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Assessment of bio-control quality of ethanolic extracts of some tropical plants on fruit rot pathogens of pineapple fruits in Ado Ekiti

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ABSTRACT: Food security in developing nations is increasingly threatened by plant diseases, particularly post-harvest fruit rot, which significantly impacts the livelihoods of rural populations, subsistence farmers, and fruit vendors who rely heavily on fruit cultivation and trade. Beyond economic losses, fruit rot pathogens may also contribute to foodborne illnesses. This study evaluated the antifungal activity of ethanolic extracts from *Khaya grandifoliola*, *Hyptis suaveolens*, *Zingiber officinale*, *Calophyllum inophyllum*, and *Datura stramonium* against fungal pathogens responsible for pineapple fruit rot. Results from this study showed that these plant extracts had varying degrees of inhibitory effects on the mycelial growth of the fungi. *Zingiber officinale* extract demonstrated the highest inhibition (38.40%) against *Aspergillus flavus* at a concentration of 1.0 g/mL, while its lowest effect was observed against *Aspergillus fumigatus* (23.10%). Similarly, *Datura stramonium* was most effective against *Aspergillus tubingensis* (24.00%) and least effective against *Colletotrichum fruticola* (10.00%). *Calophyllum inophyllum* exhibited the greatest inhibition on *Trichoderma harzianum* (18.50%), and the lowest on *Aspergillus flavus* (15.00%). The extract from *Hyptis suaveolens* showed strong activity against *Aspergillus fumigatus* (35.00%) and lower efficacy on *Aspergillus niger* (20.00%). *Khaya grandifoliola* had the highest inhibitory effects on *Aspergillus flavus* (35.00%) and the lowest on *Aspergillus fumigatus* (22.00%). These findings suggest that the tested plant extracts can serve as alternatives to synthetic fungicides for managing fungal rot of pineapple fruits, as they are effective and environmentally friendly.

Keywords: Bio-control, ethanolic extracts, fungal, fruit rot, pineapple fruit, pathogens, tropical plants.

INTRODUCTION

Hyptis suaveolens is a highly invasive annual herb found in disturbed habitats (Akomolafe *et al*., 2025). It has been reported as invasive in regions including Hawaii, Guam, Niue, Papua New Guinea, the Philippines, Singapore, Taiwan (PIER, 2016), parts of Africa and South Asia (GBIF, 2016). In Australia, it is classified as an environmental weed in northern Queensland and northwestern regions, and is listed as a noxious weed in the Northern Territory (QG, 2012). *H. suaveolens* has a unique ability to attach itself to animals' fur and humans' clothing, which aids its spread to areas that have not been disturbed. Its seeds can lie dormant until the vegetation is cleared, allowing for its emergence (Akomolafe *et al*., 2024). The plant often establishes dense thickets that outcompete and suppress native flora. This is particularly evident in areas subjected to grazing or disturbance, but it also occurs in riparian zones and floodplains (QG, 2012). *H. suaveolens* has been reported by Sèdégan *et al*. (2024) to possess antifungal properties, which were corroborated by Worku *et al.* (2024). Isamotu *et al.* (2025) reported a

similar observation that different extracts from H. suaveolens exhibited higher antimicrobial capacity. Jan *et al*. (2025) observed that higher concentrations of plant extracts displayed a higher inhibitory effect on plant pathogens.

