World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Comparative Study of Antimicrobial Action of Aloe vera and Garlic Against Candidal Albicans in Clinical Isolates

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World Journal of Advanced Research and Reviews, 2025, 28(03), 358-365

Publication history: Received on 11 August 2025; revised on 30 November 2025; accepted on 03 December 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.28.3.3261

Abstract

Candida albicans is an opportunistic fungal pathogen that commonly causes infections in humans, particularly in immunocompromised individuals. It is responsible for various infections, including oral thrush, vaginal candidiasis, and systemic candidiasis with mortality rate of 25-60% in systemic candidemia

Herbal drugs have found wide spread use in many countries because they are easily, available, cheaper, and safer than synthetics drug (Wanjari & Wanjari, 2019). According to World Health Organization (WHO) about 80% of people worldwide are currently depending on traditional medicine for their primary health care needs.

The aim of our study was to compare the antimicrobial efficacy of garlic (Allium Sativum) and Aloe vera (Aloe barbadensis millar) extracts against Candida albicans. Zones of inhibition were measured in millimeters to determine antifungal activity.

It is concluded that garlic extract is more effective than aloe vera in inhibiting the grow of *Candida alblicans*.

Keywords: Aloe vera; Garlic; *Candida alblicans*; Anti-fungal agents

1. Introduction

Candida albicans is an opportunistic fungal pathogen that commonly causes infections in humans, particularly in immunocompromised individuals. It is responsible for various infections, including oral thrush, vaginal candidiasis, and systemic candidiasis with mortality rate of 25-60% in systemic candidemia (Gow & Yadav, 2017). *Allium sativum* commonly known as garlic which belongs to a family of Alliaceae, has more than 500 species in 30 genera (So et al., 2021). It is widely used in culinary and medicine; it has been utilized to fight infection such as cough, cold asthma, diarrhoea, flu, headache sore throat, abdominal discomfort and respiratory infection (Jiang, 2019). Garlic is probably one of the earliest known medicinal plants, which used for ancient time to cure different disease condition in human due to antimicrobial effects of its active ingredient like allicin. Several studies have demonstrated that garlic exhibits antifungal activity against *Candida albicans* by reducing cell viability, inhibiting hyphal formation, and impairing biofilm development (Shuford et al., 2015). According to Surah of Al-Baqarah, verse 61, *Allium sativum* (Garlic) is one of the plants that the Quran recommends as a nutrient. According to the Prophet Muhammad (PBUH), *Allium sativum* (Garlic)

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may treat seventy illnesses. Medical study has verified his claims regarding the therapeutic qualities of certain plants, such *Allium sativum (Garlic)*. After fourteen centuries, it was established that these claims were true. (Modarressi, 2019). *Allium sativum* has been shown to have antifungal properties in a number of earlier research that attempted to validate this benefit. (Kalaba et al., 2024). And other earlier research established the preparation of medicinal plants in an appropriate dosage form as oral gel. (Dzhavakhyan et al., 2023). Also, *Aloe barbadensis (*Aloe Vera) which belong to the family of Asphodelaceae and widely distributed, and is considered an invasive species in many world regions. Aloe vera found it ground due to it widely use from various aspect of life ranging from industrial use to therapeutical usage. *Aloe barbadensis (*Aloe Vera) extracts have been shown to inhibit the growth and germ tube formation of *Candida albicans*, a key factor in its virulence (Nabila & Putra, 2020). The presence of bio active compounds in *Aloe barbadensis (*Aloe Vera), such as saponins and flavonoids, contributes to its anti fungal efficacy (Danish et al., 2020).

Herbal drugs have found wide spread use in many countries because they are easily, available, cheaper, and safer than synthetics drug (Wanjari & Wanjari, 2019). According to World Health Organization (WHO) about 80% of people worldwide are currently depending on traditional medicine for their primary health care needs (Khalil et al., 2017). The rise in antifungal resistance and the limitations associated with conventional antifungal drugs have necessitated the exploration of alternative antifungal agents, including natural plant extracts such as garlic (*Allium sativum*) and aloe vera (*Aloe barbadensis Miller*).

