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Review article "antifungal activity of black garlic (allium sativum linn) extract against candida albicans fungus"

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ARTICLEINFO

Article history:

Received Mar 3, 2026
Revised Mar 10, 2026
Accepted Mar 16, 2026

Keywords:

Active Compounds
Antifungal Efficacy
Antifungal Resistance
Black Garlic
Candida Albicans
Inhibition Zone
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ABSTRACT

This study aims to analyze the effectiveness of black garlic extract (Allium satium Linn) on the growth of candida albicans fungus, which is known as an opportunistic pathogen in humans, black garlic produced through the process of heating garlic contains active compounds such as allicin, saponins, flavonoids and tannins that have the potential as antifungals. The method used in this study is a narrative review based on articles published in the last 10 years. The results show that black garlic extract can inhibit the growth of C. Albicans with a significant inhibition zone diameter at certain concentrations. In addition, black garlic has higher antioxidant activity than fresh garlic, making it a safe and effective alternative in the treatment of fungal infections, especially in the context of increasing antifungal resistance. This study recommends the formulation of black garlic in the form of a gel preparation as a safer and more effective preparation for applications in pharmaceutical preparations.

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INTRODUCTION

Candida albicans is a species of the genus Candida known as the most pathogenic yeast. Candida albicans is an endogenous organism found in the normal human body in approximately 40-80% of cases (Nur, 2023),(Agustina, Andiarna, Hidayati, & Kartika, 2021). The fungus C. albicans can be found in the mouth, intestines, and vagina. Under certain circumstances, this fungus acts as a pathogenic organism. Changes in cellular immunity (normal flora) can cause C. albicans infection in humans. This fungus causes opportunistic infections in immunocompromised individualsc(Manurung, 2024),(SIHOTANG, 2024). C. albicans is influenced by two factors: endogenous and exogenous. Endogenous factors include physiological changes in the body, such as pregnancy, obesity, age, and immunological disorders. Exogenous factors include tropical climates, high humidity, occupation, personal hygiene, and contact with people infected with C. albicans (Sapitri, 2023). Infections caused by C. albicans are superficial mucosal infections and systemic disorders that have a high mortality rate (Rajab, 2022),(Teriyani, Inabuy, & Ramona, 2022).

Several types of diseases caused by infection by the fungus C. albicans, for example vulvaginitis (Maulana, Marsono, & Rezky, 2023), candida in the urine, nail infections, skin lesions, gastric ulcers, and cancer complications. Antibiotics are used as antifungals in the treatment of C. albicans. Commonly used antifungal antibiotics include ketoconazole, fluconazole, itraconazole, griseofulvin, and nystatin.(Agustina et al., 2021),(Novia Adiningsih, 2025). The use of antifungals has increased in line with the increasing number of infections caused by C. albicans, thus giving rise to resistance (Makhfirah, Fatimatuzzahra, Mardina, & Hakim, 2020),(Santoso, Utari, & Marpaung, 2020). Antifungal resistance results in the body becoming immune to fungal infections, where the active compounds in the drug are less effective at killing the fungus. This occurs because the antifungal is not used at the recommended dosage (Mala, 2020),(MANALU, 2024). Stated that 44% of respondents purchased antibiotics without a prescription because it was cheaper than going to a doctor, which would cost more. Other reasons included knowing which antibiotic to use and the ease of obtaining antibiotics (Dewi & Juliadi, 2021),(Djawaria, Setiabudi, & Setiawan, 2017). Administering antibiotics without a proper diagnosis can lead to resistance. Fluconazole resistance has been reported in C. albicans. Long-term and repeated use in AIDS patients has led to the emergence of fluconazole-resistant strains of C. albicans (Virginia, Iskandar, Tasya, & Utami, 2025),(Agustina et al., 2021).

Flavonoids are well-known antioxidants with antibacterial and antifungal effects. The antifungal activity of flavonoid compounds involves hydroxyl groups that combine with phospholipids in fungal cell membranes, damaging them, inhibiting cell growth, increasing membrane permeability, and denaturing fungal cell (Father Suteja, Maulana, & Pratama, 2025). Furthermore, the mechanism of action of tannin compounds as antifungals is by inhibiting the biosynthesis of ergosterol, the main sterol that makes up fungal cell membranes. Sterols are thought to play a role in increasing the permeability of fungal cell membranes (Sanjaya, Rialita, & Mahyarudin, 2021). Meanwhile, saponin compounds as antifungals work by forming complexes with sterols which are enzymes that make up the fungal cell wall so that permeability increases and fungal cells die (Septiadi et al., 2013). Research conducted by (Mikaili et al., 2013) stated that organosulfur compounds, namely alliciin in garlic, have antifungal activity against C. albicans. Organosulfur compounds can damage the formation of lipid compounds in the plasma membrane, thereby disrupting the stability of the C. albicans fungal membrane. Garlic juice with a concentration of 50% produces an inhibition zone against C. albicans fungi of 13.57 mm, so it is classified as active as an antimicrobial (Kartika, 2019).