Zingiber officinale, widely known as ginger, is a globally used spice, valued for both its medicinal and culinary properties. It contains a variety of active compounds that are responsible for its wide range of health benefits, including anti-inflammatory, anti-arthritic, anti-diabetic, antibacterial, antifungal, and anticancer effects. Ginger oil is used in food processing; it is known to improve shelf life and prevent spoilage by inhibiting rancidity and microbial growth. Its antioxidant and lipid peroxidation-inhibiting effects contribute to its ability to protect against oxidative damage and food spoilage. These benefits are attributed to the bioactive constituents found in both fresh and dried ginger oils. Traditionally, ginger rhizomes have been used in treating respiratory conditions such as asthma, colds, and bronchitis (Gupta *et al.,* 2025). Furthermore, ethanol extracts of ginger have demonstrated antimicrobial activity against pathogens like *Staphylococcus aureus*, *Streptococcus pyogenes*, *Streptococcus pneumoniae*, and *Haemophilus influenzae* (Juariah *et al.,* 2023). Overall, ginger is rich in therapeutic metabolites that contribute to its anti-inflammatory, antioxidant, anticancer, and antiemetic effects (Ballester *et al.,* 2022).

Calophyllum inophyllum L. is a mangrove-associated species commonly found in sandy coastal regions and areas with hot climates. It thrives in various environments, including lowland forests, mountainous regions, and swamps, typically at elevations ranging from sea level up to 800 meters (Baity *et al.,* 2011). This highly adaptable plant is valued for its multiple uses. Its oil is particularly notable for its application as a biodiesel source. In addition to its biofuel potential, the plant has significant medicinal properties. Various parts of *C. inophyllum* have demonstrated pharmacological activities, including antibacterial, anticancer, anti-inflammatory, antiviral, antipsychotic, antiplatelet, and photoprotective effects, as well as molluscicidal and piscicidal properties (Ling *et al.,* 2010).

Datura stramonium, commonly referred to as thorn apple, is a member of the Solanaceae family. This wild plant is recognised for its medicinal and pharmacological benefits and has been widely used in traditional medicine (Kirtikar *et al.*, 1999). The juice extracted from its flower petals is traditionally applied to ease earaches, while its seeds are employed as a purgative and to manage ailments such as cough, fever, and asthma. Due to their narcotic properties, the seeds are sometimes smoked (Khan *et al.*, 2013; Bolatkyzy *et al.,* 2025). Additionally, roasted leaves are applied externally for pain relief (Hussain, 2024). Historically, Native American communities utilised Datura seeds for their euphoric effects, and by the 19th century, the plant had gained therapeutic application in Great Britain (Srivastava and Srivastava, 2020).

Khaya grandifoliola (Welw.) C.D.C. (Meliaceae) is widely recognised in Nigerian traditional medicine, where its stem bark is commonly prepared as a decoction to manage malaria and other fever-related illnesses. Guy-Armand *et al.* (2023) demonstrated the antimalarial potential of its aqueous extract in mice infected with *Plasmodium berghei*. Additionally, investigations have assessed stem bark extracts prepared with different solvents, as well as purified fractions of the aqueous extract, for their activity against *P. berghei* in vivo and *Plasmodium falciparum* in vitro (Baah *et al*. 2020).

MATERIALS AND METHODS

Samples collection

Healthy and rotten pineapple fruit samples were acquired from a fruit market in Ado-Ekiti, Nigeria. These were taken to the laboratory of the Science Laboratory Technology in Federal Polytechnic, Ado-Ekiti, in sterile polythene bags for isolation and analysis.

Isolation of pathogens

Fruits showing symptoms of diseases were surface sterilised, sliced into 2 mm pieces and plated onto sterile potato dextrose agar (PDA) in Petri dishes supplemented with 250 mg Chloramphenicol to control bacterial contamination (Cohen *et al*., 2021). The plates were incubated at room temperature for 2-3 days, watched for fungal growth, and these were later subcultured into fresh PDA medium. The colonies that developed were counted and subcultured repeatedly on PDA plates to obtain pure cultures.

Obtained pure isolates were identified on the basis of macro and micro morphological characteristics. Morphological properties of the fungi (mycelium colouration or pigmentation, presence or absence of septate, spore morphology) were recorded. In some cases, the infected tissues were stained with cotton blue and lactophenol (Yang *et al*., 2023) and observed under a microscope. Morphological identification of fungi was based on the morphology of the culture colony or hyphae, the characteristics of the spores and reproductive structures (Olumuyiwa *et al.,* 2025). These were later stored on PDA slants for identification and characterisation.

