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Assessment of Quality and In Vitro Activities of Essential Oils Extracted from Some Selected Nigeria Dignifying Plants against Dematiaceous Fungi

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Abstract

Dematiaceous fungal infections are the major threat facing farmers in Nigeria, as they are challenged with deformation of keratinized parts, destruction of soft tissues, economic losses and loss of interest in Agriculture. The available antifungal agents with minimal therapeutic measure are faced with strain resistance, adulteration, toxicity and also expensive. Hence this study focused on the quality of essential oils extracted from the fruits of *Monodora myristica* (MM) and rhizomes of *Curcuma longa* (CI) and its *in vitro* activity against dematiaceous fungi. The soil samples were randomly collected and screened for the presence of dematiaceous fungi using appropriate microbiological and molecular techniques. Gravimetric and instrumentational techniques were employed in extraction and characterization of essential oils extracted from the plant materials. Agar-welled diffusion was employed in determining the activities of the essential oils against the fungi. *Cladosporium sphaerospermum* strain S11 (CSS1Q1), *Curvularia lunata* strain E31 (C1E31), *Phomopsis azadirchtae* strain T5 (PAT5) and *Cladophialophora bantiana* strain IL4059 (CBIL4059) were isolated from the soil samples. The essential oils (EO) contained pinene, terpinene, genaniol, cedrenes, cedrol, sapogenin, kaemferol, acetonitrile, and lunamarin. The physicochemical properties of EO extracted from MM and CI showed that the oils had edible and industrial potential. The *in vitro* activities of EO showed pronounced activities against the dematiaceous fungi, and EO from MM significantly ($p<0.05$) exhibited greater activity against the isolates than that from CL, and this was seen most against PAT5. The activities of EO extracted from CL were significantly ($p<0.05$) lower than the activities of Ketoconazole but that from MM were non significantly ($p>0.05$) higher than that of Ketoconazole. The study has shown that EO extracted from MM and CL conform to the stipulated standard, and were effective against CSS1Q1, CIE31, CBIL4059, and PAT5, of which EO from MM was more effective, mostly against PAT5.

Keywords: *Dematiaceous fungal, Essential oils, Monodora myristica, Curcuma longa, In vitro activity*

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Introduction

Dematiaceous fungi are a group of fungus typically identified in soil samples, notably in loamy soil utilised for agricultural reasons. These fungi often produce pigmented colonies that look dark on the reverse side of culture plates (Yew *et al*. 2014; Prakash *et al*. 2018; Ozgok *et al*. 2020). The black pigmentation found on the colony plate's reverse side is related to the formation of melanin pigment (Yew *et al*. 2014; Okeke *et al*. 2017).

The word "dematiaceous" refers to fungi that predominantly damage keratinized tissues of the body, such as the skin and nails (Okeke *et al*. 2017; Prakash *et al*. 2018; Ozgok *et al*. 2020; Iheukwumere *et al*. 2021). Infections induced by these

fungi vary from superficial and soft tissue infections to severe systemic infections, which may lead to significant fatality rates (Iheukwumere *et al*. 2021). The most often occurring infections are phaeohyphomycosis, chromoblastomycosis, and eumycetoma. More than 100 species spanning 60 genera of dematiaceous fungus have been connected with human disorders (Yew *et al*. 2014; Prakash *et al*. 2018; Ozgok *et al*. 2020).

Unlike many common fungal diseases, detecting dematiaceous fungus remains problematic owing to the lack of easy diagnostic tools, especially at the species level. Most diagnoses depend on pathological evaluation of clinical samples and extensive culture analysis (Yew *et al*. 2014; Prakash *et al*. 2018; Ozgok *et al*. 2020).

These fungi have caused severe tissue damage, economic losses, and anguish among both rural and urban farmers in Nigeria, eventually impeding agricultural output. Although numerous antifungal drugs have been tried to address these infections, many have been ineffectual owing to resistance, high prices, and restricted availability (Prakash *et al*. 2018; Ozgok *et al*. 2020).