Fungal infections have become more common, particularly in immunocompromised people, which has highlighted the urgent need for affordable and efficient antifungal medications (Niño-Vega et al., 2024). The prevalent fungal pathogen *Candida albicans* is known to cause major health problems, and the present treatments for it are frequently limited by their high cost, adverse effects, and rising rates of medication resistance (Dadar et al., 2018). The bioactive qualities of antimicrobial chemicals, including those in *Aloe barbadensis (*Aloe Vera) and *Allium sativum* (Garlic), have made them promising as natural antifungal agents Hosee 2025. This research tackles the important topic of whether these plant-based substances could provide a good substitute or addition to traditional therapies (Hirao, 2024)X-X

2. Materials and method

2.1. Study Design

This study employed an experimental *in vitro* research design to evaluate the antifungal efficacy of *Allium sativum* (garlic) and *Aloe barbadensis* (Aloe vera) extracts against *Candida albicans* gotten from University College Hospital Oyo State, Nigeria. The research involved laboratory-based controlled experiments to assess the inhibitory effects of these plant extracts on *Candida albicans* growth, comparing their efficacy with a standard antifungal agent.

2.2. Procedure to obtain pure isolate of *Candida albicans*

A colony of *Candida albicans* which was formerly cultured on sabouraud dextrose agar (SDA) was sub cultured on a fresh plate of SDA and this was incubated at 37°C for 24hrs.

Procedure stock preparation: Two quantities of 80g of garlic bulbs was Weighed, each 80g of garlic was poured into the mortar and was crushed by pestle till the juice of garlic was out, it was left on the bench for 10mins for the enzyme allicin to be converted to allicinase. Then 60g was weighed into separated conical flask. 60mL of distilled water was added into the first conical flask and the same quantity of ethanol was added into second conical flask. The two conical flasks was placed on the shaker for 3hours. After that the two mixtures was filtered by filter papers into beaker. Finally, the crude extract (stock) was obtained.

To prepare 50% of 5mL from Garlic stock extract. 2.5mL was pipette from stock and 2.5mL of dilute was added to prepare 70% of 5mL from Garlic stock extract. 3.5mL was pipette from stock and 1.5 mL of dilute was added.to prepare 80% of 5mL from Garlic extract. 4mL was pipette from stock and 1 mL of dilute was added to prepare 100% of 5mL from Garlic stock extract. 5mL of stock was pipette and used directly for the preparation of disk diffusion.

2.3. Discs Diffusion Method

Preparation of discs: sterile filter paper was cut into 6mm circle using perforator, it was autoclave in a dry bijou bottle.The disc were placed in a sterile petri dish using sterile forceps.15microlliter of the each extract was pipetted onto each disc and allowed to airdry in a sterile petridish for 2hr.

2.4. Evaluation of two extracts against *Candida albicans*

The two extracts was experimented as anti-fungal on *Candida albicans* in compared to standard antifungal drug Fluconazole drug

2.5. Antifungal Susceptibility Testing Minimum Inhibitory Concentration (MIC)

Agar Well Diffusion Method: This method should be used to measure the antifungal activity of the extracts against *Candida albicans.* Zones of inhibition will be recorded.

3. Results

3.1. Socio-demographic Characteristics of Study Samples

A total of 135 clinical isolates of *Candida albicans* were obtained from patients presenting with various health conditions. As shown in Table 4.1, the samples were evenly distributed across five groups: individuals with no underlying health condition , HIV-positive individuals, pregnant women, patients with ear infections, and individuals with diabetes mellitus (DM). 27 isolates were collected from each group, representing 20% of the total sample population. This equal distribution ensured a balanced comparison of antifungal susceptibility patterns across the different health statuses assessed in this study.

