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Curry Leaf Extracts as a Natural Antimicrobial Agent for Eco-Friendly Tomato Disease Control

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Abstract

Tomatoes (Solanum lycopersicum) are a vital horticultural crop worldwide, valued for their nutritional and economic importance. However, bacterial diseases significantly threaten yield and quality. This study investigates the antimicrobial potential of Murraya koenigii (curry leaf) extracts as a sustainable alternative to synthetic pesticides. Ethyl acetate, methanol, and aqueous extracts were prepared and tested at 50 and 200 µg/mL against Xanthomonas campestris and Pseudomonas syringae. Ethyl acetate extracts exhibited superior antimicrobial activity, with inhibition zones exceeding more 15mm at higher concentrations, compared to 10–15 mm for methanol and aqueous extracts. These findings suggest that curry leaf extracts, particularly ethyl acetate fractions, offer promising eco-friendly options for disease management in tomato cultivation.

Keywords: *Murraya koenigii*, tomato, antimicrobial, ethyl acetate extract, sustainable agriculture, biocontrol.

INTRODUCTION

Tomatoes (*Solanum lycopersicum*) are among the most widely cultivated and consumed horticultural crops globally, valued for their versatility in culinary applications and their considerable contribution to human nutrition (FAO, 2021). They are consumed both fresh and in processed forms such as sauces, juices, and canned products, making them a vital component of diets worldwide [1-2]. Tomatoes are nutritionally dense, providing essential vitamins such as A, C, and K, along with potassium, folate, and a variety of antioxidants. Among these, lycopene—a carotenoid pigment—is particularly noteworthy due to its strong antioxidant activity and its association with reduced risks of several chronic conditions, including cardiovascular diseases, certain cancers, and age-related degenerative disorders [3-4].

The crop's adaptability to diverse agro-climatic conditions and relatively short cultivation cycle have further enhanced its global importance, particularly in the context of food and nutritional security. However, tomato production is increasingly threatened by various biotic stresses, especially bacterial diseases that compromise both yield and fruit quality. Prominent among these are bacterial spot and bacterial speck, primarily caused by *Xanthomonas campestris* pv. *vesicatoria* and *Pseudomonas syringae* pv. *tomato*, respectively These pathogens not only lead to direct economic losses but also reduce marketability and post-harvest shelf life of tomato fruits [5].

Currently, the primary mode of disease control relies on synthetic agrochemicals such as copper-based bactericides and antibiotics. However,

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overuse and misapplication of these chemicals have led to multiple environmental and agricultural concerns, including soil and water contamination, disruption of beneficial soil microbiota, and the development of resistant bacterial strains (Popp et al., 2013). These issues underscore the urgent need for sustainable and environmentally benign alternatives to conventional chemical control methods [6].

One promising avenue in this regard is the exploration of plant-derived antimicrobials, particularly those sourced from ethnomedicinal plants known for their therapeutic properties [7-10]. *Murraya koenigii*, commonly known as curry leaf, is widely used in South Asian cuisine and traditional medicine. It is rich in a variety of phytochemicals including alkaloids, flavonoids, terpenoids, and essential oils, many of which have demonstrated antimicrobial, antioxidant, and anti-inflammatory activities (Kaleeswari et al., 2017; Kaur and Arora, 2019). The potential of *M. koenigii* extracts as natural bactericidal agents against phytopathogens presents an innovative strategy for integrated disease management in tomato cultivation. This study aims to evaluate the antibacterial efficacy of curry leaf extracts against key tomato pathogens—*Xanthomonas campestris* and *Pseudomonas syringae*—with a broader objective of identifying sustainable, plant-based interventions for managing bacterial diseases. By promoting eco-friendly, locally available resources for crop protection, this research contributes to the ongoing efforts to reduce chemical dependency in agriculture while safeguarding environmental and human health [11-15].

MATERIALS AND METHODS

Plant Material and Extract Preparation

Fresh curry leaves (*Murraya koenigii*) were collected, shade-dried, and ground into fine powder. Extracts were prepared using ethyl acetate, methanol, and water as solvents. The dried powders were soaked in each solvent for 48 hours, filtered, and evaporated to yield crude extracts [15-20].

Pathogens and Culture Conditions

Xanthomonas campestris and *Pseudomonas syringae* were obtained and cultured on nutrient agar plates at 28°C. The bacterial strain was provided from the MITS Institute of professional Studies, Rayagada, Department of Biotechnology Laboratory.

Antimicrobial Assay

The antimicrobial activity of extracts was evaluated using the agar well diffusion method. Wells were loaded with 50 and 200 µg/mL of each extract. Plates were incubated at 28°C for 24 hours, and inhibition zones were measured.

