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REVIEW ARTICLE

Toothed Dock (*Rumex dentatus*) – Deciphering its Medicinal Realm

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ABSTRACT

Background: toothed dock (*Rumex dentatus* L) has been extensively utilized in traditional medicine across the world for treating various diseases. Different parts of the plants have been used for centuries in the treatment of a wide range of diseases.
Objective: This study evaluates the current level of knowledge regarding the pharmacology, phytochemistry, ethnopharmacology, and toxicity of toothed dock. This review has compiled and examined all of the compelling evidence regarding its traditional uses that has been backed by pharmacological research to determine its applicability as a possible medicinal plant.
Methodology: This review highlights current scientific findings related to its phytochemical constituents and therapeutic properties. Literature was collected primarily through Google Scholar, with access to articles from PubMed, Science Direct, and Research Gate. Most studies reviewed involved phytochemical screening and biological assays. These effects have been demonstrated through various i*n vitro* and *in vivo* studies.
Results: Toothed dock demonstrates significant antibacterial activity against multidrug-resistant pathogens. It reduces the expression of inflammatory markers. The plant shows quite strong scavenging abilities towards free radicals and reduces blood glucose levels. Key bioactive compounds include flavonoids, anthraquinones, phenolic acids, and tannins.
Conclusion: It has ethnomedicinal, antibacterial, antioxidant, anti-inflammatory, antidiabetic, anticancer, and allelopathic properties. Despite promising therapeutic potential, significant research gaps exist in clinical validation and safety assessments. This review provides a foundation for evidence-based utilization of the toothed dock in modern healthcare.

INTRODUCTION

Since ancient times, people have been utilizing plants for therapeutic purposes. Egypt, China, and India all use these plants for a variety of medicinal purposes (Zhou *et al*. 2020; Asigbaase *et al*. 2023). Most people believe that natural remedies are not only readily available but also reasonably priced. Additionally, they typically have no adverse side effects (Shikov *et al*. 2021). Herbal remedies are two to three times as popular worldwide as prescription medications. Most of modern medicine is based on the ancient use of plants for medical treatment, which existed before the written records of humanity. Polygonaceae family is important due to its pharmaceutical properties. The knotweed or smartweed families are other names for the Polygonaceae family (Chaudhury *et al*. 2021). Because of its ecological and therapeutic significance, botanists are particularly interested in the genus *Rumex*, which includes species like toothed dock here are approximately 200 species that belong to this genus, and some possess beneficial pharmacologic properties (Li *et al*. 2022).

It is an herbaceous perennial plant with a variety of morphological traits. They have deeply toothed or serrated edges and are ovate to lanceolate in shape. This is the reason behind the common name for this plant (Munir *et al*. 2016). Toothed dock has thrived in many parts of the world, particularly the temperate and subtropical zones. Because of its quick growth and ability to displace native vegetation, it

may be considered an invasive species in some regions of the world. It is considered a weed in the majority of regions, particularly in places where it has become naturalized (Jamil *et al.* 2025). Due to the wide range of biological uses of plants and compounds derived from them, toothed dock was selected for characterization of phytochemicals, medication, conventional benefits, and allelopathic properties. This review evaluates the current level of knowledge regarding the pharmacology, phytochemistry, ethnopharmacology, and toxicity of toothed dock. This review has compiled and examined all the compelling evidence regarding its traditional uses that has been backed by pharmacological research to determine its applicability as a possible medicinal plant.

PHYTOCHEMISTRY

Phytochemicals are plant-based compounds that have therapeutic and health benefits, such as preventing and curing illnesses. Foods naturally contain them, and work in association to treat various infections. Researchers from all over the world studied toothed dock, extracted several phytochemicals, and conducted various biological tests for numerous bioactivities (Khaliq *et al.* 2023a). According to preliminary phytochemical analyses, toothed dock contains alkaloids, tannins, terpenoids, quinones, flavonoids, cardiac glycosides, and saponins. There are now sixty three compounds that have been identified and isolated. Quinones, chromones, naphthalene glucoside, c-glucosyl anthrones, flavonoids, stilbenes, and essential oils are also phytochemical constituents of toothed dock (Khalil *et al.* 2022; Fig. 1).