Pathogenicity test

Pathogenicity test was done by adopting the method of Sama *et al.* (2025). Healthy pineapple fruits were washed under running tap to get rid of dirt, surface sterilised in 1% NaOCl for three minutes. These were rinsed in three changes of sterile distilled water and wiped dry with a sterile blotting paper. A sterile inoculating needle containing a fungal spore was punched into the pineapple fruit. The isolated fungal pathogens were introduced into

healthy pineapple (Kuruppu *et al.,* 2025). The wound on the inoculated pineapple was labelled with a paper tape and smeared with petroleum jelly. The negative control was also set in the same manner. Disease development was checked after 24 hours. The point of inoculation of each fungus was examined and recorded. The diameter of the rotten portion of the fruits was measured, and the fungi were later re-isolated from the inoculated samples and compared with the initial isolates.

Preparation of plant crude extracts

The extraction process described by Bitwell *et al*. (2023) was adopted in obtaining crude extracts from *Datura stramonium*, *Calophyllum inophyllum*, ginger rhizome (*Zingiber officinale*), leaf of *Hyptis suaveolens* and *Khaya grandifoliola*. Collected plant parts were washed under tap water, rinsed in three changes of sterile distilled water and dried using sterile blotting paper. These were later dried at 40°C for three weeks. Similarly, the rhizomes were washed under tap water and rinsed in three changes of sterile distilled water. These were then blotted dry with sterile blotting papers, peeled, chopped into smaller pieces and placed in the oven at the same temperature for three days. All the plant materials were then pulverised using a sterile mortar and pestle to release the active cell contents. The extracts were placed in sterile specimen bottles. This was done to maximise the surface area, which in turn enabled mass transfer of active ingredients from the plant material to the solvent.

Fifty (50 g) of each test plant sample was put into separate sterile conical flasks, and 200 mL of solvent (ethanol and aqueous) was added to each of the plant powders, ensuring that the powder was completely immersed in the solvent. This was then shaken vigorously and intermittently for two days at room temperature. A sterile funnel was placed into a 500 mL conical flask, and then a Whitman's (No.1) filter paper was folded and placed into the funnel. The extract was poured gradually into the filter paper and allowed to trickle into the conical flask. The filtrate was then poured into sterile universal bottles. The crude extracts in the universal bottles were placed in a rotary evaporator for 60 minutes at 50°C to concentrate the extracts by evaporating the solvent. The concentrated crude extracts were dried in an oven at 40°C for two days until a powder-like substance remained at the bottom of the universal bottles. The labelled universal bottles containing the powder were stored in the refrigerator at 4°C.

Preparation of inoculum

The fungal inoculum was prepared from a 5-day-old culture grown on PDA. The Petri dishes were flooded with 8 to 10 mL of distilled water, and the conidia were scraped using a sterile spatula. The spore density of each fungus was adjusted with a spectrophotometer (A_{595} nm) to obtain a final concentration of approximately 10^5 spores/mL according to Cheesbrough (2005).

Effects of crude plant extracts on the growth of fungal mycelia

The antifungal effects of crude extracts of test plants were evaluated on eight fungal isolates, namely: *Aspergillus nidulans*, *Aspergillus flavus, Colletotrichum fruticola, Rhizopus sp, Trichoderma harzianum, Aspergillus niger, Aspergillus fumigatus* and *Aspergillus tubingensis*

