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Anti-acne Mushrooms: A Review

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ABSTRACT

Acne is a common chronic inflammatory skin disease in which the skin pores are clogged with oil and dead skin cells. One of the factors that influence the appearance of acne is the colonization of acne-causing bacteria. Mushrooms are now offered as an alternative and complementary therapy for acne. This review aimed to evaluate natural sources of fungal origin for preventing and treating acne caused by bacteria. This review presents the application of several mushrooms in the management of acne. Electronic databases such as Web of Science, PubMed, Scopus, and Google Scholar were reviewed to identify the anti-acne effects of mushrooms. Based on the results of a literature review, it was proven that the methanol extract and hexane extract of the fungus *Auricularia auricula* Judei showed activity against *Staphylococcus aureus* bacteria at a concentration of 100 mg/mL with inhibition zones of 25.3 mm and 22 mm respectively with an Minimum Inhibitory Concentration (MIC) of 3.125 µg/mL and 6.25 µg/mL. Methanol extract and hexane extract of the fungus *Auricularia polytricha* showed activity against *Staphylococcus aureus* bacteria at a concentration of 100 mg/mL with inhibition zones of 28.6 mm and 25.3 mm respectively with the same MIC value of 0.78 µg/mL. Shiitake mushroom ethanol extract showed activity against *Propionibacterium acnes* bacteria at a concentration of 25 mg/mL with zone of inhibition of 13.4 mm. while n hexane and ethyl acetate extracts had MIC values of 256 µg/mL against *Propionibacterium acnes*, *Staphylococcus aureus* and *Staphylococcus epidermidis*. *Agaricus bisporus* methanol extract showed activity against *Bacillus subtilis* bacteria at a concentration of 200 µg/mL with an inhibition zone of 19 mm. In conclusion, mushroom can be used to manage acne caused by bacteria.

Keywords: Acne, *Lentinula edodes*, Auricularia, *Agaricus bisporus*, *Propionibacterium acnes*

INTRODUCTION

Acne is a skin condition characterized by chronic inflammation skin condition of the pilosebaceous follicles that often develops (Tan & Bhate, 2015; Vasam et al., 2023). As a result, the skin pores are blocked by oil and dead skin cells, causing small blackheads to large spots filled with pus to appear on the face, neck, chest, back, shoulders and in the pilosebaceous area (hair follicles). roots, and sebaceous glands (Claire & Lake, 2018; Xu & Li, 2019).

The symptoms of acne can range from mild to severe in teenagers and young adults (Goodarzi et al., 2020). According to the American Academy of Dermatology Association (AAD), acne affects a lot of teenagers and young adults, but it can also happen to anyone at any age. In fact, 85% of people experience acne between 12 and 25 years old. Still, it can now occur before age 12 due to earlier childhood puberty (Gollnick & Dreno, 2015). 15% to 20% of all acne cases are severe. Acne makes up 0.29% of all skin illnesses, or 1.79% of the worldwide disease burden, according to statistics from the 2013 Worldwide Burden of Disease research. Dermatitis is the most prevalent dermatological illness, with acne coming in second. Numerous factors affect the development of acne, including gender, genetics, oily hair, environmental hygiene, lifestyle, androgen hormones, inflammation, stress, disruption of the skin's surface microflora, increased sebum production, hyper-cornified sebaceous ducts, bacterial colonization, and keratocyte cell hyperproliferation (Mottin & Suyenaga, 2018; Patel, 2015).

This causes hyperkeratosis to build up, become blocked, and the linoleic acid carried by the sebum turns into blackheads. As a result, acne can develop from these comedones (Moradi et al., 2015). Acne often appears on the face, scalp, neck, chest, upper back and upper arms. When pores are blocked by sebum and dead skin cells due to inadequate skin washing, acne-causing bacteria can multiply excessively, resulting in inflammatory acne. These bacteria secrete enzymes that break down sebum and cause skin irritation (Reddy & Jain, 2019). Because *Propionibacterium acnes (P. acne)* has been identified as the primary cause of the development of acne vulgaris, the presence of normal skin flora bacteria, including *P. acnes*, granulosum, *S. epidermidis*, and *Staphylococcus aureus*, may worsen acne. Propionic acid is a byproduct of the metabolism of these anaerobic gram-positive bacteria (Lambrechts et al., 2018). *Propionibacterium acnes* is produced with the help of a cell-oil mixture and thrives in blocked follicles, thereby increasing leukocyte attack and causing skin inflammation (Reddy & Jain, 2019).