MEDICINAL PROPERTIES

It has medicinal properties and is used to treat many diseases (Beshah *et al.* 2020), such as anti-inflammatory, stringent, tumor-fighting, diuretic, and antidermatitic. Additionally, it contains cholagogues, laxative agents, and has a tonic nature. According to observations, every part of the toothed dock has significant and practical medical uses. Conventional uses of the plant's leaves included diuretic, refrigerant, and cooling properties. Toothed dock roots were utilized as a purgative, dysentery, and anti-ascariasis remedy. Traditionally, the plant has also been utilized to heal a number of infections caused by bacteria and fungi, such as dysentery, ascariasis, and enteritis (Thaher *et al.* 2024). Fig. 2 shows the most common traditional uses of this plant and its modern scientific validations (Khaliq *et al.* 2023a).

Toothed dock has been used in folk medicine, especially in different cultural regions of Asia and Europe. Diverse therapeutic applications ranging from anti-inflammatory, antimicrobial, antioxidant agents, cytotoxic, antibacterial, antifungal, hepato-protective, antitumor, and skin disorders. It included flavonoids, tannins, and phenolic acids. Methanol, hexane, ethyl acetate, chloroform, DCM

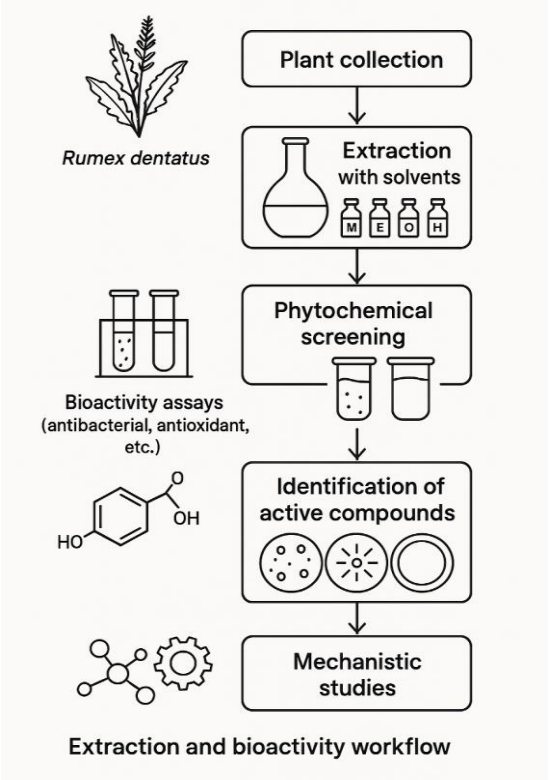

Fig.1: Overview of extractions and bioactivity workflow

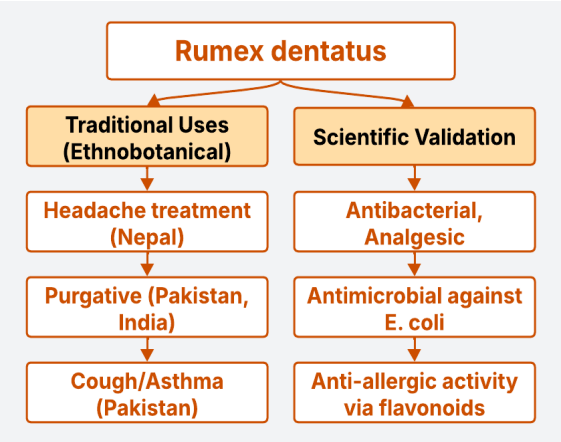

Fig. 2: Traditional uses and scientific validation of *R. dentatus*

(dichloromethane), and H_2O are among the diverse solvents tested for a range of biological assays. Notably, extracts from various parts, such as the leaves, stem, and roots, demonstrated primarily distinct biological assays. Previous research also demonstrated that the methanolic extracts of shoots and roots were active against every bacterial strain examined. However, the hexane extract was more effective than the methanolic extract for inhibiting fungal growth (up to 80%) (Khaliq *et al.* 2023a). Toothed dock shoots have been utilized as an astringent to treat skin conditions and produce purgative outcomes. Leaves and shoots were utilized as