Determination of the effects of the crude extracts on the isolates

Effects of the crude extracts on the rot fungi were determined using the procedure of Gyasi *et al*. (2023). Concentrations of the crude extracts were prepared by weighing separately 0.2, 0.4, 0.6, 0.8 and 1.0 mg of *Datura stramonium*, *Calophyllum inophyllum*, ginger rhizome (*Zingiber officinale*), leaf of *Hyptis suaveolens* and *Khaya grandifoliola* powder, respectively. Each powder was dissolved in 1mL of ethanol to form solutions of different concentrations. The Muller-Hinton agar medium was prepared according to the manufacturer's instructions and autoclaved at 121°C for 15 minutes. The media was poured into each Petri dish and set aside to solidify under the laminar hood chamber. After solidifying the media, the sterile glass spreader was used to uniformly spread the inoculum on the medium. Then, 100 µL of each extract was adjusted to the same concentration (50 mg/mL) and perforated filter papers (discs) were soaked for two hours before placing them on the agar plate. The agar plate was allowed to stand for 1 hour under incubation, later at 37°C for one day. The sensitivity of the test microorganisms was determined by assessing the diameter of the zone of inhibition percentage was taken thus:

$$\text{Growth inhibition } (\%) = \frac{\text{DC} - \text{DT}}{\text{DC}}\ x\ 100$$

Where DC = Average diameter of colony with control & DT = Average diameter of colony with treatment

Data analysis

The data were analysed using the PROC ANOVA procedure of GENSTAT version 15, and significant differences among the means and compared using Father's protected LCD at 5% probability level.

RESULTS

Figure 1 shows the various fungal pathogens isolated from rotten pineapple fruits. *Aspergillus flavus* (24%) was the most frequent, this was followed by *Colletotrichum fruticola*

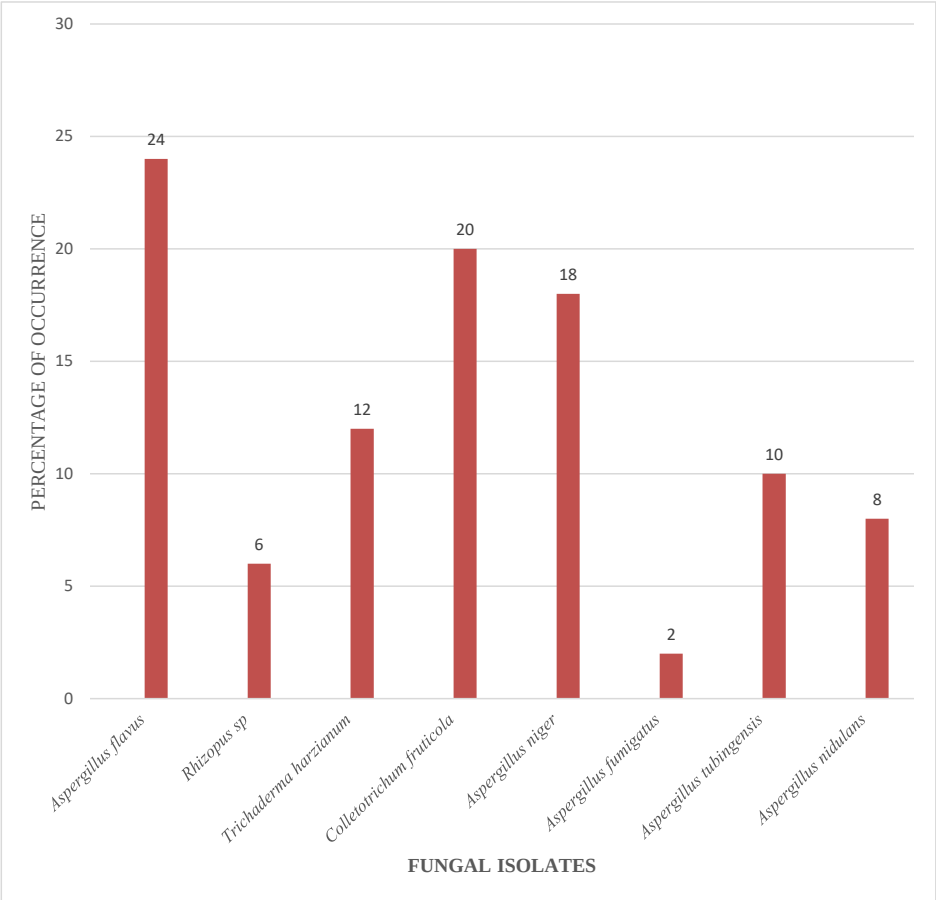

Figure 1. Frequency of occurrence of fungi isolated from pineapple fruit in Ado-Ekiti.

