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ANTIFUNGAL ACTIVITY OF ETHANOLIC EXTRACT OF POTATO PEELS ON FUNGI CAUSING ROT IN MANGO FRUITS

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ABSTRACT

There is a growing concern recently on the effect of synthetic drugs on human health and the environment. This has led to the search for natural antimicrobial agents. In this research, the antifungal and antioxidant properties of ethanolic extract derived from potato peels as potential natural preservatives for fruits like mango was examined. The potato peels were collected, processed, and extracted using ethanol (70 %), with phytochemical composition analyzed using Gas Chromatography-Mass Spectrometry (GC-MS) and Fourier Transform Infrared Spectroscopy (FTIR) techniques. The analysis identified 16 bioactive compounds, including l-Verbenone, Pyrogallol, and Palmitic acid, which exhibited antifungal activity. The FTIR peak at 3400 $cm^{-1}$was attributed to O-H stretching, peaks at 1700 $cm^{-1}$and 1635 cm^{-1} correspond to C=O and C-O stretching vibrations, Absorptions between 1400-1000 cm^{-1}were assigned to C-H bending vibrations. The antioxidant ability was assessed using 1,1-Diphenyl 2-picryl-hydrazyl (DPPH),and the crude extract showed 94.41±0.15 %inhibition at the concentration of 600 µg/mL. Antifungal activity of the crude extract was tested against some fungi known to cause mango rots: *Aspergillus niger* and *Aspergillus flavu*s. The result showed that at higher concentrations (250 mg/mL), the extract completely inhibited fungal growth. These findings suggest that potato peels can be a sustainable source of natural antifungal agents and antioxidants for fruit preservation.

Key words: Antifungal, Antioxidant, Bacteria, Mango, Potato peels

INTRODUCTION

Fungal contamination presents a serious challenge to the quality and preservation of fruits, including mangoes, which are highly susceptible to spoilage by various fungal pathogens. The increasing demand for natural and eco-friendly alternatives to synthetic fungicides has led to a growing interest in exploring the antifungal properties of plant-based extracts [1]. Among the potential sources of such bioactive compounds, potato peels, often discarded as biomass, have emerged as a promising sustainable candidate. Recent studies have highlighted the rich phytochemical profile of potato peels, which includes compounds with documented antifungal activity [2]. The microorganisms which are responsible for spoilage, exploit the host by using extracellular lytic enzymes that degrade principal storage polymers to release water and the fruit's other intracellular constituents for use as nutrients for their growth (Barth et al. 2009). There are several fungi which infect the fruits either on the trees or during storage. These include *Aspergillus*

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sp, Phomopsis astromella causing soft rot and scab of fruits respectively

Ethanol is known for its efficacy in extracting a diverse range of both polar and non-polar compounds from plant materials, making it an ideal solvent for isolating bioactive substances from potato peels [3]. Studies have shown that ethanolic extracts from plant materials frequently contain high levels of phenolic compounds, flavonoids, and other bioactive substances [7]. These compounds possess various health benefits, including antioxidant properties that help combat oxidative stress and exhibit antimicrobial effects. Recent research has focused on the antimicrobial properties of phytochemicals, investigating their roles as control agents to inhibit pathogenic microorganism growth and enhance food quality [2].

GC-MS is widely used for the analysis of complex mixtures, such as plant-derived substances, due to its ability to separate and identify individual components. By analyzing plants chemical composition through techniques like Gas Chromatography-Mass Spectrometry (GC-MS), valuable insights can be gained into their possible uses in the pharmaceutical, food, or cosmetic industries among others [6].

Initial studies suggest that ethanolic extracts of potato peels can effectively inhibit fungal growth. However, there is a lack of detailed research focusing specifically on the efficacy of these extracts against fungi that spoil mangoes. Investigating this, could offer valuable insights into alternative methods for managing mango spoilage and decreasing dependence on synthetic antimicrobial agents.