cooling agents, diuretics and refrigerants. Disorders relating to bones and pain were known to be significantly cured by using this plant. As a result, the plant was used to relieve body pain and apply a potent decoction to dislocated bones. Asthma, coughing, jaundice, high temperature, fragility, scabies, foot, mouth illness, and other ailments were also treated with its roots and leaves. In India, this plant is used in a diverse array of traditional consumptions. Therefore, it was considered extremely important (Lal *et al*. 2024).

ANTIMICROBIAL PROPERTIES

One of the most important scientific concerns of our day is the global issue of antibiotic resistance. The development of novel antibiotics is an exhausting and lengthy process. Several bioactive components found in this plant can be utilized for treating infections and multidrug-resistant bacteria. Aqueous and methanolic extracts showed significant antibacterial activity against various strains. Its water-based extracts are particularly effective against *Pseudomonas aeruginosa*. Its phytochemical screening confirmed the presence of terpenoids, carbohydrates, and phenolics (Zakir *et al*. 2020). Najafabadi *et al*. (2020) assessed the impact of different methanolic extract concentrations on *P. aeruginosa* biofilm formation for 48 and 72 hours. Due to the bacteria's ability to withstand antibiotic treatment, *P. aeruginosa* biofilm formation accounted for a significant percentage of hospital-acquired infections. *P. aeruginosa* biofilm's extracellular polymeric material was a mixture of extracellular proteins, polysaccharides and microbial cells. To cultivate biofilm and assess the antibiofilm action, they employed the microtiter plate method. Gas chromatography was used to examine the arrangement of the methanol sample. Methanolic extracts also inhibited *P. aeruginosa* biofilm formation in a dose-dependent manner, with a minimum biofilm inhibitory concentration (MBIC) of 250 mg/mL.

Using the extract of its leaves, Rehan *et al*. (2020), isolated its phytochemical compounds to test for antibacterial activities. They extracted hexacosanol and hexacosanoic acid by using spectroscopic analysis. Molecular analysis was used to determine the antibacterial relationships of isolated compounds. Using the agar well diffusion assay, the antibacterial behaviour against various bacterial strains was assessed. *Staphylococcus aureus* showed maximum inhibition due to its phytochemicals, indicating strong antibacterial activity. The extract and hexacosanol compound showed the best effects on *Escherichia coli* (20 mm) and *S. aureus* (23 mm). Khan and Ahmed, (2022) also assessed the antimicrobial properties by using different solvents. Specifically, water, ethanol, ethyl acetate, methanol, and hexane extracts were tested. Using the *in-vitro* agar diffusion technique its antimicrobial activity was confirmed against Gram-positive bacteria such as *Bacillus atrophoeus*, *S. aureus*, and *Bacillus subtilis*; Gram-negative bacteria such as *Klebsiella pneumoniae*, *E. coli*, and *Salmonella typhi*; and fungal strains such as *Rhizopus stolonifer*, *Candida albicans*, and *Aspergillus niger*. The order of effectiveness of the various solvent extracts ethanol> ethyl acetate> methanol> hexane> aqueous extracts. It showed a zone of inhibition of 22±0.23 mm. The plant ethanolic extract under study demonstrated the highest inhibitory activity against the fungus *C. albicans*. Ethanolic extract also demonstrated a significant effect against all bacterial strains. It showed a zone of inhibition of 18±0.16 mm for S. aureus and 19±0.08 mm for *E. coli*. Whole plant extracts contain bioactive substances with strong antibacterial and antifungal properties. Additionally, based on the many strains of organisms the zone of inhibition order was fungi> Gram-positive bacteria> Gram-negative bacteria.