Table 1. Antifungal activities of *Datura stramonium* ethanol extract on fruit rot fungal pathogens.

Isolates	Diameter of zones of inhibition (mm)				
	Concentrations (g/mL)				
	1.0	**0.4**	**0.6**	**0.8**	**0.2**
Aspergillus flavus	22.00^{ab}	18.00^{b}	16.00^{b}	10.00^{c}	9.00^{b}
Rhizopus sp	16.00^{c}	12.00^{d}	10.00^{d}	8.00^{d}	0.00^{d}
Trichoderma harzianum	12.00^{d}	10.00^{e}	8.00^{e}	0.00^{e}	0.00^{d}
Colletotrichum fruticola	10.00^{e}	10.00^{e}	0.00^{f}	0.00^{e}	0.00^{d}
Aspergillus niger	23.00^{a}	18.00^{b}	16.00^{b}	10.00^{c}	8.00^{c}
Aspergillus fumigatus	20.00^{b}	16.00^{c}	14.00^{c}	12.00^{b}	8.00^{c}
Aspergillus tubingensis	24.00^{a}	22.00^{a}	20.00^{a}	18.00^{a}	14.00^{a}
Aspergillus nidulans	12.00^{d}	10.00^{e}	8.00^{e}	0.00^{e}	0.00^{d}

Values are mean ± standard error of the mean for bioassay conducted. Means followed by the same letter(s) are not significantly different (multivariate analysis, Fisher's protected LSD at $p \leq 0.05$). Key: Control Nil.

(20%), *Aspergillus niger* (18%), *Trichoderma harzianum* (12%), *Aspergillus tubingensis* (10%), *Aspergillus nidulans* (8%), *Rhizopus sp* (6%), and the least occurring being *Aspergillus fumigatus* (2%).

Aspergillus tubingensis (24.00 %), *Aspergillus niger* (23.00%) and *Aspergillus flavus* (22.00%) were more inhibited by 1.0 g/ml of *Datura stramonium* ethanol extract, while *Colletotrichum fruticola* (10.00%) was least inhibited, as the same concentration inhibited *Rhizopus* sp (16.00%), *Trichoderma harzianum* (12.000%), *Aspergillus fumigatus* (20.00%) and *Aspergillus nidulans* (12.00%) (Table 1).

Trichoderma harzianum (18.50%) and *Aspergillus fumigatus* (18.00%) were more inhibited by 1.0 g/mL of

Table 2. Antifungal activities of *Calophyllum inophyllum* ethanol extract on fruit rot fungal pathogens.

Isolates	Diameter of zones of inhibition (mm)				
	Concentrations (g/mL)				
	1.0	0.8	0.6	0.4	0.2
Aspergillus flavus	15.00^{d}	13.00^{d}	10.50^{c}	7.00^{c}	0.00^{c}
Rhizopus sp	17.70^{ab}	14.20^{cd}	11.50^{b}	8.10^{b}	0.00^{c}
Trichoderma harzianum	18.50^{a}	17.00^{a}	15.50^{a}	9.20^{ab}	7.80^{b}
Colletotrichum fruticola	16.20^{c}	15.00^{bc}	11.00^{b}	10.00^{a}	8.60^{a}
Aspergillus niger	17.00^{b}	15.00^{bc}	15.50^{a}	10.10^{a}	8.00^{ab}
Aspergillus fumigatus	18.00^{a}	16.50^{ab}	10.20^{c}	7.00^{c}	0.00^{c}
Aspergillus tubingensis	16.00^{c}	14.80^{c}	11.00^{b}	8.90^{b}	8.10^{a}
Aspergillus nidulans	17.70^{ab}	16.00^{b}	15.50^{a}	9.10^{ab}	8.00^{b}