For millennia, medicinal plants have been extensively exploited in traditional medicine to support human health (Dhifi *et al*. 2016). Research has found that several plant species contain bioactive chemicals with considerable medicinal effects (El-Sayed *et al*. 2017). Traditional herbalists have found these therapeutic herbs via gathering and clinical testing on patients. With improvements in technology, contemporary analytical methods are being employed to assess their phytochemical and bioactive components (Noordin *et al*. 2018).

Studies suggest that *Monodora myristica* includes phytochemicals such as tannins, saponins, flavonoids, steroids, terpenoids, cardiac glycosides, alkaloids, and phenols, all of which contribute to its therapeutic qualities (Vieira *et al*. 2019). Essential oils isolated from M. myristica have exhibited antifungal, antibacterial, antiviral, and antiprotozoal properties (Kwiatkowski *et al*. 2017).

A natural approach to addressing these illnesses might be the most effective option. This work analyses the potential of essential oils isolated from various noteworthy Nigerian plants with protective benefits on keratinized tissues (Angjili *et al*. 2016; Mohamed *et al*. 2016; Uma *et al*. 2017; Rezgori *et al*. 2020; AbdRasheed *et al*. 2021; Obianom *et al*. 2024). These essential oils might be made into a cream, emphasising the notion that "prevention is better than cure."

Materials and Methods

Collection of Soil Sample: The procedure followed the methodology outlined in the study by Iheukwumere *et al*. (2021). Litter present on the soil surface was carefully removed using a sterile stainless-steel spoon. A soil auger was used to reach a plough depth of 15 cm in the farmland, and up to 10 soil samples were collected from each sampling unit into a sterile tray. Extraneous materials such as roots, stones, pebbles, and gravel were carefully eliminated before thoroughly mixing the samples. The soil was then quartered by dividing it into four equal portions; two opposite quarters were discarded, while the remaining two were combined. The same procedure was applied to all other soil samples used in this study. Once properly labeled, the samples were placed in a sterile cooler to maintain both temperature and microbial integrity. They were then transported to the laboratory for further analysis.

Isolation of the fungal isolate: The approach given by Iheukwumere *et al*. (2021) was utilised for this process. A accurate analytical weighing scale (JJJ430BC) was used to quantify one gram of the soil sample, which was then transferred into a 50 mL Pyrex beaker. A little amount of normal saline (0.85% NaCl) was added, followed by vigorous mixing, and the volume was increased to 10 mL with normal saline. In accordance with the manufacturer's specifications, the sample was aseptically inoculated onto Sabouraud Dextrose Agar (SDA) supplemented with 0.05% chloramphenicol. The plates were cultured for 7–10 days at room temperature (30±2ºC). Fungal isolates that displayed dark pigmentation on the reverse side were subcultured onto new SDA containing 0.05% chloramphenicol and incubated under the same conditions for 7–10 days.

Identification of fungal isolates: Based on their macroscopic, microscopic, and molecular traits, the fungal isolates from pure cultures were identified down to the genus/species level. Iheukwumere and associates (2020)

Extraction and Characterization of Essential Oils+
Preparations of plant materials:
Fresh African nutmeg (Monodora myristica) fruits and turmeric (Curcuma longa) rhizomes were sourced from Onitsha Market in Anambra State, Nigeria. The plant materials were properly authenticated before processing. They were washed thoroughly and left to dry in the shade at room temperature for 14 days. Once dried, a sterile electric grinder was used to grind them into a fine powder (Iheukwumere *et al*. 2020).

Extraction of the essential oils:
A 2000 mL Soxhlet extractor consists of three primary components: a thimble (typically made of thick filter paper) that holds the solid sample for extraction, a siphon mechanism that periodically drains the thimble, and a percolator (boiler and reflux system) that circulates the solvent.