For *in vitro* analysis, the disc diffusion method and brine shrimp mortality assay were performed by Moniruzzaman *et al*. (2023). These in-silico studies were conducted using standard computational tools and servers, including Discovery Studio, PyRx and Pymol. *S. aureus* was collected from eczema patients' infected areas and identified using 16S rRNA analysis, biochemical analysis, and morphological analysis. Leaf methanolic extract demonstrated the maximum region of resistance (14.33 ± 0.68 mm) when applied at a dose of 150 µg/disc on *S. aureus*. Thus, the leaf extract from toothed dock could be utilized as an organic medicine source to fight the pathogen that is resistant to antibiotics.

Agar well diffusion and minimum inhibitory concentration assays on medical isolates of *P. aeruginosa* were used by Khan et al. (2024) to assess the antibacterial activity of the methanolic extract of Toothed dock root. MIC values for the crude extract, fractions and subfractions tested ranged from 200 to 1000 µg/mL, respectively. Notably, the water fraction had the strongest anti-*P. aeruginosa* activity among the fractions. A spectroscopic analysis employing HPLC-ESI-Q-TOF-MS revealed that emodin and gallic acid were the main constituents and their fractions were the same that produced the antibacterial and antibiofilm effects. This study offered strong evidence in favour of its traditional use as described in folklore. Additionally, this investigation advanced our knowledge of its ability to treat infections. According to Nazir et al. (2022), biologically synthesized ZnO nanoparticles by using its leaf extract and showed significant antibacterial activity. According to Khaliq *et al*. (2023b), toothed dock yielded five bioactive molecules. Furthermore, the majority of the plant extracts exhibited significant to mild antimicrobial action ($IC_{50,}$ half-maximal inhibitory concentration), when tested on six pathogenic organisms from humans, which included five bacteria and

one fungal pathogen. In the microtiter plate assay, the n-hexane and methanolic extracts were identified to have beneficial antibacterial ability out of all the extracts that were assessed for antimicrobial activities. Moreover, advanced phytochemical studies identified nineteen natural products, mainly anthraquinone derivatives, with most fractions showing inhibitory activity against *S. aureus* and some also active against *E. coli* and *C. albicans* (Aierken *et al*. 2023). This study identified that one of the new compounds isolated from the roots, specifically musizin that exhibited moderate antifungal activity. This compound demonstrated an inhibitory rate of 39.539 ± 0.412% against the fungus *Epidermophyton floccosum* at a concentration of 100 µM. This suggested that this plant may have potential applications in treating fungal infections, particularly through the activity of its phenolic compounds (Li *et al*. 2023). Silver nanoparticles or AgNPs were widely used in medicine because of their strong antimicrobial properties. Amir *et al*. (2023) prepared tooth dock silver NPs and tested Gram-positive *S. aureus* and Gram-negative *E. coli* bacterial strains to assess their antibacterial activity. They recorded more antimicrobial activity against *E. coli* and it was near to the usual control group. According to SEM and XRD morphological analysis, the plant extract is responsible for the agglomerated, polydispersed, spherical shape of the nanoparticles as well as their high display of inconsistent morphology.

