizing ability in vitro, which is the ability to keep the gastric pH on levels above the critical levels over extended periods.
- N 6 Progreater decrease in index of ulcers in animal models, which implies more powerful mucosal protection.
- Increased antioxidant activity, increased free radical scavenging and lipid peroxidation inhibition.

Enhanced antimicrobial action, applicable in secondary infections in relation to ulcers.

Plant extracts also in most cases have a disadvantage of poor solubility, instability in a physiological environment and low bio-availability. Nanoparticle preparations address most of these drawbacks by increasing stability, surface area, and cellular uptake phytochemicals. Consequently, nanoparticles prepared using *Cynodon dactylon* are usually more biologically active at low concentrations than crude extracts. The above properties render nanoparticle formulations viable solutions in order to gain better therapeutic applications [26].

In vitro assays for gastric acid neutralization

Acid neutralizing capacity (ANC) Assay [27]

- **Principle:** Measures the ability of a substance to neutralize hydrochloric acid, mimicking gastric acid.
- **Procedure**
  - Prepare a known concentration of 0.1 N HCl at 37 °C.
  - Add the test sample (extract, formulation, or nanoparticle suspension).
  - Titrate with acid while maintaining pH at a set threshold (commonly pH 3.5).
  - Record the volume of acid consumed.
- **Readouts:** Expressed in milliequivalents (mEq) of acid neutralized.
- **Significance:** Standard method used for antacids; higher ANC indicates stronger neutralization capacity.

Simulated gastric fluid (SGF) pH–Time Profile [28]

- **Principle:** Evaluates how long a sample can maintain gastric pH above critical thresholds.

- **Procedure:**
  - Prepare SGF (0.1 N HCl ± pepsin).
  - Add the test sample and monitor pH continuously for 30–60 minutes.
  - Record peak pH, time to reach peak, and duration above pH 3–4.
- **Readouts:** Area under the pH–time curve (AUC), duration of neutralization.
- **Significance:** Mimics real gastric conditions; useful for sustainedrelease or nanoparticle formulations

Buffer capacity assay (BackTitration) [29]

- **Principle:** Determines the resistance of a sample to pH change.
- **Procedure:**
  - Titrate the sample with acid and base across physiologic pH ranges (1.5–4.0).
  - Calculate buffer capacity ($\beta = \Delta B/\Delta pH$).
- **Readouts:** Buffer capacity values at different pH points.
- **Significance:** Distinguishes transient neutralizers from true buffers; important for plant extracts rich in polyphenols

USP antacid assay [30]

- **Principle:** Official method for evaluating antacid formulations, adapted for herbal extracts.
- **Procedure:**
  - Add sample to 0.1 N HCl at 37 °C.
  - Measure onset of action (time to reach pH ≥ 3.0).
  - Record duration above pH threshold and total acid consumed.
- **Readouts:** Neutralization capacity, onset time, duration of effect.
- **Significance:** Provides standardized comparison with marketed antacids

Pepsin activity inhibition assay [31]

- **Principle:** Elevated pH and direct inhibition reduce proteolysis of gastric mucosa.
- **Procedure:**
  - Incubate pepsin with protein substrate (e.g., hemoglobin or albumin) ± sample.
  - Quantify peptide release spectrophotometrically.
- **Readouts:** % inhibition of pepsin activity, IC50 values.
- **Significance:** Shows whether extracts/nanoparticles protect mucosa by suppressing enzymatic activity in addition to neutralization.

Applications

The *Cynodon dactylon,* commonly referred to as Durva or Bermuda grass is a multifunctional plant that is applicable in modern technology, farming, culture, and medicine [32]. It is administered to heal ulcers, bleeding disorders, infections, and skin disorders due to gastroprotective, anti-inflammatory, antioxidant, antidiabetic, hepatoprotective, and cardioprotective properties of the traditional medicine. Due to this rich phytochemical compounds, *C. dactylon* is effective in reducing oxidative stress and healing wounds as well as neutralizing stomach acid besides having significant cultural and religious significance outside of medicine, specifically, in the Hindu rites that are dedicated to Lord Ganesha as a reminder of long life and purity. It finds application in agriculture to provide strong ground cover to lawns and sports fields, it is an erosive preventive soil binder and as highly nutritious cattle food. Its application in nanotechnology has increased over the past several years, as plant extracts are applied in the eco-friendly production of nanoparticles [33,34]. Compared to crude extracts, such nanoparticles are superior in acid neutralizing and gastroprotective effect, enhancing bioavailability, stability and therapeutic activity. *C. dactylon* is also utilized in herbal skincare products and stress-relieving treatments, demonstrating its incorporation into the wellness and cosmetics sectors. The plant is an important resource for biotechnology, healthcare, agriculture, and spirituality since it unites old knowledge with contemporary innovation [35-40].

Limitations of conventional extracts [41,42]

Crude plant extracts have difficulties in clinical translation despite encouraging outcomes. Phytochemicals frequently have low bioavailability, poor solubility, and instability in the stomach.