This study aims to investigate the phytochemical, antioxidant, and antifungal properties of sweet potato peel crude extract and its efficacy in inhibiting the radial growth of some fungal organisms responsible for mango fruit spoilage. This research not only addresses the need for effective and green antifungal treatments but also supports the utilization of agricultural by-products, which are the recent trends in environmental sustainability and waste management [1,3].

MATERIALS AND METHODS

Samples Collection and Preparation

Fresh Potatoes were bought at Wurukum market in Makurdi, Benue State of Nigeria, and taken to the Department of Chemistry, Benue State University, Nigeria. Healthy potato tubers were selected and washed with distilled water to remove any adhering dirt or residues, peeled carefully and peels blanched for 3 minutes to deactivate any starchy portion left on the peels. After blanching, the peels were dried in an oven at 40 °C until they maintained consistent weight. It was then pulverized using a mortar, sieved and kept for further use.

Extraction

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About 1000 gram of the potato peels powder was subsequently extracted using 70% absolute ethanol in a Soxhlet apparatus at the ethanol boiling point for 48 h. The crude extract obtained from the potato peels was concentrated using a rotary evaporator, coded as sample A and stored for further analyses.

Characterization of Crude Extract
GC-MS Analysis

GC-MS analysis was carried out using the GCMS-QP2010 PLUS SHIMADZU. The column used was Perkin Elmer Elite - 5 capillary column measuring 30m × 0.25 mm with a film thickness of 0.25 mm composed of 95 % Dimethyl polysiloxane. The carrier gas used was Helium at a flow rate of 0.5 mL/min. Exactly 1 µL sample injection volume was utilized. The inlet temperature was maintained as 250 °C. The oven temperature was programmed initially at 80 °C for 4 min, then an increase to 200 °C, and then programmed to increase to 280 °C at a rate of 20 °C ending at 5 min. Total run time was 25 min. The MS transfer line was maintained at a temperature of 200 °C. The source temperature was maintained at 180 °C. GC-MS was analyzed using electron impact ionization at 70 eV and data was evaluated using total ion count (TIC) for compound identification and quantification. The spectrums of the components were compared with the database of spectrum of known components stored in the GC-MS library [4].

Fourier transform infrared spectroscopy (FT-IR) analysis

Fourier transform infrared spectroscopy (FT-IR) analysis of potato peel crude extract was performed.The plant extract was mixed with KBR (1:10) and made into a pellet by hydraulic press/IR press. Pellet was then inserted in sample slit and then transmittance was observed. All spectra were recorded from 4000-400 cm^{-1} using the Pelkin Elmer 3000 MX spectrometer. Scans were 32 per spectrum with a resolution of 4 cm^{-1}. The IR spectra were analyzed using the spectroscopic software Win-IR Pro Version 3.0 with a peak sensitivity of 2 cm^{-1} [5].

Antioxidant Assay
With 1,1-Diphenyl 2-picryl-hydrazyl (DPPH)

Exactly 0.1mM working solution of DPPH in Methanol was prepared. 1 mg/mL of the sample was prepared in appropriate solvent. The concentration of the samples was varied to 100-500 µg/mL by serial dilution. The reaction mixture contained 1000 µL of the sample and 500 µL of DPPH reagent. The mixture was allowed to incubate at room temperature for 30 min in dark. The absorbance of the reaction mixture was taken at 518 nm against the reagent blank, methanol. The control involved methanol and DPPH reagent. Ascorbic acid was used as standard to compare the % inhibition [8].

$$\text{Scavenging activity (\%)} = \frac{A-B}{A} \text{x } 100$$

Where A is the absorbance of control and B is the absorbance of sample and sample combination.