Antibiotic resistance to C. albicans requires special attention. The use of bioactive compounds in natural products offers an alternative for use as antifungals (Maryuananda, 2026),(Triasih, 2022). Natural ingredients, for example, include plants that are high in antioxidants, which have antibacterial and antifungal properties. One such plant is black garlic. Black garlic is garlic that has been heated at a specific temperature and time to produce black garlic (Hidayati, Andiarna, & Agustina, 2020),(Pramitha & Sundari, 2020). Black garlic extract has been shown to have a dramatically increased antioxidant activity potential, up to 25 times greater than that of fresh garlic. This is demonstrated by the presence of active compounds in black garlic extract, such as tannins, saponins, sterols, flavonoids, and organosulfur. These active compounds have antifungal activity (SALSABILA, 2021).

Garlic (Allium sativum Linn.) is a natural remedy for anti-inflammatory, antibacterial and antioxidant properties (Prasonto, Riyanti, & Gartika, 2017). The main ingredient in garlic is allicin (S-allyl-cysteine sulphoxide). This antibacterial activity works by inhibiting the synthesis of DNA, RNA, and proteins, which are essential for bacterial growth. However, garlic extract has a pungent odor and a burning sensation on the skin, making it uncomfortable to apply directly. Therefore, garlic preparations are needed without altering the ingredients, such as Black Garlic (Marfitania, Hidayani, Chiuman, Fachrial, & Marbun, 2024).

RESEARCH METHOD

The method used in this narrative review is based on published original research articles. It was conducted in December 2024 using PubMed and Google Scholar. The search used a combination of keywords: Candida albicans and Black gargic. Exclusion criteria included that most of the literature search results were over 10 years old, and the articles were incomplete and irrelevant to fungi.

RESULTS AND DISCUSSIONS

The active compounds in black garlic extract that can inhibit the growth of Candida Albicans fungus are Allicin and S-Allyl Cystein (SAC) compounds (Farhana, 2018), secondary metabolite compounds such as saponins, phenols, tannins (Kulsum, 2014). Allicin and S-Allyl Cystein compounds can damage the tissue of a microbe such as bacteria and fungi. Allicin and S-Allyl Cystein compounds have a thiosulfinate functional group (R-SOS-R). The presence of electrophilic compounds in the thiosulfate group can destroy the fat content in the cell wall membrane and DNA of bacteria or fungi more easily (Gao et al., 2013). The content of black garlic extract compounds that also act as antifungals is diallyldiulfide or ajoene. Diallyldiulfide can inhibit fat synthesis in fungi and affect the formation of RNA to produce other forms. Diallyldiulfide compounds can damage the permeability of cell walls by breaking the chain of SH groups (sulfuhydryl and disulfide) that are needed. The formation of an inhibition zone or clear zone around the well that has been given black garlic ethanol extract is caused by the killing of test bacteria. This proves that black garlic ethanol extract has active compounds that have antibacterial activity against Candida albicans The active compound responsible for this antibacterial activity is the allicin compound. The allicin compound is formed from the hydrolysis of allin which comes from the enzymatic reaction of the non-volatile amino acid γ-glutamyl cationic which is able to bind food sources from the bacteria so that it will inhibit nutrients (food) from entering the cell. S-alk (en) Li-L-cysteine and SAC as precursor compounds of transpeptidase (γ-GTP) and γ-glutamyl-peptidase through oxidation reactions. So the higher the precursor compounds contained in black garlic, the higher the levels of allin compounds and their derivatives. However, γ-GTP and γ-glutamyl-peptidase are thermolabile enzymes, so that when black garlic undergoes thermal processing of more than 75oC for 30 minutes, the enzyme stabilization will change to inactive.

Allin then undergoes hydrolysis to produce allicin and allyl sulfide compounds. This hydrolysis process involves the enzyme allicinase, which is activated when it interacts with water. Therefore, the water content in black garlic is crucial for the hydrolysis of allin. Furthermore, heating above 60°C can inhibit allinase activity, rendering it inactive due to its volatile nature.

One of the mechanisms in black garlic is quorum sensing (QS), a process of intercellular communication that allows microorganisms to respond to environmental changes and coordinate collective behavior. In the context of fungi, QS plays a crucial role in regulating virulence, biofilm formation, and resistance to treatment. By inhibiting QS, there is the potential to reduce the ability of fungi to adapt and survive adverse conditions, including exposure to antifungal drugs.