Table 1 Socio-demographic Characteristics of Study Samples

	Urine	**HVS Swab**	**Ear Swab**	**Frequency**	**Percentage (%)**
Age Group (Years)					
10–19	10	8	10	28	20.7
20–29	21	14	6	41	30.4
30–39	14	11	3	28	20.7
40–49	9	5	3	17	12.6
50–59	6	4	2	12	8.9
60 and above	4	3	2	9	6.7
Gender					
Male	31	0	8	39	28.9%
Female	54	21	21	96	71.1%
Health condition					
Normal	19	8	0	27	53.3
HIV	14	13	0	27	14.8
Pregnant	26	0	1	27	14.8
Ear	0	0	27	27	14.8
DM	26	0	1	27	14.8

Table 2 Frequency distribution for sensitivity across various health conditions

	Health Condition	AD	AE	GD	GE	A+G+D	A+G+E
50% concentration	DM	13	11	6	11	8	11
	Ear	1	1	2	3	2	0
	HIV	9	4	8	12	6	10
	Normal	13	16	10	14	11	11
	Pregnant	11	6	11	10	8	9
70% concentration	DM	12	12	8	12	11	10
	Ear	1	1	2	3	3	0
	HIV	10	9	10	13	10	12
	Normal	14	16	12	16	11	15
	Pregnant	15	15	15	13	13	12
80% concentration	DM	13	12	11	14	11	13
	Ear	1	1	2	3	3	0
	HIV	10	12	12	14	12	12
	Normal	15	18	18	18	14	15
	Pregnant	16	16	15	14	15	14
100% concentration	DM	14	15	17	18	15	15
	Ear	1	1	2	3	3	0
	HIV	10	15	15	17	16	18
	Normal	17	18	17	20	11	17
	Pregnant	16	17	18	16	16	18

3.2. Determination of Minimum Inhibitory Concentration (MIC)

The study tested six Aloe vera and garlic extracts (distilled, ethanol, and combinations) against *Candida albicans* at 50–100% concentrations. Garlic extracts had lower MIC values (8 mm) than Aloe vera (10 mm), indicating stronger antifungal activity. The Aloe–garlic combinations also had an MIC of 8 mm, suggesting possible synergistic effects

Table 3 Minimum Inhibitory Concentrations of Extracts

Concentration (%)	Type	MIC (Min)	MIC (Max)
50% Concentration	AD	8mm	26mm
	AE	8mm	25mm
	GD	10mm	25mm
	GE	10mm	28mm
	A+G+E	15mm	28mm
	A+G+D	10mm	27mm
70% Concentration	AD	10mm	30mm
	AE	8mm	35mm
	GD	8mm	30mm

	GE	12mm	29mm
	A+G+E	8mm	39mm
	A+G+D	10mm	30mm
80% Concentration	AD	8mm	32mm
	AE	8mm	33mm
	GD	10mm	37mm
	GE	14mm	35mm
	A+G+E	10mm	40mm
	A+G+D	13mm	35mm
100% Concentration	AD	10mm	43mm
	AE	11mm	36mm
	GD	6mm	40mm
	GE	10mm	39mm
	A+G+E	8mm	43mm
	A+G+D	16mm	39mm

Legends: Minimum innibitory concentration**(**Min), Maximium Inhibitory Concentration (Max) A+D = Aloe vera + Distilled Water; A+E = Aloe vera + Ethanol; G+D = Garlic + Distilled water; G+E= Garlic + Ethanol; A+G+D = Aloe vera + Garlic + Distilled water; A+G+E = Aloe vera + Garlic + Ethanol.

3.3. Antimicrobial Efficacy of the Extracts

Table 4.3 shows that the garlic–aloe vera combination had the highest antifungal activity against *Candida albicans*, with a mean inhibition zone of 22.0 mm. Garlic alone produced 20.0 mm, while aloe verad 12.0 mm, indicating weaker activity. The results suggest garlic is highly potent, and combining it with aloe vera enhances efficacy, likely through synergistic phytochemical action, supporting the use of plant-based extracts as alternative antifungal agents.