Values are mean ± standard error of the mean for bioassay conducted. Means followed by the same letter(s) are not significantly different (multivariate analysis, Fisher's protected LSD at $p \leq 0.05$). Key: Control Nil.

Table 3. Antifungal activities of Ginger rhizome (*Zingiber officinale*) ethanol extract on fruit rot fungal pathogens.

Isolates	Diameter of zones of inhibition (mm)				
	Concentrations (g/mL)				
	1.0	0.8	0.6	0.4	0.2
Aspergillus flavus	38.40^{a}	35.30^{a}	30.00^{a}	28.20^{a}	26.00^{a}
Rhizopus sp	24.50^{f}	22.80^{e}	21.00^{c}	17.20^{f}	14.30^{d}
Trichoderma harzianum	33.30^{c}	31.50^{b}	28.30^{ab}	21.00^{c}	17.00^{cd}
Colletotrichum fruticola	28.00^{e}	27.00^{c}	25.10^{b}	20.00^{d}	18.00^{c}
Aspergillus niger	30.00^{d}	26.70^{cd}	23.00^{b}	20.10^{d}	19.30^{bc}
Aspergillus fumigatus	23.10^{g}	22.00^{e}	21.00^{c}	18.00^{e}	10.90^{d}
Aspergillus tubingensis	35.10^{b}	30.30^{bc}	27.20^{ab}	24.00^{b}	20.00^{b}
Aspergillus nidulans	26.20^{ef}	23.40^{d}	21.10^{b}	20.00^{d}	17.00^{c}

Values are mean ± standard error of the mean for bioassay conducted. Means followed by the same letter(s) are not significantly different (multivariate analysis, Fisher's protected LSD at $p \leq 0.05$). Key: Control Nil.

Calophyllum inophyllum ethanolic extract, while *Aspergillus flavus* (15.00%) was least inhibited as the same concentration inhibited *Aspergillus nidulans* (17.70%), *Rhizopus sp* (17.70 %), *Aspergillus niger* (17.00%), *Colletotrichum fruticola* (16.20%) and *Aspergillus tubingensis* (16.00%). Higher concentration of extract caused higher inhibition of fungal growth (Table 2).

Aspergillus flavus (38.40%) and *Aspergillus tubingensis* (35.10%) were more inhibited by 1.0 g/ml of *Zingiber officinale* ethanolic extract, while *Rhizopus sp* (24.50%) was less inhibited as the same concentration inhibited *Trichoderma harzianum* (33.30%), *Colletotrichum fruticola* (28.00%), *Aspergillus niger* (30.00%), *Aspergillus fumigatus* (23.10%) and *Aspergillus nidulans* (26.20%). Higher concentration of extract promoted higher inhibition of fungal growth (Table 3).

Aspergillus fumigatus (35.00%) and *Aspergillus tubingensis* (32.00%) were more inhibited by 1.0g/ml of *Hyptis suaveolens* ethanol extract, while *Aspergillus niger* (20.00%) was less inhibited as the same concentration inhibited *Aspergillus flavus* (25.00%), *Rhizopus* sp (24.00%), *Trichoderma harzianum* (28.00%), *Colletotrichum fruticola* (31.00%), *Aspergillus niger* (20.00%) and *Aspergillus nidulans* (27.00%) (Table 4).