ANTIOXIDANT PROPERTIES

Natural substances called phytochemicals exist in plants and are vital for supporting human health. Phytochemicals act as antioxidants and provide defence against harmful free radicals. This antioxidant action enhances the general health of cells (Pawase *et al*. 2024). Spectrophotometric assays were one of the specific methods used to measure the activity of antioxidant enzymes. These tests measured how quickly the enzymes react with particular substrates. Toothed dock increased activities of antioxidant enzymes (peroxidase, catalase, superoxide dismutase) when exposed to lead and zinc, helping the plant neutralize reactive oxygen species and suggesting strong adaptive antioxidant defence. It has been assessed by different studies using techniques like TPC, TFC, and DPPH for its antioxidant properties. Ethyl acetate extracts from roots and leaves showed high total phenolic content and strong DPPH radical scavenging activity (IC_{50} as low as 0.012 mg/mL). Moreover, β-carotene bleaching assays confirm potent antioxidant properties linked to phenolic compounds (Elzaawely and Tawata 2012). A study by Humeera *et al*. (2013) demonstrated that the extracts of this plant showed antioxidant activity and were helpful for neutralizing free radicals. DPPH assay, riboflavin photooxidation, deoxyribose assay, and lipid peroxidation assay were used to evaluate the antioxidant activity. This validated the accuracy of the findings. The petroleum ether extract has a lower total phenolic content (45 µg/mg). The butanol extract has the highest TPC (145 µg/mg). This variation in phenolic content affected the total antioxidant capability of the various samples. Moreover, its extracts exhibited dose-dependent scavenging of hydroxyl and superoxide radicals. Butanol extracts showed the highest total phenolic content and antioxidant capacity with the presence of tannins, terpenoids, and flavonoids (Humeera *et al*. 2013). Polar lipid fractions were especially associated with antioxidant activity, as confirmed by advanced chromatography and mass spectrometry (Elfotoh *et al*. 2013). Methanolic extracts of shoots and roots also showed significant DPPH scavenging activity. The higher antioxidant activity was seen in aerial parts. The quantitative study of roots and shoot extracts revealed a high content of tannins and phenolics. Toothed dock extracts demonstrated scavenging activities of 52.88% for roots and 62.78% for shoots at 50 mg mL^{-1}. For roots and shoots the coastal samples had IC50 values of 23.99 and 34.99 mg mL^{-1} for methanolic extract. The coastal and inland samples had respective IC50 values of 31.67 and 41.59 mg mL^{-1} (Hafaz *et al*. 2022). Ethanol and methanol extracts demonstrated up to 96% and 85% DPPH inhibition at 300 µg/mL, comparable to ascorbic acid and butanol fractions that showed 90% inhibition in lipid peroxidation assays (Khalil et al. 2022), suggesting strong antioxidant potential.

ANTIDIABETIC ASSAY

A condition known as diabetes is brought on by an excessively high blood glucose level, or blood sugar. The primary energy source that comes from food is glucose. The pancreas produces the hormone insulin, which facilitates the uptake of glucose from food for energy production. Nepodin, isolated from toothed dock, showed significant antidiabetic effects by stimulating glucose uptake in cultured L6 myotubes through the activation of AMPK (AMP-activated protein kinase). This led to enhanced GLUT4 (glucose transporter protein 4) translocation, crucial for cellular glucose entry. In diabetic mice (C57BL/KsJ-db/db), nepodin improved glucose tolerance and reduced fasting blood sugar, confirming its mechanism via AMPK activation and GLUT4 regulation (Ha *et al*. 2014).

Toothed dock was recognized for its potential antidiabetic properties through a range of experimental studies. One of the most prominent findings was its ability to significantly reduce blood glucose levels. This indicated its role in counteracting hyperglycemia, which is a primary characteristic of diabetes. Toothed dock can enhance insulin

sensitivity. Polyphenol-rich extract significantly lowered blood glucose and improved insulin sensitivity in type 2 diabetic rats. Toothed dock also up-regulated *PPARγ* (peroxisome proliferator-activated receptor gamma) expression, a key regulator of glucose and lipid metabolism and inflammation suppression. Molecular docking showed strong binding to *PPARγ*, confirming their involvement in glucose homeostasis (Elsayed *et al*. 2020). It improved carbohydrate metabolism, reduced insulin resistance, and alleviated liver damage and hyperglycemia in diabetic rats. Gene expression and *in-silico* studies confirmed that isolated compounds from toothed dock bind to *PPARγ* and help lower blood glucose, highlighting its promise as a natural antidiabetic remedy (Khaliq *et al*. 2023a). Fig. 3 shows a flowchart of the mechanism of action of all the bioactivities mentioned above of the toothed dock.