Black garlic has long been known for its antimicrobial and therapeutic properties. The active compounds in garlic, particularly allicin, have the ability to inhibit the growth of various pathogens, including fungi. It not only inhibits fungal growth but also prevents biofilm formation, a key mechanism of resistance. The following are several journal articles demonstrating the effectiveness of black garlic against fungi.

Table 1. The following are several journal articles demonstrating the effectiveness of black garlic against fungi

Writer	Title	Research design	Method	Results
(Indraswari, Setyowati, &	(Effectiveness of Garlic (Allium	With the laboratory experimental method	With 36 samples divided into 3 research groups,	Black garlic extract showed inhibitory activity against

Writer	Title	Research design	Method	Results
Hamzah, 2023,	sativum) and Black garlic Extract in Suppressing Growth of C. albicans)-	with the post test only control group design research design,	effectiveness testing was conducted using the disc diffusion method, where garlic and black garlic extracts were diluted and tested on Sabouraud Dextrose Agar (SDA) media inoculated with C. albicans. The inhibition zone was measured to determine the inhibitory power of each extract concentration.	Candida albicans growth at 75% and 100% concentrations. At 75% concentration, the average inhibition zone diameter was 6.36 mm, and at 100% concentration, the average inhibition zone diameter was 9.80 mm. The positive control (nystatin) showed an inhibition zone of 11.37 mm, while the negative control and concentrations of 25% and 50% showed no inhibition zone (0.00 mm).
Nikmaratus, 2020	Inhibition zone test of garlic juice on the growth of Malassezia fungus causing tinea versicolor in vitro	This descriptive research design uses a laboratory observation approach. This study aims to identify the inhibition zone of garlic (Allium sativum L.) juice.	Antifungal activity examination using the Disc diffusion method (Kirby-Bauer test) with swab cultures at different concentrations (5%, 10%, 15%, and 20%) as well as positive and negative controls.	This study concluded that garlic juice was effective in inhibiting the growth of Malassezia furfur fungus at concentrations of 15% and 20%, while at concentrations of 5% and 10% it did not show any inhibitory effect.
Eva.A 2021	Antifungal activity test of black garlic extract against the growth of Candida albicans fungus	This research was experimental, with researchers conducting a series of experiments to test the effectiveness of black garlic extract on the growth of C. albicans. The study involved extract preparation, antifungal activity testing, and analysis of the results.	• Diffusion Method: Paper discs soaked with black garlic extract are placed on the media inoculated with the fungus. The clear zone formed is measured to determine the antifungal activity. •Dilution Method: Black garlic extract was diluted to determine the Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) by observing the growth of fungi on the media.	The study also identified that the content of secondary metabolite compounds in black garlic, such as saponins, phenolics, tannins, flavonoids, and essential oils, contribute to antifungal activity by damaging fungal cell walls and disrupting the protein synthesis process.
Hyun-Joo Jang, 2018	Antioxidant and antimicrobial activities of fresh garlic and aged garlic by-products extracted with different solvents	This is a laboratory experimental study designed to evaluate the antioxidant and antimicrobial activities of fresh garlic (non-aged garlic, NG) and aged garlic (AG).	Antimicrobial Activity Testing: Using the disk diffusion test method against various bacteria, including Staphylococcus aureus, Escherichia coli, Salmonella enteritidis, Bacillus cereus, and Listeria monocytogenes.	Total Phenol and Flavonoid Content: Aged garlic (AG) extract with distilled water had the highest total phenol (147.58 mg GAE/g) and flavonoid (338.04 mg QE/g) content compared to fresh garlic (non-aged garlic (NG) extract. The phenol and flavonoid contents of the AG extract were higher than those of NG, indicating an increase during the aging process.

The mechanism between complex compounds and bacteria is through the chelation theory, where when metal ions are chelated with ligands, the polarity of the metal ions will decrease due to the overlap of various ligand orbitals and contribute some of the positive charge of the metal ions to the donor group so that its lipophilicity increases and the complex can penetrate or enter the bacterial membrane.

CONCLUSION

Black garlic (Allium sativum Linn.) extract has potential as an alternative antifungal treatment for Candida albicans infections. The active compounds in black garlic, such as tannins, flavonoids, saponins, and organosulfur, are known to inhibit the growth of C. albicans through damage to fungal cell membranes and disruption of protein synthesis. Compared with fresh garlic, black garlic has up to 25 times higher antioxidant activity.

In pharmaceutical applications, black garlic can be formulated as a gel. Gel preparations are considered superior to ointments or creams because they are easy to use, provide a cooling sensation, do not leave a strong odor, and are stable under various conditions. Research has shown that black garlic extract at certain concentrations can create a zone of inhibition against the growth of C. albicans, although its effectiveness is still slightly below that of positive controls such as nystatin. The use of black garlic as an antifungal offers a safe and potential alternative solution to overcome antifungal resistance that often occurs due to inappropriate antibiotic use.

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