For the extraction process, twenty grams (100 g) of the plant material was placed into the thimble, which was then inserted into the main chamber of the Soxhlet extractor. A 1000 mL distillation flask was filled with 1000 mL of n-hexane and positioned on a 2000 mL, 220 V, 500 W heating mantle. The Soxhlet extractor was mounted on top of the flask, with a reflux condenser placed above the extractor.

Upon heating the n-hexane to reflux, the solvent vapors ascended through the distillation arm into the chamber containing the solid-filled thimble. The reflux condenser ensured that any solvent vapors condensed and trickled back

onto the solid material. As the warm solvent gradually filled the chamber, the siphon periodically emptied it, returning the solvent to the distillation flask. The thimble functioned as a barrier, preventing solid particles from reaching the still pot.

This continuous cycle was maintained for 12 hours. After extraction, the solvent was removed, typically using a rotary evaporator, to collect the essential oil. The extracted essential oils were then analyzed using a gas chromatographic method, as described by Iheukwumere *et al*. (2021).

Essential oil characterization

The gravimetric and instrumental methods outlined in the paper by Maliki *et al*. (2020) were used to accomplish this.

Determination of Percentage Oil Yield

After allowing foreign items to settle by gravity in a dark container, the extracted oil was filtered to get rid of the settled particles. Weighing the oil allowed us to use an algorithm to get the oil output percentage.

$$\text{Oil Yield (\%)} = \frac{Mo \times 100}{Ms}$$

Where: Mo represents the weight of oil extract and, Ms represents the weight of sample.

Determination of moisture content of oil

About 2 g of the oil sample was measured, and this was placed in the electric oven to heat at 105 ^{o}C for 4 h. The moisture content of the oil can be calculated as below

$$\text{Moisture Content (\%)} = \frac{\text{Weight of Sample} - \text{Weight of Oil} \times 100}{\text{Weight of Sample}}$$

Determination of specific gravity: A dried specific gravity container was carefully filled with the oil sample, ensuring that no air bubbles were trapped. The stopper was then securely placed in the bottle. The filled bottle was submerged in a water bath maintained at 20°C for 30 minutes.

Afterward, any excess oil that had emerged from the capillary opening of the bottle was gently wiped off. The bottle was then removed from the water bath, cleaned thoroughly, and allowed to dry completely. To ensure accuracy, the sample was quickly weighed before the temperature dropped below 20°C. The equivalent weight of distilled water was then determined, and the specific gravity of the oil sample was calculated using the following formula.

$$\text{Specific gravity} = \frac{A -- B}{C -- B}$$

Determination of iodine value: Approximately 2 g of the oil sample was weighed into a 500 mL flask, followed by the addition of 20 mL of carbon tetrachloride and 25 mL of DAM's reagent. The flask was securely sealed and vigorously swirled to ensure proper mixing. It was then kept in the dark for 1 hour and 30 minutes.

After the incubation period, 20 mL of potassium iodide solution and 150 mL of water were added to the flask. The mixture was then titrated with 0.1 mol/L sodium thiosulphate solution until a yellow coloration appeared. At this stage, a few drops of starch were added, and the titration continued with constant shaking until the blue color completely disappeared.

The same procedure was performed for the blank sample, and the iodine value was calculated using the appropriate equation.

$$\text{Iodine value} = \frac{12.69\ (A\text{-}S) \times C}{B}$$

Where, C is the concentration of sodium thiosulphate; B is the volume in ml of standard sodium thiosulphate used for blank; S is the volume in ml of standards sodium thiosulphate used for the sample and M is the mass of the sample.

Determination of peroxide value: A one-gram oil sample was accurately weighed into a clean, dry boiling tube. To this, 1 mL of freshly prepared saturated potassium iodide solution and 20 mL of a solvent mixture (comprising two parts glacial acetic acid and one part chloroform) were added. The tube was then vigorously shaken for 30 seconds to ensure proper reaction.