RESULTS AND DISCUSSION

Among the various solvent extracts tested, ethyl acetate extracts of *Murraya koenigii* demonstrated the most pronounced antimicrobial activity against both *Xanthomonas campestris* and *Pseudomonas syringae*, with inhibition zones exceeding 15 mm at a concentration of 200 µg/mL. In contrast, methanol and aqueous extracts exhibited comparatively moderate inhibitory effects, producing zones of inhibition ranging from 10 to 15 mm. The superior efficacy of ethyl acetate extracts can be attributed to the solvent's intermediate polarity, which enables efficient solubilization of a broad spectrum of bioactive phytochemicals such as alkaloids, flavonoids, phenolic acids, and terpenoids—compounds extensively documented for their antimicrobial properties (Singh et al., 2018; Prakash and Gupta, 2020). These secondary metabolites are known to disrupt bacterial cell walls, inhibit protein synthesis, and interfere with microbial enzyme systems, thereby impairing pathogen viability and proliferation [21-24].

The findings of this study are consistent with previous research that reported the antimicrobial potential of *M. koenigii* extracts against several phytopathogenic bacteria and fungi. For instance, Verma et al. (2011) and Shekar et al. (2016) observed significant antibacterial activity of curry leaf extracts against *Ralstonia solanacearum*, *Erwinia carotovora*, and *Fusarium* spp., supporting its broad-spectrum antimicrobial efficacy. Such results not only validate the use of curry leaf in traditional plant-based remedies but also highlight its potential application in crop protection strategies.

The use of plant-derived antimicrobials like curry leaf extract is especially important in the current context of rising concerns regarding synthetic pesticides. Chemical-based disease control, while effective, often leads to several unintended consequences, including the development of resistant pathogen strains, contamination of soil and water resources, and toxicity to non-target organisms, including beneficial insects and soil microbiota). Additionally, prolonged exposure to pesticide residues has been linked to adverse health effects in humans, prompting regulatory restrictions and consumer demand for organic alternatives

In contrast, phytochemicals from plants such as *M. koenigii* offer a biodegradable, eco-compatible alternative that poses minimal risk to ecosystems. These botanicals often have multiple modes of action, reducing the likelihood of resistance development in pathogens (Isman, 2006). Moreover, their selective toxicity ensures safety for pollinators, natural enemies, and other beneficial organisms critical for maintaining agroecological balance This aligns with the principles of integrated pest and disease management (IPDM), which advocate for sustainable, non-chemical interventions that maintain crop health while preserving environmental integrity [25-28].

The incorporation of curry leaf-based biopesticides into disease management frameworks could particularly benefit smallholder and organic farmers, offering a cost-effective and locally available solution for managing bacterial diseases in tomatoes and other horticultural crops. Future research should focus on the isolation and characterization of individual active constituents, formulation development, and field-level efficacy trials to pave the way for commercial application.

CONCLUSION

This study underscores the promising antimicrobial potential of *Murraya koenigii* (curry leaf) ethyl acetate extracts against two major bacterial pathogens affecting tomato—*Xanthomonas campestris* and *Pseudomonas syringae*. The pronounced inhibitory activity observed, particularly with ethyl acetate extracts, highlights the presence of potent bioactive phytochemicals capable of disrupting pathogenic mechanisms. These findings provide strong scientific support for the use of curry leaf extracts as a natural, plant-based alternative to synthetic pesticides in the management of bacterial diseases in horticultural crops. The integration of such botanical antimicrobials into disease management frameworks aligns well with the principles of sustainable agriculture, offering multiple benefits: reduced environmental pollution, preservation of beneficial soil and plant microbiota, and mitigation of the growing problem of pathogen resistance associated with conventional chemical treatments. Furthermore, the use of locally available plant resources like *M. koenigii* may be especially advantageous in low-input farming systems, promoting cost-effective and eco-friendly practices for smallholder farmers.

However, to move from laboratory validation to practical agricultural application, several critical steps are necessary. Future research should prioritize the optimization of extraction protocols to enhance yield and activity of antimicrobial constituents. Advanced analytical techniques such as GC-MS, HPLC, and NMR should be employed to isolate and characterize the specific bioactive compounds responsible for antimicrobial effects. Moreover, understanding the mode of action of these compounds at the cellular and molecular levels would further strengthen their potential as targeted disease control agents. Equally important is the evaluation of efficacy and safety under field conditions across different agro-climatic zones. This includes assessing the stability, persistence, and phytotoxicity of the extracts, as well as their compatibility with existing integrated pest management (IPM) practices. Formulation development, including the use of adjuvants or encapsulation techniques, could improve the shelf life and delivery efficiency of these extracts for commercial-scale use.

In conclusion, the findings of this study contribute valuable insights toward the development of sustainable crop protection strategies. *Murraya koenigii* extracts, particularly those obtained using ethyl acetate, represent a viable and environmentally responsible alternative to conventional bactericides.

With further refinement and field validation, these plant-derived products have the potential to play a significant role in the future of eco-friendly agriculture and plant health management.

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Conflict of Interest
The authors declare no conflict of interest.

Declaration of Interest
The author(s) declare(s) that there is no conflict of interest regarding the publication of this manuscript.

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