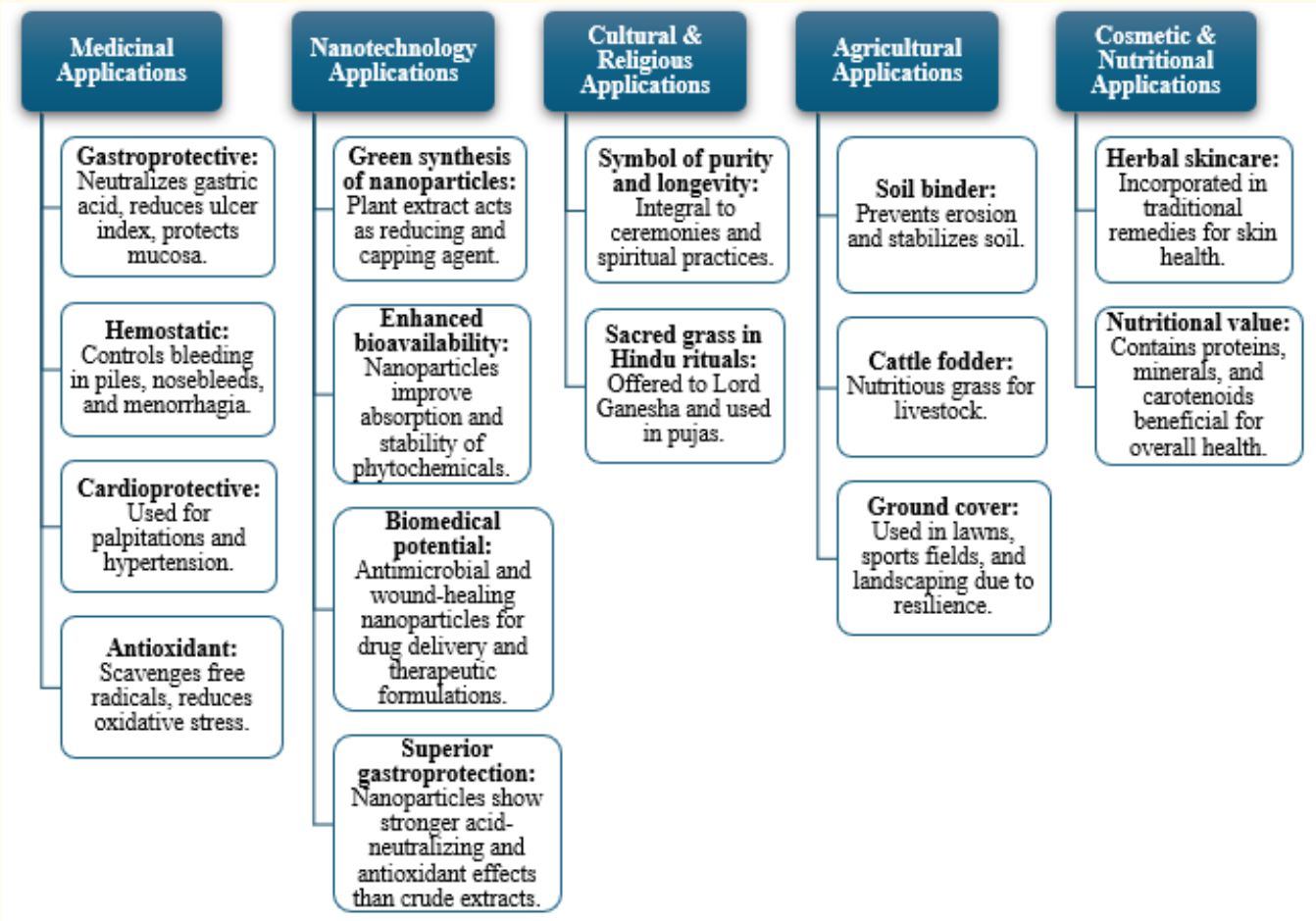

Figure 3: Uses of *C. dactylon*.

Their therapeutic potency is diminished by rapid metabolism and degradation. Furthermore, conflicting results are caused by differences in plant sources and extraction techniques. Researchers have looked to nanotechnology to get beyond these restrictions.

Conclusion

Cynodon dactylon is a significant medicinal plant that has significant potential in the treatment of acidity of the stomach and ulcer related ailments. It has a strong phytochemical composition which leads to antioxidant, anti-inflammatory and gastro protective activity. The latest improvements in the field of green nanotechnology have facilitated the establishment of nanoparticle formulations that enhance the stability, bioavailability and therapeutic functioning of plant extract substances. The comparative studies reveal that nanoparticles produced using *Cynodon dactylon* exhibit excellent acid neutralizing ability and increased biological activity over traditional extracts. Combination of nanotechnology and traditional herbal medicine can thus result to creation of more safe and effective gastrointestinal disease treatments.

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Conflict of Interest

The author(s) do not have any conflict of interest.

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