Anti-acne drugs have been used in medicine for more than 40 years. Various topical and oral medications are available in the market such as Clindamycin, Salicylic acid, Isotretinoin, Erythromycin, Triclosan, Tetracycline, Minocycline, and Metronidazole for the treatment of acne. However, excessive use of this drug over a long period of time can cause increased bacterial resistance. These medicines have limitations in terms of toxicity and also side effects like dry skin, headache, nausea etc. To overcome these limitations, it is necessary to develop anti-acne drugs that are effective, safe and cheap. In addition, the use of antibiotics on skin microorganisms is less effective because many acne medicines are distributed online and come from unknown sources. Exploration of herbal resources can provide valuable clues that can be further developed as anti-acne drugs. It has been reported that natural ingredients derived from plants are used for various types of acne treatment. This has prompted the search for herbal alternatives to conventional acne treatments, including edible mushrooms, which offer anti-acne-causing properties (Gollnick & Dreno, 2015).

The primary nutrients in edible mushrooms include carbohydrates, proteins, and minerals (Ca, Na, K, and Mg), depending on the species, age, and production methods. Mannan, glucan, pectin, chitin, and cellulose are the most common polysaccharides that can be digested and create carbohydrates (Kadnikova et al., 2015). Shitake mushrooms contain several amino acids, including eritadenine, extracted from lentils or lentinan (Amin et al., 2022). Lentinan has also been studied as an effective anti-microbial. Ethyl acetate and n-hexane fractions has antibacterial activity against *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Propionibacterium acnes* (Sukmawati et al., 2018). Extracts and fractions of *Auricularia auricula* has antibacterial activity against *Staphylococcus aureus*. Ethyl acetate fraction of *Auricularia auricula* can change the morphology of *Staphylococcus aureus* bacteria where the cells become round and tapered and there are visible indications of cell shrinkage and damage (Sukmawati et al., 2019). Agaricus bisporus has antimicrobial activity against *Bacillus subtilis* with an MIC = 5 μg/mL which is lower than standard ampicillin (MIC = 12.5 μg/mL) (Mukul et al., 2014).

The specific role of mushrooms in acne treatment, highlighting their bioactive compounds, such as polysaccharides, terpenoids, and phenolic compounds, which may address key mechanisms involved in acne pathogenesis. Furthermore, we have emphasized the novelty of exploring edible mushrooms as a natural and less-explored alternative treatment for acne, pointing out gaps in current research, particularly the lack of clinical studies and the limited understanding of their exact mechanisms in skin care. Edible mushrooms have high potential to be used as anti-acne herbal products. This study was prepared to support the development of herbal compounds to study natural solutions for the prevention and treatment of acne from edible mushrooms namely *Agaricus bisporus, Lentinula edodes, Auricularia auricula* Judei and *Auricularia polytricha*.

METHODS

Search Strategy

Review article was prepared by conducting a study of literature published up to 2024. The literature used consists of scientific articles, research journals and books at both national and international levels. A literature review was carried out by searching for articles using the keywords "antiacne", "acne", "antibacterial", “edible mushrooms,” “acne treatment,” "*Propionibacterium acnes*", "*Agaricus bisporus*", "*Lentinula edodes*", "*Auricularia auricula* Judei", "*Auricularia polytricha*", "Microbes Skin” at Google Scholar, ScienceDirect, Springer, MDPI, PubMed, and Researchgate. Next, all articles collected were filtered through their titles and abstracts.

Study Selection

The search results obtained 156 pieces of literature which were then selected to obtain 74. There is limited literature on mushrooms as anti-acne, both in the form of preclinical reports (*in vivo* and *in vitro*) and clinical ones. Selected research discusses acne, characteristics of acne, causes of acne, microbes that cause acne, acne treatment, compounds contained in fungi, and antibacterial fungi against bacteria that cause acne. The selection process is based on search keywords in the title or abstract. The stages of selecting appropriate articles are first seen from the title, abstract and content analysis, specifically books from the table of contents.

Inclusion Criteria

The inclusion criteria used in this study were experimental research or clinical trials, and randomized study. Articles used in this research is a writing in Indonesian and in English that discusses acne, characteristics of acne, causes of acne, microbes that cause acne, acne treatment, bioactive compounds from *Agaricus bisporus, Lentinula edodes, Auricularia auricula* Judei and *Auricularia polytricha* as antibacterials against acne-causing bacteria. Search conducted by how to scan the title and abstract articles and then filter them according to inclusion, exceptions, and eligibility criteria. Relevance of each article is determined by reading each article in full for each article. All articles used were retrieved via Mendeley Reference Manager.