Anti-Fungal Test Analysis

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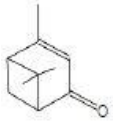
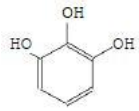
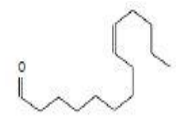
The poison plate method was used for *Aspergillus niger* and *Aspergillus flavus according to the method of* Babarinde *et al.,* 2023. A fully grown culture of the fungal isolates was prepared for 72 h. Petri dish was poisoned with 2 mL of different concentration (62.5 mg/mL, 125 mg/mL and 250 mg/mL) and potato dextrose agar was introduced into the plates containing the different concentrations and allowed to solidify. A sterile cork borer (8 mm diameter) was used to remove portion (well) of the plates with different concentrations, after which a portion of fungi from the petri dish with full grown isolates was removed and inoculated into the already made well in Petri dish containing different concentrations and kept at room temperature for 48 h. After incubation, radial growth of fungal mycelium observed was measured and recorded accordingly. A control plate without any sample was used. The none appearance of radial growth indicate susceptibility of the fungi to the antimicrobial agent.

RESULTS AND DISCUSSION

In this research, potato peels were collected, extracted using ethanol, characterized and investigated for antioxidant and antifungal activities and the results are presented in Table 1-4 and Figure 1.

Table 1. Qualitative and Quantitative Phytochemical Analysis of Potato Peels Ethanolic Extractby GC-MS

Structure	Name of Compound	R. Index	% Composition	Class of Compounds	Mass Spectra
	l-Verbenone	1119	0.69	Terpene	41, 55, **91**, 135, 150
	Pyrogallol	1342	17.94	Phynols	**52**, 63, 80, 97, 108
	Tridecanol	1556	0.10	Fatty alcohol	41, **55**, 69, 83, 97
	(Z)-9-Tetradecenal	1609	4.02	Aldehyde	41, 55, 67, 81, 95
	Methyl tetradecanoate	1680	0.77	Fatty acid methyl ester	41, 57, **74**, 87, 101

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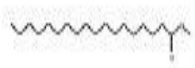
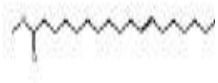
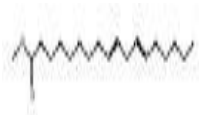
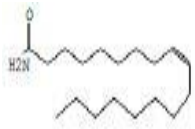
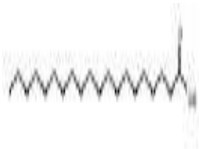
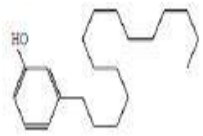
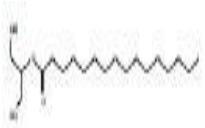
	Methyl 14-methylpentadecanoate	1814	0.45	Fatty acid methyl ester	43, 57, **74**, 87, 101
	Palmitic acid	1976	39.66	Fatty acid	41, **55.10**, 69, 83, 97
	(Z,Z)-9,12-Octadecadien-1-ol	2069	2.34	Fatty Alcohol	41, **55**, 67, 81, 95
	Methyl n-octadecanoate	2077	0.28	Fatty acid methyl ester	43, 57, **74**, 87, 101
	Methyl 11-octadecenoate	2085	0.94	Fatty acid methyl ester	41, **55**, 69, 74, 98
	Methyl linolelaidate	2093	0.86	Fatty acid methyl ester	55, 67, **81**, 95, 109
	Oleic acid amide	2228	4.22	Amide	41, 55, **59**, 72, 86
	Arachidic acid	2366	5.31	Fatty acid	41, 43, 57, 73, 85
	Cyclogalliphara ol	2406	10.63	Sesquiterpenes	41, **108.15**, 149
	2-mono-Palmitin	2498	4.18	Monoglyceride	41, **55**, 74, 84, 98
	1,3-di-Stearin	4395	5.73	Glyceride	**57**, 84, 98, 116, 129

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The qualitative and quantitative phytochemical composition of potato peel ethanolic extract was analyzed using gas chromatography-mass spectrophotometry (GC-MS) and the results are presented in Tables 1. The most dominantphytochemicals of the extract was; Palmitic acid (39.66 %), Pyrogallol (17.94 %), Cyclogallipharaol (10.63 %), 1,3-di-Stearin (5.73 %) and Arachidic acid (5.31 %). A total of 16 peaks corresponding to 16 distinct phytoconstituents were identified in the extract which include l-Verbenone, Pyrogallol, Tridecanol, Z)-9-Tetradecenal, Methyl tetradecanoate, Methyl 14-methylpentadecanoate, Palmitic acid, (Z,Z)-9,12-Octadecadien-1-ol, Methyl n-octadecanoate, Methyl 11-octadecenoate, Methyl linolelaidate, Oleic acid amide, Arachidic acid, Cyclogallipharaol, 2-mono-Palmitin and 1,3-di-Stearin.

