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Research Article

The Efficacy of Plant-Based Ginger Essential Oil Fungicide for the Management of Some Selected Fungi

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ABSTRACT

Recent research demonstrates that the number of virulent phytopathogenic fungi continually grows, which leads to significant economic losses worldwide. Several methods are currently available for the management of phytopathogenic fungi. Since 1940, synthetic fungicides have been typically used to control phytopathogenic fungi. However, the substantial increase in the development of fungal resistance to these fungicides in addition to the negative effects caused by the fungicides on the health of animals, human beings, and the environment calls for the exploration of several new strategies of fungal control by scientists from all over the world. This study aimed to determine the efficacy of using ginger essential oils for the management of some fungal diseases in plants. The minimum inhibitory concentration (MIC) was determined using broth microdilution assays where different concentrations (100, 150, 200, 250, 300, 350, and 400 mg/mL) of the extract and control are added to a series of tubes containing a standardized microbial inoculum (x10^6) and incubated at 25 °C. The results of antifungal activity showed that ginger essential oil has an effect on the two tested organisms for all the concentrations. At 100 mg/mL, the inhibition of 31 mm at day 3 for *Rhizoctonia solani.* It can be concluded from this work that ginger essential oil showed strong antifungal activity against the test organism.

Keywords: Essential oil; Fungi; *Fusarium oxysporium*; Inhibition; *Rhizoctonia solani*

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INTRODUCTION

Plant fungal pathogens cause most of the diseases occurring in agricultural and horticultural setups (Agrios, 2009). Collectively, phytopathogens have developed mechanisms and ways to attack any plant (Hann, 2014, 1996), seeking entry and sourcing nutrients forcefully for growth and development (Horbach *et al.,* 2021). These pathogens can reproduce asexually and/or sexually (Gould, 2009) and can overcome plant immune defences (Tripathi *et al*., 2020 a & b). This negatively affects plant health, plant homeostasis, and plant physiology and in some cases, causes systemic damage (Agrios, 2005). Even though other researchers used different approaches like the use of synthetic chemicals and cultural methods to control the infection, up to now, these methods have not been promising in controlling the disease,

Ginger essential oil is among the earliest known essential oils. Its usage worldwide has a long history (Adamu *et al*., 2021). Being an important food spice plant, it has a significant role in disease prevention and control, many diseases can be cured with ginger (Adamu *et al*., 2021). However studies are less regarding the usage of ginger against plant pathogens. Most of the previous works used different methods like the use of chemical fungicides, cultural methods, and the use of plant extracts to manage fungal diseases of plants, this goes contrary to this study that intends to use ginger essential oil to control the growth of the fungi.

Ginger essential oil has also shown promising antifungal activities against various pathogenic yeasts. Similarly, ginger essential oil has been reported to inhibit the growth of pathogenic fungi,

such as *Botrytis cinerea*, *Penicillium expansum*, *Neofabraea alba*, *Fusarium,* and *Rhizopus* species (Kutawa *et al*., 2018). The wide range of antifungal activities of ginger essential oil has also been confirmed against various plant-pathogenic fungi. Based on the mechanisms of action, it was reported that the ginger essential oil inhibits the growth of conidia and mycelia. Moreover, it also disrupts the internal organelles of the fungal cell (Rafi *et al*., 2023). Ginger exhibited promising antifungal activities both *in vitro* and *in vivo* against several plant pathogenic fungi. This work aimed to determine the efficacy of using ginger essential oils for the management of some fungal diseases in plants.

MATERIALS AND METHODS

Collection and Preparation of Samples

Three kg of fresh ginger was purchased from Dutsin-Ma central market. The rhizome was separated, peeled, and washed before being cut into smaller portions. The ginger essential oil was extracted using the steam distillation method, and around 4 mL of essential oil per one kg of ginger was obtained.

Isolation and Identification of Fungi

Isolation and identification of fungi were done according to the methods described by Kutawa *et al*. (2017). The 15 samples of the infected tissues were washed and surface sterilized with Clorox for five minutes. The samples were transferred to ethanol (20%) for 3 minutes. The samples were then transferred to sterilized filter paper to dry before being mounted on the media. The plates were incubated at 28 °C. After growth, the fungi were subcultured on fresh media to obtain the pure culture.

Media Preparation

The media was prepared according to the manufacturer's specifications. About 7.8 grams of Sabouraud dextrose agar (SDA) was weighed using a weighing balance and dissolved into a conical flask containing 120 mL of sterile distilled water. It was then shaken to mix up and dissolved in a hot plate. It was further sterilized by autoclaving at 121 °C for 15 min and allowed to cool down. The pH of the media was adjusted to 6 before been dispensed into sterile Petri dishes arranged in 3 replicates and allowed to solidify.

Determination of Antifungal Activity

The determination of the antifungal activity of essential oil involves conducting bioassays to assess the inhibitory effect of the essential oil on fungal growth. The antifungal screening of the essential oil was carried out using the agar well diffusion method as described by Kutawa *et al*. (2018). In these assays, a 96 well plate was used for the experiment, the essential oil was applied to a culture of the target fungi, and the extent of inhibition of fungal growth was measured and compared to a control group (containing only the media). The concentrations of the essential oil tested were 100, 200, and 300 mg/mL, while the inoculum of the fungal suspension used was $x10^6$. The samples were then incubated at 25 °C. Other experimental conditions are carefully controlled to ensure accurate and reproducible results.