Exclusion Criteria

This systematic review meets the following Exclusion criteria: literature review, conferences articles, theses, dissertations, and cases, and reports that are not relevant to the topic.

Cause of Acne

Numerous factors affect the development of acne, including gender, genetics, oily hair, environmental hygiene, lifestyle, androgen hormones, inflammation, stress, disruption of the skin's surface microflora, increased sebum production, hyper-cornified sebaceous ducts, bacterial colonization, and keratocyte cell hyperproliferation (Mottin & Suyenaga, 2018; Patel, 2015).

Although this disease does not pose a direct threat to life or health and has a low mortality rate, it is a serious health problem because it can have a physical and psychological impact on a person's quality of life (Lambrechts et al., 2018). Facial skin is one of the most important organs that directly influences self-confidence, which can cause obstacles in social communication. It appears to be a simple skin disease that is unpleasant because it impacts appearance in human social contacts (Aydemir, 2014). To prevent acne, maintaining healthy and clean skin is very important. Long-term acne problems can cause psychological and psychiatric illnesses such as insomnia, anxiety disorders due to anger, restrictions on activities and lifestyle, and depression (Annissa & Ekamawanti, 2017; Solmaz Asnaashari, 2023).

Each hair follicle in the skin is associated with a sebaceous gland that secretes an oily substance known as "sebum." One of the key elements that contributes to the development of acne lesions is increased sebum production (Reddy & Jain, 2019). Increased oil production by the skin's sebaceous glands is the precursor to the mechanism for the appearance of acne. Increased levels of androgen hormones in teenagers and young adults can cause the sebaceous glands to produce excessive amounts of sebum which can clog pores and cause acne. The pilosebaceous duct allows the sebum produced to escape and reach the surface of the skin. Sebum provides linoleic acid to keratinocytes in hair follicles as it moves through the pilosebaceous duct. Free fatty acids are formed when acne-causing substances are stimulated, and these free fatty acids then cause the release of inflammatory cytokines such as Interleukin-8 (IL-8), Interleukin-6 (IL-6), Interleukin-1 (IL-1), and Tumor Necrosis Factor-alpha (TNF-α), which cause inflammation and an increase in keratinocytes activity (Lee et al., 2019).

This causes hyperkeratosis to build up, become blocked, and the linoleic acid carried by the sebum turns into blackheads. As a result, acne can develop from these comedones (Baboo Prasad, 2016; Moradi, et al., 2015). Acne often appears on the face, scalp, neck, chest, upper back and upper arms. When pores are blocked by sebum and dead skin cells due to inadequate skin washing, acne-causing bacteria can multiply excessively, resulting in inflammatory acne. These bacteria secrete enzymes that break down sebum and cause skin irritation (Reddy & Jain, 2019). Because *Propionibacterium acnes* has been identified as the primary cause of the development of acne vulgaris, the presence of normal skin flora bacteria, including *Propionibacterium acnes*, granulosum, *Staphylococcus epidermidis*, and *Staphylococcus aureus*, may worsen acne. Propionic acid is a byproduct of the metabolism of these anaerobic gram-positive bacteria (Lambrechts et al., 2018). *Propionibacterium acnes* is produced with the help of a cell-oil mixture and thrives in blocked follicles, thereby increasing leukocyte attack and causing skin inflammation (Reddy & Jain, 2019).

The sebaceous glands grow and produce more sebum due to increased androgen levels in both sexes, especially during adolescence. In both men and women, acne has an impact on puberty. Stimulation of the cells lining the follicular ducts by testosterone and expansion of the sebaceous glands, which increases sebum production, are both factors in keratin formation. A family history of acne or genetic factors may also contribute to acne. Environmental factors that cause acne include UV radiation, heat, humidity, and air pollution, all of which can harm skin health. However, these factors do not affect everyone, and different combinations of elements may affect others.