L-Verbenone, monoterpene has demonstrated notable antifungal activity, especially in its esterified form, verbenone oxime esters. Studies indicate strong inhibition against fungi like *Alternariasolani and Physalosporapiricola*, showing comparable effectiveness to commercial fungicides [9]. Pyrogallol is known for its antioxidant properties. It has also been found to possess antifungal properties, particularly against species such as *Candida albicans* [10]. It works by disrupting fungal cell walls and metabolic processes. Tridecanol is a long-chain fatty alcohol which disrupts fungal cell membranes, causing cell lysis. While not as potent as some other antifungal agents, it has demonstrated moderate efficacy in this regard [9]. (Z)-9-Tetradecenal is unsaturated aldehyde which has been reported for its ability to disrupt fungal cell membranes, showing moderate antifungal potential, especially when used in combination with other bioactive agents [9]. Generally, all fatty acids have been reported to interfere with fungal lipid membranes, leading to reduced viability of fungal cells. Its antifungal properties are primarily based on membrane disruption [8], (Z,Z)-9,12-Octadecadien-1-ol is an unsaturated alcohol which exhibits antifungal properties by disrupting fungal lipid membranes, compromising cell integrity and inhibiting growth. Methyl n-octadecanoate has been shown to inhibit fungal growth by affecting membrane structure and function, leading to cell death [10]. Methyl 11-octadecenoate has been reported to possess variable antifungal activity, depending on the fungal species, but generally works by disrupting lipids membrane. Methyl linolelaidate which is a methyl ester of linoleic acid, has demonstrated mild antifungal activity, likely due to its ability to alter fungal membrane structures [9]. Oleic acid amide has shown moderate antifungal activity, particularly against yeast species. Cyclogallipharaol has not been reported for antifungal properties; however, its structural relationship to other bioactive molecules suggests potential antifungal activity. 2-mono-Palmitin is amonoglyceride derivative of palmitic acidwhich exhibits antifungal effects by compromising the

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integrity of fungal membranes [9]. 1,3-di-Stearin is a diacylglycerol and has shown limited antifungal activity on its own, but its structure suggests it could contribute to antifungal formulations through membrane disruption.