Following this, 50 mL of distilled water was added, and the mixture was titrated with 0.01 M sodium thiosulphate solution using 1 mL of starch solution as an indicator. The titration was carried out with continuous shaking until the blue coloration completely disappeared.

A blank titration was also performed, and the peroxide value was calculated using the corresponding equation.

$$\text{Peroxide Value} = \frac{(V_1 - Vc) \times C \times 1000 \times T}{M}$$

Where, V1 is the volume of 0.01 M sodium thiosulfate solution consumed in the main test; V0 is the volume of 0.01M sodium thiosulfate solution consumed in the blank test; C is the molar concentration of the sodium thiosulfate solution; T is the titre of the thiosulfate solution and M is the mass of oil sample in grams

Determination of Saponification Value: A 2.5 g oil sample was accurately weighed into a conical flask, followed by the addition of 25 mL of alcoholic potassium hydroxide (KOH). A blank sample was similarly prepared in a separate conical flask. The mixture was then refluxed in a water bath for 1 hour, ensuring it boiled gently but steadily until saponification was complete. This was confirmed by the absence of any oily residue and the formation of a clear solution.

Once cooled, 1 mL of phenolphthalein indicator was added to each flask, and the contents were titrated with 0.5 M hydrochloric acid (HCl). The saponification value was then determined using the appropriate equation.

$$\text{Saponification Value} = \frac{(S - B) \times C \times 56.1}{M}$$

Where S is the sample titre value; B is the blank titre value, C is the concentration of the HCl, 56.1 is the molecular weight of KOH and M is the weight of the sample.

Determination of free fatty acid: The acidity is frequently expressed as Free Fatty Acid (FFA) for which calculation was made using equation

$$\text{FFA as Oleic Acid (\%)} = \frac{28.2 \times V \times C}{M} \quad \text{or} \quad \text{Acid Value} = 2\,\text{FFA}$$

Oil profiling: This was carried out using Gas Chromatography (GC). One microgram of the oil sample was injected into the injection chamber, and press run, the information containing the chromatogram was displayed in the system as stated in the study published by Hashimoto *et al.* (2019).

***In vitro* Antifungal Susceptibility Test of the Essential oils using Agar Well Diffusion Method:** This procedure was performed following the modified method of Iheukwumere and Umedum (2013). Each labeled plate was uniformly inoculated with the test organism using the spread plate technique. A sterile cork borer with a 5 mm diameter was used to create wells in the medium.

Next, 0.1 mL of each essential oil sample was carefully introduced into the corresponding labeled wells. The plates were then incubated at room temperature (30±2°C) for 5 days. After incubation, antifungal activity was assessed by measuring the diameter of the inhibition zones (mm) formed around the wells.

Statistical Analysis: The data obtained in this study were presented in tables. Chi square(x^2) was used to determine the significance of the sample sources 95% confidence level. Pairwise comparison was carried out using student "t" test (Iheukwumere *et al*. 2021).

Results

The characteristic features of the fungal isolates are presented in Table 1 and Plates 1–4. The study highlighted the macroscopic attributes of the isolates, including colony texture, shape, color, reverse side appearance, and growth rate. Additionally, microscopic characteristics such as hyphal structure, conidiophore morphology, conidial shape, texture, and coloration were detailed in Table 1.

Macroscopic analysis showed that the dematiaceous fungal isolates exhibited dark pigmentation on the reverse side, with moderate growth rates, though they varied in surface color, texture, and margin structure. Microscopically, the isolates were septate, displaying distinct conidiophore and conidial morphologies. The extracted nucleic acids (DNA) from the isolates fell within the standard range (1.80–1.90) for purity, which was determined by calculating the absorbance ratio (A260/A280) as shown in Table 2. The amplified nucleic acid (DNA) fragments were purified and re-electrophoresed. Sequencing of these amplified regions confirmed a 100% identity match for each isolate. The study identified the presence of *Cladosporium sphaerospermum* strain S1Q1 (CSS1Q1), *Curvularia lunata* strain E31 (CLE31), *Cladosphialophora bantiana* strain IL4059 (CBIL4059), and *Phomopsis azadirachtae* strain T5 (PAT5), as shown in Table 3.