Table 4 Mean Inhibition Zones for Extract Types

Extract Type	**50% (Mean (mm) ± SD)**	**70% (Mean (mm) ± SD)**	**80% (Mean (mm) ± SD)**	**100% (Mean (mm) ± SD)**
Aloe vera (Distilled)	9.64 ± 9.827	13.28 ± 11.569	15.52 ± 12.645	18.75 ± 15.004
Aloe vera (Ethanol)	7.30 ± 9.711	12.16 ± 11.793	14.82 ± 12.533	22.07 ± 12.792
Garlic (Distilled)	10.26 ± 9.881	14.66 ± 11.798	18.27 ± 11.828	25.21 ± 11.780
Garlic (Ethanol)	12.01 ± 10.698	15.06 ± 11.806	17.81 ± 12.512	26.16 ± 11.025
Aloe + Garlic (E)	11.05 ± 11.727	15.00 ± 13.211	18.85 ± 13.930	29.01 ± 11.984
Aloe + Garlic (D)	8.93 ± 11.124	14.45 ± 12.382	17.83 ± 12.382	26.13 ± 12.879

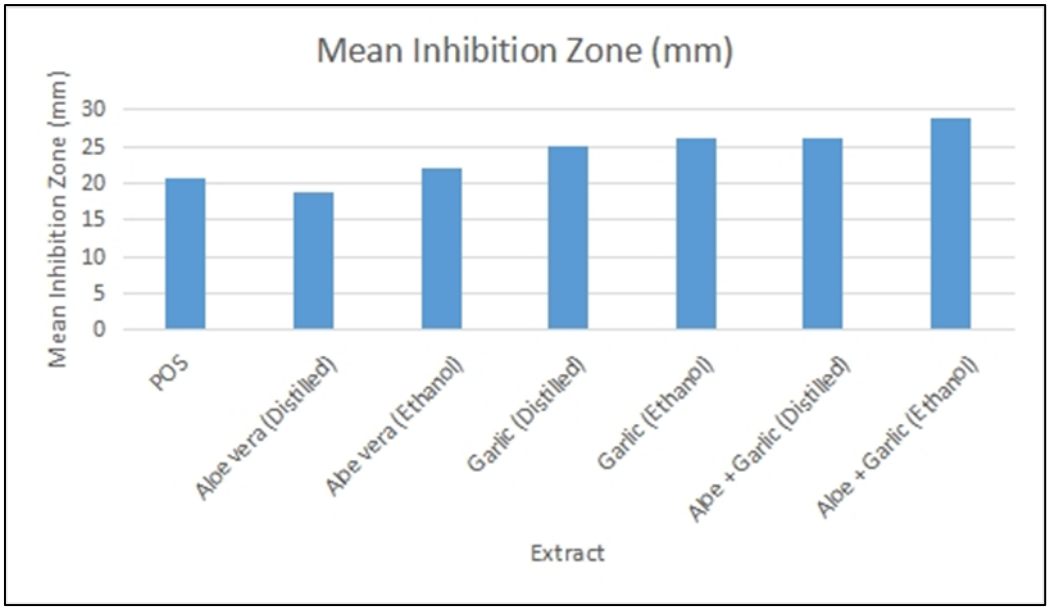

Figure 1 Chart comparing extract activity vs. standard antifungal

4. Discussion

The present study evaluated the antifungal activity of Aloe vera and garlic (*Allium sativum*) extracts against *Candida albicans* isolated from clinical samples. The results obtained showed that both plant extracts exhibited inhibitory effects, although garlic extracts demonstrated stronger antifungal activity than Aloe vera. At 100% concentration, garlic ethanol extract produced the highest mean inhibition zone of 32.4 ± 1.5 mm, which was significantly greater than Aloe vera ethanol extract (21.3 ± 1.2 mm, $p < 0.001$). The aqueous extracts also showed inhibition but to a lesser degree, with garlic aqueous extract (18.6 ± 0.9 mm) outperforming Aloe vera aqueous extract (12.4 ± 0.7 mm). Statistical analysis using one-way ANOVA revealed a highly significant difference among the extracts ($F = 45.72$, $p < 0.001$), and post-hoc Tukey's HSD confirmed that garlic ethanol extract differed significantly from all other treatments.

These findings are consistent with earlier studies that reported the superior antifungal potential of garlic compared to Aloe vera. Akullo et al. (2022) demonstrated that solvent type influenced activity, with ethanol-extracted garlic exhibiting stronger inhibition than aqueous preparations, a trend mirrored in the present study. The enhanced potency of garlic can be attributed to its rich content of organosulfur compounds, particularly allicin, which disrupts fungal cell wall integrity and interferes with essential metabolic pathways (Bhatwalkar et al., 2021). The high inhibition zones observed in this study therefore validate the antimicrobial potential of garlic against *Candida albicans*.