Aspergillus flavus (35.00%) and *Trichoderma harzianum* (31.00%) were more inhibited by 1.0g/ml of *Khaya grandifoliola* ethanolic extract, while *Rhizopus sp* (22.80%) was less inhibited, as the same concentration inhibited *Colletotrichum fruticola* (27.00%), *Aspergillus niger* (26.00%), *Aspergillus fumigatus* (22.00%), *Aspergillus tubingensis* (30.00%) and *Aspergillus nidulans* (23.00% (Table 5).

DISCUSSION AND CONCLUSION

This study showed the frequency of occurrence of fungi isolated from pineapple fruits sold in Ado-Ekiti market, Nigeria. It was observed that *Aspergillus flavus* had the highest occurrence (24.0%), *Colletotrichum fruticola* (20.0%), *Aspergillus niger* (18.0%), *Trichoderma harzianum* (12.0%), *Aspergillus tubingensis* (10.0%),

Table 4. Antifungal activities of *Hyptis suaveolens* ethanol extract on fruit rot fungal pathogens.

Isolates	Diameter of zones of inhibition (mm)				
	Concentrations (g/mL)				
	1.0	**0.8**	**0.6**	**0.4**	**0.2**
Aspergillus flavus	25.00^{c}	24.00^{c}	22.00^{c}	23.00^{a}	20.00^{b}
Rhizopus sp	24.00^{cd}	22.00^{cd}	20.00^{cd}	19.00^{c}	18.00^{cd}
Trichoderma harzianum	28.00^{b}	26.00^{bc}	24.00^{bc}	22.00^{b}	21.00^{ab}
Colletotrichum fruticola	31.00^{ab}	27.00^{b}	25.00^{bc}	22.00^{b}	20.00^{b}
Aspergillus niger	20.00^{e}	19.00^{e}	18.00^{e}	13.00^{d}	10.00^{e}
Aspergillus fumigatus	35.00^{a}	28.00^{ab}	27.00^{b}	23.00^{ab}	19.00^{c}
Aspergillus tubingensis	32.00^{ab}	31.00^{a}	30.00^{a}	25.00^{a}	23.00^{a}
Aspergillus nidulans	27.00^{bc}	23.00c	19.00^{d}	16.00^{cd}	15.00^{d}

Values are mean ± standard error of the mean for bioassay conducted. Means followed by the same letter(s) are not significantly different (multivariate analysis, Fisher's protected LSD at p≤0.05). Key: Control Nil.

Table 5. Antifungal activities of *Khaya grandifoliola* ethanol extract on fruit rot fungal pathogens.

Isolates	Diameter of zones of inhibition (mm)				
	Concentrations (g/mL)				
	1.0	**0.8**	**0.6**	**0.4**	**0.2**
Aspergillus flavus	35.00^{a}	33.00^{a}	27.00^{a}	26.00^{a}	20.00^{a}
Rhizopus sp	22.80^{e}	21.00^{d}	17.20^{e}	14.30^{d}	13.00^{e}
Trichoderma harzianum	31.00^{b}	27.30^{b}	21.00^{cd}	17.00^{c}	16.00^{c}
Colletotrichum fruticola	27.00^{cd}	24.10^{c}	23.00^{c}	19.00^{b}	15.30^{cd}
Aspergillus niger	26.00^{d}	23.00^{cd}	21.10^{cd}	18.30^{bc}	12.00^{f}
Aspergillus fumigatus	22.00^{ef}	21.00^{d}	18.00^{d}	16.90^{cd}	14.20^{d}
Aspergillus tubingensis	30.00^{bc}	27.20^{b}	25.00^{b}	21.00^{ab}	18.00^{ab}
Aspergillus nidulans	23.00^{e}	21.10^{d}	20.00^{d}	17.00^{c}	14.00^{d}

Values are mean ± standard error of the mean for bioassay conducted. Means followed by the same letter(s) are not significantly different (multivariate analysis, Fisher's protected LSD at p≤0.05). Key: Control Nil.