The essential oil extracted from *Monodora myristica* was darker and more viscous than that of *Curcuma longa*, with a higher oil yield. However, *C. longa* exhibited higher moisture content, iodine value, peroxide value, and saponification value compared to *M. myristica* (Table 4). Conversely, *M. myristica* had higher specific gravity, free fatty acid value, and acid value than *C. longa*. Their refractive indices showed slight similarities. The oil yield from *M. myristica* was significantly ($P < 0.05$) higher than that of *C. longa*, while *C. longa* had significantly ($P < 0.05$) higher moisture content than *M. myristica*.

Gas Chromatography (GC) profiling of the essential oils revealed multiple active antifungal compounds. The essential oil extracted from *C. longa* lacked atlantone and thujopsene, whereas *M. myristica* contained camphor, lunamavin, kaempferol, acetonitrile, and terpinolene. The variations in antifungal components between the two essential oils were not statistically significant ($P > 0.05$) (Table 5).

The *in vitro* antifungal activity of essential oils from *Monodora myristica* (African nutmeg) and *Curcuma longa* (turmeric) demonstrated strong efficacy against dematiaceous fungi. The essential oil from *M. myristica* exhibited significantly ($P < 0.05$) greater antifungal activity than that from *C. longa*, particularly against PAT5, as shown in Table 6. While the antifungal activity of *C. longa* oil was significantly ($P < 0.05$) lower than that of Ketoconazole, the activity of *M. myristica* oil was not significantly ($P > 0.05$) different from that of Ketoconazole.

Table 1: Macroscopic and microscopic characteristics of the fungal isolate

Macroscopic Characteristic	Microscopic Characteristic	Possible Isolate
The colony was gray-olivaceou and velvety to powdery, it had white to gray-olivaceous margin. The reverse side was black, and the growth rate was moderate.	The hyphae were septate. The conidiophore was dark with different branching patterns. The acrogenous conidia were subglobose, obovoid to limoniform. The was presence of ramoconidia and absent of chlamydospore	*Cladosporium sphaerospermum*
The colony was woolly, olivaceous brown in front and dark on the reverse side. The growh rate was moderate to rapid	The hyphae were septate. It produced unicellular, long chains of conidia that had lemon shaped. the conidia were brown without attachment scar.	*Cladophialophora bantiana*
The colony was whitish brown to brown with pale to pink margin, and dark on the reverse side .The growh rate was slow to moderate	The hyphae were profusely branched, septate and pigmented. The conidiophore was short and simple, bearing alpha and beta conidia. The conidia were subglobose with thick wall	*Phomopsis azadirachtae*
The colony was pinkish gray Initially and turned olive brown When fully matured. The reverse Side was brown to black. The growh rate was rapid	The hyphae were brown and septate. The conidiophore was brown, simple, branched and bent where the conidia originated forming sympodial geniculate growth. It had proconidia that were straight, pyriform, brown, multiseptate with dark basal protuberant hila	*Curvularia lunata*

Table 2: Purity of nucleic acids extracted from the test isolates

Sample	Conc (mg/mL)	A280	A260	260/280
X	84.20	0.4448	0.8140	1.83
Y	87.10	0.4745	0.8730	1.84
FC2	82.40	0.4432	0.8110	1.83
FA3	88.60	0.4833	0.899	1.86