ANTICANCER PROPERTIES

The term "cancer" describes any of a wide range of illnesses that are characterized by the unchecked and aberrant proliferation of cells that can infiltrate and destroy healthy body tissue. It is frequently possible for the illness to spread all over the body. Since cancer is the 2nd most common cause of death worldwide therefore its effective treatment is required. The study used a brine prawn cytotoxicity assay along with the potato disc experiment. Frequently employed as a first assessment for medicinal activity, this technique offers valuable information regarding the possible toxicity of herb extracts. Extracts showed weak to moderate inhibition of carcinoma cell growth *in vitro*, with higher concentrations yielding better effects. *In vivo* testing in mice (Ehrlich ascites carcinoma model) confirmed dose-dependent cytotoxicity (Hawas *et al*. 2011). Batool *et al*. (2017) assessed their anticancer activity against the cell line MDA-MB-231, which exhibited invasive characteristics. The MTT assay was utilized to assess the toxicity against a cancer cell line. To examine any alterations in the cell cycle or apoptotic effect, flow cytometry was used. The disruptive and wound-healing abilities were also investigated along with the NF-κB pathway and Western blotting of apoptotic genes. Extracts used were methanol and chloroform. Cell proliferation was mostly inhibited in both terms of concentration and time. By suppressing the stimulation of NF-κB and the resulting transcripts, surviving, Cyclin D1, XIAP, Bcl-xl and Bcl-2, it was demonstrated that both RC and RM prevented growth of cancerous cells and caused cell death. Methanolic and chloroform extracts and isolated compounds, showed cytotoxicity against lung (A549), breast (MDA-MB-468, MDA-MB-231), pancreatic (MIAPaCa) and colon (HCT-116) cancer cell lines. One compound (B) had strong activity against colon cancer cells (IC50 = 11.29 µg/mL) and inhibited cell migration and invasion (Khaliq *et al*. 2023c). Neopodin and other compounds from toothed dock roots exhibited antiproliferative and pro-apoptotic effects in various cancer cell lines, supporting their potential as natural anticancer agents. Toothed dock roots yielded compounds showed antiproliferative activity against several cancer cell lines. NMR spectroscopy was used to clarify their planar structures. However, because of differences in the precise rotation values, their exact configurations were still unknown. L-glucosides and their derivatives found in nature are special compounds with important pharmacological and biosynthetic potential. Toothed dock extract, in combination with cisplatin, enhanced anticancer effects against oral squamous cell carcinoma (HNO97) cells by promoting cell cycle arrest, apoptosis and reducing autophagy. Network pharmacology suggested involvement of EGFR, microRNAs and PI3K-Akt pathways, indicating potential for combination therapy (Ragab *et al*. 2025).

ANTI-INFLAMMATORY PROPERTIES

Tissue damage from toxins, bacteria, heat, trauma, or any other source triggers the inflammatory response, or inflammation. The dysregulation of numerous intracellular signaling pathways, such as kinases cell, surface receptors and transcription factors, is a common feature of chronic inflammation. Toothed dock contains flavonoids, tannins and phenolic acids, which are linked to its traditional anti-inflammatory uses. Analytical studies confirmed these compounds and established quality standards for herbal preparations (Singh *et al*. 2013). Ethanolic extracts of Toothed dock leaves and stems showed anti-inflammatory and antioxidant effects in rats, reducing inflammatory markers (TNF, IL-2, IL-6), improving liver and kidney function and lessening fibrosis. Leaves, with higher phenolic content, were particularly effective (Mohamed *et al*. 2014).

Toothed dock extracts reduced the expression of inflammatory markers (COX-2, TNF-α, p-NF-κB) in gastric tissues and lowered pro-inflammatory cytokines (IL-8, PGE2) in models of ethanol-induced gastric injury. Extracts also restored antioxidant enzyme levels, supporting their role in protecting against oxidative stress and inflammation (Qazi *et al*. 2022). Toothed dock has been shown to reduce the expression of inflammatory markers like COX2 and TNF-α, indicating its potential being an anti-inflammatory agent. The plant was also classified in a lower toxicity class (Kazamel *et al*. 2024).