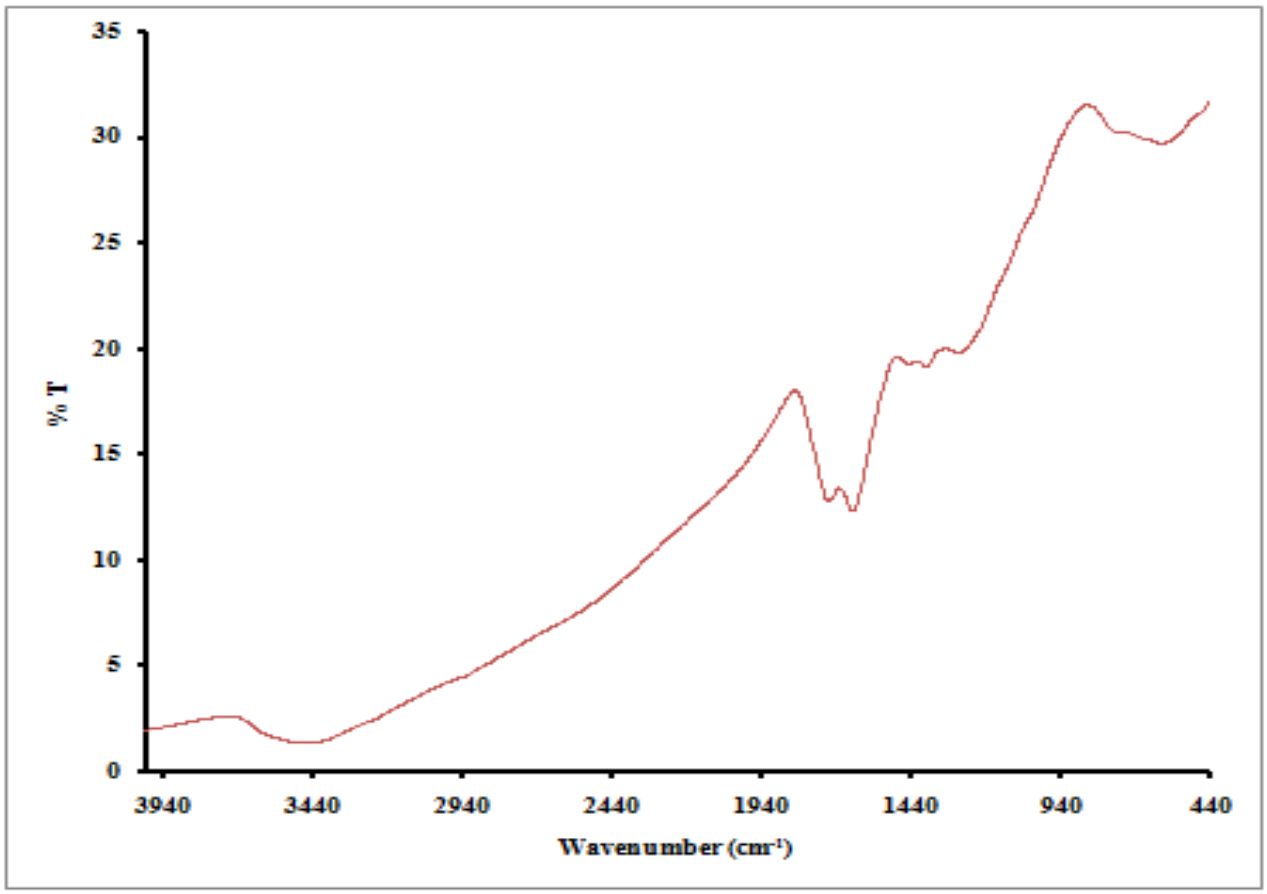

Figure 1. Fourier Transform Infrared Spectral of Potato Peels Ethanolic Extract

Table 2. Wavelengths of the main bands obtained from Potato Peels Ethanolic Extract

Vibrational mode	Wavenumber (cm^{-1})
C=N stretching	506
C-H stretching	1400
C-O vibration	1635
C=O vibration	2159
OH stretching	3400

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The functional groups in Potato Peels Ethanolic Extract were investigated by FTIR spectroscopy (Figure 1) and the vibrational modes of main bands are outlined in Table 2. The FTIR spectrum suggests that the sample contains hydroxyl groups (from alcohols or phenols), aliphatic hydrocarbons (C-H), and carbonyl-containing groups (C=O), potentially indicating the presence of fatty acids, esters, or other organic compounds. The broad peak around 3400 cm^{-1} is typically attributed to O-H stretching vibrations, suggesting the presence of hydroxyl groups, likely from alcohols, phenols or water molecules from the moisture content of the sample [11]. Sharp peaks at 1700 $cm^{-1}$and 1635 cm^{-1}correspond to C=O and C-O stretching vibrations, indicative of carbonyl groups found in esters, aldehydes, ketones, or carboxylic acids and ethers respectively [12]. Absorptions between 1400 - 1000 cm^{-1} were assigned to C-H bending vibrations which can indicate the presence of alcohols, esters, carboxylates or aromatic ring vibrations [13]. The peaks below 1000 cm^{-1} are due to the presence of metals which occur as minerals in the extract.