Table 3: Molecular characteristics and identities of the fungal isolates

Isolate	**Max Score**	**Total Score**	**Query Cover (%)**	**E-Value (%)**	**Identity (%)**	**Accession Number**	**Description**
X	989	989	100	0.0	100	MN518383.1	*Cladosporium Sphaerospermum* Strain S1Q1
Y	715	715	100	0.0	100	MT524329.1	*Curvularia lunata* Strain E31
FC2	979	979	100	0.0	100	MN809181.1	*Cladophialophora Bantiana* strain strain IL4059
FA3	643	643	100	6e-180	100	KJ961647.1	*Phomopsis azadirachtae* Strain T5

Table 4: Characteristics of the extracted essential oils

Parameter	*Curcuma longa*	*Monodora myristica*
Oil yield (%)	17.18±0.41	39.41±0.14
Moisture (%)	18.05±0.58	7.16±0.14
Specific gravity	0.914±0.000	0.955±0.000
Iodine Value	90.45±1.08	63.86±1.21
Refractive Index	1.464±0.000	1.463±0.000
Free Fatty Acid(mg KOH/g)	5.65±0.11	8.06±0.14
Acid Value(mg KOH/g)	11.30±0.41	16.11±0.33
Peroxide Value (M equ/g)	0.221±0.001	0.115±0.001
Saponification Value (mg KOH/g)	194.54±3.14	155.82±1.87

Table 5: GC profiling of the essential oils

Active Constituent	*Curcuma longa*	*Monodora myristica*
Camphori	2.90	_
Alpha-Pinene	6.016	4.100
Beta-Pinene	7.470	9.146
Pentane	10.366	12.016
Alpha-Cedrenes	15.460	14.310
Beta-Cedrenes	20.313	20.116
Lunamarin	17.966	_
Kaemferol	22.730	_
Alpha-cedrols	25.650	25.573
Sapogenin	27.536	32.263
Gamma-terpinene	29.860	29.456
Acetonitrile	32.996	_
Genaniol	39.200	40.080
Terpinolene	42.276	_
Terpinolene	44.170	_
Atlantone	_	35.140
Thujopsene	_	1.006

Table 6: In vitro activity of the essential oils against the studied dematiaceous fungi

Isolate	Mean Diameter zone of Inhibition (mm)		
	MM	CL	KET
CSS1Q1	14.42 ± 0.11	8.82 ± 0.22	12.18 ± 0.51
CLE31	18.84 ± 0.33	11.14 ± 0.17	15.48 ± 0.33
CBIL4059	15.22 ± 0.82	10.86 ± 0.42	13.82 ± 0.12
PAT5	19.36 ± 0.22	12.64.0.33	14.21 ± 0.17

Discussion

The characteristic features of *Cladosporium sphaerospermum* strain S1Q1 (CSS1Q1), *Curvularia lunata* strain E31 (CIE31), *Cladophialophora bantiana* strain IL4059 (CBIL4059), and *Phomopsis azadirachtae* strain T5 (PAT5) observed in this study exhibited similarities to dematiaceous fungi isolated and characterized by several researchers (Brandt *et al.* 2013; Umedum and Iheukwumere 2013, 2014; Yew *et al*. 2014; Okeke *et al.* 2017; Prakash *et al*. 2018; Ozgnok *et al.* 2020; Iheukwumere *et al.* 2020, 2021). Other studies (Hershimoto and Kawakami 2015; Kawakami *et al*. 2016; Bensch *et al*. 2018; Hashimoto and Kawakami, 2018; Hashimoto *et al*. 2019) have reported that *Cladosporium* species are commonly associated with household environments, particularly *C. halotolerans*. However, in this study, *C. sphaerospermum*, a well-known environmental fungus, was detected in garden soil samples.