ALLELOPATHIC PROPERTIES

The term "allelopathic properties" describes the chemical interactions that occur between plants. Plant produces

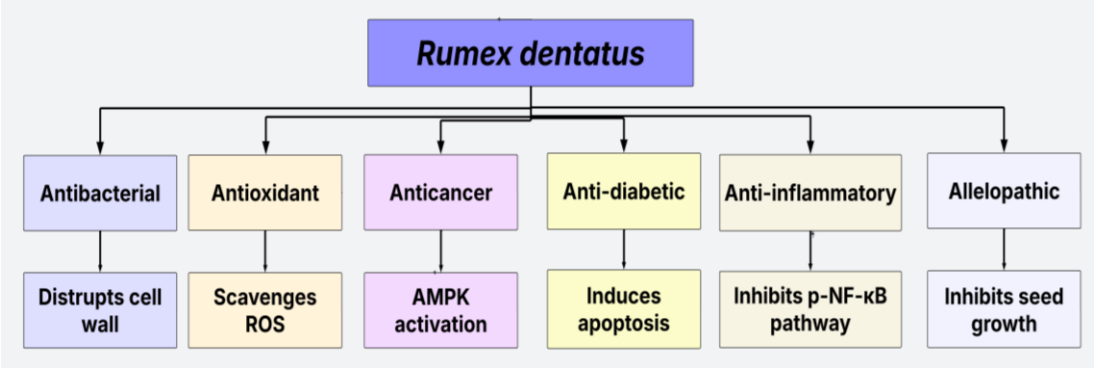

Fig. 3: Mechanism of action of *R. dentatus* bioactivities

biochemicals called "allelochemicals" that can affect the behaviour, growth, survival, or reproduction of other plants. Different studies examined the allelopathic effect of aqueous extracts of toothed dock and other plants. Root extracts of Toothed dock, rich in allelochemicals like vanillic, caffeic, benzoic, sinapic, gallic, ferulic, and cinnamic acids. Higher extract concentrations increased lipid peroxidation and hydrogen peroxide, while catalase and superoxide dismutase activities were also elevated, suggesting oxidative stress as a mode of inhibition. Cinnamic and ferulic acids were particularly effective in inducing these effects, highlighting toothed dock as a bioherbicide (El-Shora *et al.* 2014). Its aqueous extracts reduced germination, radicle, and plumule growth in both intact and pre-germinated seeds of weeds (*Avena fatua*) and crops (sunflower, maize, wheat). Filter paper and soil bioassays showed strong inhibition, supporting its use in organic weed management (Anwar *et al*. 2017). Field studies demonstrated that its increasing density significantly reduced wheat yield and yield-related parameters. Yield losses increased sharply as weed density exceeded 20 plants/m², establishing this as a critical management threshold for minimizing crop loss due to its competition with toothed dock (Waheed *et al*. 2017). Allelochemicals are released through leaching, volatilization, leaf litter, and root exudation. Both aqueous and leaf powder extracts reduced radicle and plumule growth in wheat, maize, and sunflower up to 82%, confirming strong allelopathic suppression. These findings support the practical application of toothed dock extracts for natural weed control in sustainable agriculture (Anwar 2018).

CONCLUSIONS

R. dentatus stands out as a versatile medicinal plant with a rich history of traditional use across the world. Modern scientific investigations have validated many of its ethnomedicinal claims, demonstrating significant antibacterial, antioxidant, anti-inflammatory, antidiabetic, anticancer, and allelopathic properties. The plant contains diverse bioactive compounds, including flavonoids, phenolic acids, tannins, and anthraquinones. These are responsible for its broad spectrum of biological activities. Notably, extracts and isolated compounds from this plant have shown potent activity against multidrug-resistant bacteria, strong free radical scavenging capacity, and the ability to modulate inflammatory and metabolic pathways. Its combination with nanoparticle further amplifies its therapeutic potential, especially in antimicrobial and antioxidant applications. The plant also displays promising allelopathic effects, suggesting a role in sustainable agriculture as a natural bioherbicide. Despite these promising findings, further research is warranted to standardize extraction methods, clarify mechanisms of action and conduct comprehensive clinical trials to ensure efficacy and safety in humans. Overall, it offers significant potential as a source of novel natural products for pharmaceutical, nutraceutical and agricultural applications, bridging traditional knowledge with modern scientific validation.

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AUTHOR CONTRIBUTIONS

Fatma Hussain designed and supervised the research and final draft of the manuscript; Anza Rubab completed the research, Iqra Saleem assisted in write-up, rephrasing, and final draft preparation.

DATA AVAILABILITY

The data will be made available on a fair request.

ETHICS APPROVAL

Not applicable to this paper.

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