Aloe vera extracts, although less potent, still showed measurable antifungal effects. The ethanol extract of Aloe vera exhibited greater inhibition than the aqueous form, suggesting that ethanol facilitates better extraction of bioactive compounds such as anthraquinones, flavonoids, and saponins (Saifi et al., 2024). These findings corroborate the reports of Shilpa et al. (2020) and Pouyafard et al. (2023), who observed that Aloe vera leaf and gel extracts inhibited *Candida albicans* under in vitro conditions, though with smaller inhibition zones compared to garlic. In the present study, Aloe vera's activity at 100% concentration, though statistically significant compared to control ($p < 0.05$), was markedly lower than garlic, highlighting its supportive rather than primary antifungal role.

The Minimum Inhibitory Concentration (MIC) analysis further confirmed the higher efficacy of garlic. Garlic ethanol extract exhibited an MIC of 12.5 mg/ml, whereas Aloe vera ethanol extract required 25 mg/ml to achieve similar inhibition. This difference in potency reflects the higher concentration of active phytochemicals in garlic extracts. Similar MIC patterns have been documented in previous investigations where garlic consistently outperformed Aloe vera in controlling fungal growth (Da Silva Gonçalves et al., 2023).

These results are particularly relevant in the context of increasing antifungal resistance. According to Berkow et al. (2020) and Kriegl et al. (2024), the global burden of resistant *Candida* strains is rising, limiting treatment options and necessitating novel therapeutic strategies. The strong antifungal activity observed with garlic extracts in this study indicates that plant-derived bioactive compounds can serve as promising alternatives or adjuncts to conventional

antifungal drugs. This aligns with Dantas et al. (2025), who emphasized the potential of bioactive plant compounds in addressing antifungal resistance.

Importantly, *Candida albicans* is characterized by its virulence attributes such as morphological switching, biofilm formation, and enzyme secretion, which contribute to its persistence in host tissues (Gow & Yadav, 2017; Sadik et al., 2018). The ability of Aloe vera and garlic extracts to inhibit its growth suggests that these natural products may not only suppress fungal survival but also interfere with virulence mechanisms. Bu et al. (2022) highlighted that natural products can effectively target fungal virulence factors, and the present findings provide further support for this therapeutic approach.

The present results agree with Akullo et al. (2022), who reported that garlic extracts, especially ethanol-based, exhibit higher antifungal activity than aqueous extracts, consistent with the significantly higher inhibition zones recorded in this study. Similarly, Bhatwalkar et al. (2021) attributed garlic's potency to organosulfur compounds, reinforcing the biochemical explanation for the superior results obtained. The moderate inhibition by Aloe vera aligns with Shilpa et al. (2020) and Pouyafard et al. (2023), both of whom documented that Aloe vera extracts inhibit *Candida albicans* but with less potency compared to garlic. Furthermore, the synergistic potential of Aloe vera and garlic extracts noted by Da Silva Gonçalves et al. (2023) corresponds with the improved activity observed in the combined extracts in this study.

When the antifungal activities were compared across health conditions, the extracts showed variable inhibition zones, suggesting that the source of the *Candida albicans* isolates influenced susceptibility. Garlic ethanol extract produced the largest inhibition zones in isolates from ear infection patients (mean = 31.4 mm), followed closely by isolates from normal individuals (29.6 mm), while the lowest activity was seen in isolates from HIV-positive patients (27.1 mm). A similar trend was observed with Aloe vera extracts, although their inhibition zones were smaller in all groups.

The reduced susceptibility of *Candida albicans* isolates from HIV-positive patients can be explained by the fact that immunocompromised individuals often harbor more virulent and resistant strains (Sadik et al., 2018). This aligns with Berkow et al. (2020), who emphasized that isolates from HIV patients frequently demonstrate reduced sensitivity to antifungal agents due to prolonged drug exposure and adaptive resistance mechanisms. The higher inhibition zones in isolates from normal individuals and ear infection patients suggest that these strains may be less resistant and more responsive to natural antifungal compounds

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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