The characterized essential oils extracted from *Monodora myristica* and *Curcuma longa* confirmed their edibility, aligning with findings from previous studies (Dhifi *et al*. 2016; Onoji *et al.* 2016; Maliki *et al.* 2020). The iodine value, which indicates the degree of unsaturation and drying properties of the oil, was higher in *C. longa*, suggesting a greater level of unsaturation. This result is consistent with the reports of Dhifi *et al*. (2016), Negash *et al*. (2019), and Maliki *et al.* (2020). The acid value, a measure of free fatty acids and an indicator of oil deterioration, rancidity, or edibility, was lower in *C. longa*, supporting its edibility, as also reported by Konuskan *et al*. (2015), Kaur *et al*. (2016), Mengistie *et al*. (2018), Negash *et al.* (2019), and Maliki *et al*. (2020).

The observed variation in oil yield percentage may be attributed to differences in plant genetics and ecological factors, as suggested by Maliki *et al*. (2020). The specific gravity values obtained in this study were comparable to those of other edible vegetable oils and fell within the specifications outlined by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), as reported by Nagash *et al*. (2019). The saponification value, which reflects the

molecular weight of fatty acids and the purity of the oil, varied between the two plants, indicating differences in their saponification potential and purity level, consistent with findings from Kaur *et al.* (2016), Onoji *et al*. (2016), Mengistie *et al*. (2018), Nagash *et al.* (2019), and Maliki *et al*. (2020).
Peroxide value, an indicator of oil quality and stability, determines the extent of rancidity due to heat or oxidation during storage. According to the Standards Organization of Nigeria (SON), a peroxide value exceeding 10 M eq/g classifies an oil as rancid (Onoji *et al*. 2016). The essential oils extracted from *M. myristica* and *C. longa* in this study were of good quality and remained stable, as their peroxide values fell within the acceptable range.

The presence of key bioactive compounds such as pinene, terpinene, geraniol, cedrenes, cedrol, sapogenin, kaempferol, acetonitrile, and lunamarin in the essential oils of *M. myristica* (African Nutmeg) and *C. longa* (Turmeric) confirmed their antimicrobial potency, as previously reported by Brandt *et al*. (2013) and Iheukwumere *et al*. (2021).

The pronounced antifungal activity of these essential oils against *C. sphaerospermum* (CSS1Q1), *C. lunata* (CIE31), *C. bantiana* (CBIL4059), and *P. azadirachtae* (PAT5) observed in this study is likely due to the bioactive components within the oils. These highly potent compounds play crucial roles in antifungal activity, a phenomenon widely reported by researchers (Brandt *et al*. 2013; Arezoo *et al.* 2013; Casella *et al*. 2013; David *et al*. 2014; Rahman *et al*. 2014; Reyes-Jurado *et al.* 2016; D'Agostino *et al*. 2019; De Jesus *et al*. 2020; Basavegowda *et al.* 2020; Iheukwumere *et al.* 2021).

Conclusion

This study has shown that essential oils (EO) extracted from fruits of *Monodora myristica* (MM) and rhizomes of *Curcuma longa* (CI) contained potent bioactive compounds, conform to the stipulated standard, and were effective against *Cladosporium sphaerospermum* strain S11 (CSS1Q1), *Curvularia lunata* strain E31 (C1E31), *Phomopsis azadirchtae* strain T5 (PAT5) and *Cladophialophora bantiana* strain IL4059 (CBIL4059), of which EO from MM was more effective, mostly against PAT5.

Recommendation

This study recommends that the Government or Health funding Organizations should volunteer to the sponsor of mass production of this essential oil, and engage in production of creams with it in order to protect the skin, health status and economic status of the people living in the developing areas.

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Author contributions

Iheukwumere, I. H., Iheukwumere, C. M.., Ikunna, A. E., Unaeze, B. C., Obiefuna, O. H. and Onyemekara, N. N. participated in isolation, characterization and classification of the isolates, and determination of the influence of the physical factors on the growth of the isolates Obianom, A. O. and Nnadozie, C. H. carried out the sampling and data analysis. All authors read and commented on the final manuscript.

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Data availability

Data used in this study is available upon reasonable to the corresponding author' Iheukwumere, I. H.

Competing interest

There is no competing interest.

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