Determination of Minimum Inhibitory Concentration (MIC)

The determination of the minimum inhibitory concentration (MIC) of the essential oil (EO) involves testing a range of concentrations of the EO against a specific microorganism to determine the lowest concentration that inhibits microbial growth. This is done using broth microdilution assays where different concentrations (100, 150, 200, 250, 300, 350, and 400 mg/mL) of the EO were added to a series of tubes containing a standardized microbial inoculum. The tubes were then incubated for 72 hours to observe any potential growth, and the lowest concentration of the essential oil that prevented visible growth of the micro-organism after 72 hours was considered the MIC. The Minimum Inhibitory Concentration (MIC) was determined using the modified broth microdilution methods of Wayne (2012).

Data Analysis

The data collected was subjected to one-way analysis of variance (ANOVA), and mean differences were determined using the Duncan Multiple Range test (DMRT).

RESULTS

The results of antifungal activity showed that ginger essential oil has an effect against *Rhizoctonia solani* for all the concentrations. At 100 mg/mL, the inhibition of 41mm at day 3 was observed for the fungus. Likewise, at 200 mg/mL, the inhibition of 26 mm was recorded on at day 3. Moreover, *Rhizoctonia solani* showed an inhibition of 26 mm at day 3 for 300 mg/mL concentration as presented in Table 1 while the control had 42 mm.

The results of antifungal activity showed that essential oil has an effect on the tested organism for all the concentrations. At 100 mg/mL, the inhibition of 13 mm at day 3 was observed for *Fusarium oxysporium.* Likewise at 200 mg/mL, the inhibition of 27 mm at day 3 was also observed. Moreover, *Fusarium oxysporium* showed an inhibition of 18 mm at the third day for 300 mg/mL concentration as presented in Table 2 while the control had 30 mm. The result showed minimum inhibitory concentration (MIC) of essential oil. The

MIC was found to be 0.11 mg/ml for *Rhizoctonia solani* as presented in Table 3.

Table 1: Antifungal activity of ginger essential oil on the growth of *Rhizoctonia solani*

Concentration (mg/ml)	Diameter of zone of inhibition against the *Rhizoctonia solani* (mm) at third day after incubation
100	41
200	26
300	26
Control	42

Table 2: Antifungal activity of ginger essential oil on the growth of *Fusarium oxysporium*

Concentration (mg/ml)	Diameter of zone of inhibition against the *Fusarium oxysporium* (mm) at third day after incubation
100	13
200	27
300	18
Control	30

Table 3: Minimum inhibitory concentration of ginger essential oil against *Fusarium oxysporium* and *Rhizoctonia solani*

Essential Oil	Isolates	Concentration (mg/ml)		
		100	200	300
Ginger	*Fusarium oxysporium*	+	-	-
Ginger	*Rhizoctonia solani*	+	-	-

Key: + means growth, - means no growth

DISCUSSION

Based on the findings of this research work, it was observed that ginger essential oil has shown strong antifungal activity against the *Rhizoctonia solani* and *Fusarium oxysporium* fungal pathogens. This antifungal activity could be a result of the presence of unique phytochemical components of ginger, like gingerols, shagaols, and paradols. These findings are in line with the works of Gunasena *et al*. (2022) and Adamu *et al*. (2021).

It is clear that fungi cause enormous problems in the plant production industry and that inadequate control can lead to serious problems in food production. Phytopathogens do not influence only food and floricultural production but in the medicinal plant industry, fungi can also affect the production and the safety of the medicinal plant after harvesting. Existing control measures are not enough to deal with the emergence or outbreaks of plant fungal pathogens (Hamanshu *et al*., 2022).

Therefore, continued research, including using plant-based products, is required to provide effective biological products that are cheap, less toxic and effective (Kumar *et al*., 2021). Control by using plant-based products may offer relief in the fight against plant fungal diseases (Tripathi *et al*., 2020a). Although much research has been done on screening plants for their antifungal against phytopathogens, only a few secondary metabolites have been isolated (Shang *et al*., 2019). One approach would be to identify new antifungal compounds from plants and test the efficacy of other essential oils.

This approach has the advantage that there may be reduced development of resistance if the different antifungal compounds in an extract target different receptors. There is, however, an advantage compared to using a single chemical product in ensuring good quality control and variation of activity based on genetic or environmental factors. Therefore, thorough methods have to be used to find new antifungal products that may be of potential use in agricultural production. We also have to investigate how plants which may be of no use in agricultural and horticultural Complement production protect themselves against pathogen. They may produce novel compounds to overcome pathogen invasion.

CONCLUSION

This study observed a strong antifungal activity of ginger essential oil against *Rhizoctonia solani* and *Fusarium oxysporum*. The findings of this work will contribute to future research on plant-based fungicides and their potential as sustainable and environmentally friendly options for controlling fungal diseases. Ginger essential oil could offer a viable alternative to conventional fungicides, promoting sustainable agricultural practices and

reducing the environmental impact of disease management strategies. . It is therefore recommended that future works should focus on the determination of phytochemical constituents of ginger essential oil in order to explore more active ingredients that are responsible for the fungicidal effect.

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