Aspergillus nidulans (8.0%), *Rhizopus sp* (6.0%), while the least was *Aspergillus fumigatus* (2.0%). Some of these pathogens were similarly isolated by Kuruppu *et al.* (2025).

It was also observed that the symptoms observed and the organism re-isolated in the pathogenicity test were similar to the pineapple fruit rot samples, which confirmed that *Aspergillus flavus, Rhizopus sp, Trichoderma harzianum, Colletotrichum fruticola, Aspergillus niger, Aspergillus fumigatus, Aspergillus tubingensis* and *Aspergillus nidulans* caused post-harvest fungal decay of pineapple fruit in Ado-Ekiti market, Nigeria. Some of these pathogens were reported by Oniah and Tawose (2018) and Zakaria (2024) as fungal pathogens of pineapple.

In this study, the bioactivity of the test plant could possibly be attributed to fungitoxic principles present in the test plants. This report also agrees with the report of several researchers that used different plants to control the growth of fungal organisms (Ijato *et al.,* 2021; Yaouba *et al.,* 2021; Kalhoro *et al*., 2022; Ijato *et al.,* 2023). Fungicidal properties of ginger (Zingiber officinale) essential oils against *Phytophthora colocasiae* have been repeatedly reported by Ballester *et al.* (2022) and Juariah *et al.* (2023). Ginger extract has been reported to exhibit antifungal capacity against fungal pathogens of plants (Xi *et al.,* 2022). Benzene extract of *Zingiber officinale* rhizome has been reported to show antibacterial activity against drug-resistant *P. aeruginosa* isolated from wound and pus samples. Yodkeeree *et al.* (2009) reported antimicrobial activities of 140 commercial ginger pastes against *Escherichia coli.*

Higher extract concentration supported higher antimicrobial effect. *Z. officinale* was observed to have the highest inhibitory effect on *A. flavus* (38.40%). The highest inhibitory effect of *D. stramonium* was observed on *A. tubingensis* (24.00%). *Datura stramonium* was highly inhibitive against fungal rot pathogens of pineapple. Inhibition of *Escherichia coli* and *Staphylococcus aureus* has been reported by Sreenivasa *et al.* (2012). Antimicrobial potential of *Datura stramonium* was reported against Xylophagous fungi by Vega-Ceja *et al.* (2022).

The highest inhibitory effect of *C. inophyllum* was observed against *T. harzianum* (18.50%). The fungicidal effect of *C. inophyllum* was reported by Saravanan *et al.* (2011). The highest inhibitory effect of *H. suaveolens* was observed on *A. fumigatus* (35.00%). The efficacy of methanolic leaf extract from *H. suaveolens* against soil-

borne pathogens has been reported by Okoro and Onaebi (2022). The highest inhibitory effect of the ethanolic extract of *K. grandifoliola* was observed on *A. flavus* (35.00%). Antimicrobial *activity of Khaya grandifoliola Stem Bark* was reported by Stephen *et al.* (2009).

The test plant extract used in this study has the capacity to preserve pineapple fruit against fungal rot pathogens. It has also revealed the potential of ethanolic extracts of *D. stramonium, Z. officinale, K. grandifoliola, H. suaveolens* and *C. inophyllum* as alternatives or complementary to synthetic chemicals in controlling pineapple rot due to their fungitoxic activities on the test organisms. The efforts of many researchers directed towards finding an alternative to chemical control of microbial contamination provoked the use of ethanolic extracts of *D. stramonium, Zingiber officinale, Khaya grandifoliola, Hyptis suaveolens* and *Calophyllum inophyllum* to combat fungal pathogens of pineapple fruits. It was observed that ethanolic extracts of the test plants had inhibitory properties on the isolated microorganism. Therefore, ethanol extract of *Zinginber officinale, Khaya grandifoliola, Hyptis suaveolens, Calophyllum inophyllum* and *Datura stramonium* could be used as bio-protector against fungal rot pathogens of pineapple fruits.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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