Table 3. Antioxidant Properties of Potato Peels Ethanolic Extract

Samples	200 µg/mL	400 µg/mL	600 µg/mL	800 µg/mL	1000 µg/mL
Potato Peel	92.41±0.29	92.51±1.04	94.41±0.15	89.77±0.15	93.35±0.15
Standard	86.63±0.23	87.75±0.23	90.79±0.23	91.91±0.45	93.92±0.57

Standard = Ascorbic acid; n= 2.

The antioxidant properties of the ethanolic extract have been presented above (Table 3) which compares the antioxidant efficacy of potato peel ethanolic extracts at varying concentrations (200 to 1000 µg/mL) against a standard reference (ascorbic acid). Generally, the data suggests a dose-dependent relationship for both the extract and ascorbic acid. However, a slight decrease in antioxidant activity is observed at 800 µg/mL for the extract (89.77 %), suggesting that concentration-activity relationship may not be perfectly linear, a pattern observed in many natural extracts where optimal activity is seen within specific concentration ranges [14]. The sample showed high antioxidant activity across all tested concentrations, ranging from 89.77% to 94.41%, indicating that potato peels is a rich source of antioxidant compounds. This aligns with findings that plant-based materials like potato peels often contain polyphenols, flavonoids, and other bioactive compounds with significant radical scavenging ability [15]. Comparing the extract with the ascorbic acid standard, it is evident that at lower concentrations (200–600 µg/mL), the potato peel extract exhibited higher antioxidant activities than

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ascorbic acid. At higher concentrations (800–1000 µg/mL), both show comparable antioxidant activities. This suggests that potato peels can serve as a natural, potent alternative to synthetic antioxidants such as ascorbic acid [16].

Table 4. Antifungal Activities of Potato Peels Ethanolic Extract

Sample	Concentration of Extract (mg/mL)	Diameter of Radial growth	
		A. niger	***A. flavus***
	250	0±0.00	0±0.00
	125	31.33±1.15	0±0.00
P. peel	62.5	66±7.02	31.33±5.51
Control	0	84	83.33

The antifungal properties of potato peel crude extract at different concentrations (62.5, 125, and 250 mg/mL) against some fungi known to cause rots in mango (*Aspergillus niger and Aspergillus flavus*) are presented in Table 3. It can be seen from the table that at the highest concentration (250 mg/mL), the extract completely inhibited *A. niger*, demonstrating its strong antifungal capacity. At lower concentrations of 125 and 62.5 mg/mL, there was partial inhibition, with growth of 31.33±1.15 mm and 66±7.02 mm, respectively. This suggests a concentration-dependent response, where the antifungal effect improves as the extract concentration increases [17]. Similarly, the extract completely inhibited *A. flavus* at 250 mg/mL and 125 mg/mL. However, at 62.5 mg/mL, the extract showed reduced effectiveness, with a radial growth of 31.33±5.51 mm. This further supports the idea that the antifungal activity is concentration dependent [17]. Generally, the difference between radial growth response of the control and the sample at different concentrations indicates the effectiveness of the crude extract against the test organisms.

CONCLUSION

In this research, potato peels were extracted using ethanol, characterized and tested for antifungal activities. The results clearly show that the ethanolic extract from potato peels was effective in suppressing the growth of some fungi known to cause rots in mango fruit especially where *A. niger* and *A. flavus* are the point of concern particularly at higher concentrations. The antifungal activities are attributed to the presence of the detected bioactive compounds in the crude

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extract. Such findings highlight the potential of utilizing potato peel waste in antifungal applications, including food preservation or agricultural use.

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AUTHOR CONTRIBUTIONS

Conceptualization, methodology, formal analysis, supervision, funding acquisition, (Ikyenge B. Aloo), formal analysis, writing, review & editing (Samoh F. Teghtegh), investigation, data Curation, review (Agbidye G. Isaac), formal analysis, characterization (Asogwa Nnaemeka).

DATA AVAILABILITY

The data for this article cannot be made available due to ethical confidentiality.

CONFLICTS OF INTEREST

There are no conflicts to declare.

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