Acne Vulgaris Types and Their Causes

Acne is classified as follows: comedonal acne (Wong et al., 2024), mild or moderate papulopustular acne, severe papulopustular acne, moderate nodular acne, and nodular-cystic acne (or acne that tends to leave scars) (López-Estebaranz et al., 2017). A characteristic acne lesion is seborrhea, which is red, scaly skin with increased sebum oil secretion. Blackheads are pores where a mixture of sebum and keratin blocks the opening. An overgrowth of bacteria and inflammation of the pilosebaceous unit cause acne. Whiteheads are caused by irritated sebaceous glands that have blocked pores filled with their secretions. Different kinds of bacteria can enter if there is an opening pore. Pustules are tiny, pus-filled skin lesions that develop around hair follicles from a combination of leukocytes, bacteria, and dead skin cells. Due to the tissue reaction to acne, papules are inflammatory lesions on the skin that are tiny and solid and can occur in clusters. Nodules are extremely painful, solid lesions brought on by pimples and are a severe form of acne. These wounds frequently cause tissue damage by penetrating deeper layers of the skin. It is extremely painful to remove and causes scars. Macules, caused by acne lesions, are red areas of skin on the face. Cysts are skin lesions that resemble capsules in structure and contain semi-liquid or liquid pus. They are larger than pustules and are more likely to recur, whereas pimples penetrate the skin deeper and leave scars. The most awful form of acne is likely nodulocystic (Reddy & Jain, 2019).

Acne can be brought on by environmental factors such as high humidity, prolonged sweating, increased skin hydration, contact with evaporating cooking oil, dirt, or chemicals, use of certain medications (such as Rifampin, Phenytoin, Isoniazid, Phenobarbital, and Lithium), psychological factors (such as increased stress), infections (such as *Propionibacterium acnes* bacterial species), and diet (such as consumption of dairy products) parasitic mites (Demodex) and genetic factors such as polymorphism in tumor necrosis factor (TNF)-α, toll-like receptor genes (TLRs), interleukin-1α (IL-1α) and CYP1A1 are related to acne susceptibility (Solmaz Asnaashari, 2023).

Acne Is Caused by Skin Microbes

Skin microorganisms, which impact sebum secretion, comedone formation, and inflammatory reactions, are among the many variables that contribute to the development of acne (Xu & Li, 2019). The eukaryotic members of the skin microbiome (mycobiome) are mostly yeasts of the genus Malassezia (Ianiri et al., 2025). Overall, the four main phyla on the skin are Firmicutes, Bacteroidetes, Actinobacteria, and Proteobacteria (Woo & Kim, 2024). The bacteria form colonies on the skin that range in size per cm2 from 3.7104 to 1.2106. Skin health and disease are influenced by the balance of the skin microbiome and its interactions with the host (Xu & Li, 2019). The propionibacteria microbiota, staphylococcus, corynebacteria, and Gram-negative bacteria that colonize sebaceous regions, whether the skin is moist or dry, are recognized as one of the causes of acne (Lee et al., 2019)

Propionibacterium acnes and Acne

Propionibacterium acnes was initially identified by Unna in 1896, and Sabouraud later isolated it from acne lesions in 1897, which raised questions regarding its potential role in the pathogenesis of acne. Because it resembled Corynibacteria in morphology, *Propionibacterium acnes* was initially known as *Bacillus acnes* before being renamed *Corynibacterium acnes*. Due to the synthesis of propionic acid, the name was once again changed to *P. acne* in the 1940s. When separate phylogenetic groups were discovered in 2015 using multi-locus sequence typing (MLST) and whole genome sequencing, the three major bacterial kinds were divided into three subspecies designated as *P. acnes subsp. Acne*, *Propionibacterium acnes* sub sp. Defender, and *Propionibacterium acnes* subsp. (McDowell A, 2016). Despite being known as Propionibacterium dermal, a new genus Cutibacterium, was proposed in 2016 (Scholz & Kilian, 2016). As a result, *Propionibacterium acnes* was renamed *Cutibacterium acnes*. According to Alexeyev et al. (2018) and Xu & Li (2019), acne is still used in the field to distinguish between Cutibacterium and Corynebacterium. About 90% of the microbiome's *Propionibacterium acnes* population is concentrated in the pilosebaceous region. The skin on the scalp and face had the highest concentration of *Propionibacterium acnes* (105-106/cm2), followed by the skin on the upper limbs and trunk, while the skin on the lower limbs had the lowest concentration (102/cm2). Age affects *Propionibacterium acnes* colonies' height as well. Before puberty, it is most lacking in a child's skin, but it steadily rises with age from adolescence to adulthood until declining in people over 50 (Alexeyev et al., 2018); (Xu & Li, 2019).

The pathogenesis mechanism of *Propionibacterium acnes* is increased sebaceous gland activity, comedo formation, and host inflammation. *Propionibacterium acnes* can increase sebum secretion in the pilosebaceous, where the number of colonies correlates with the lipid composition of the skin. *Propionibacterium acnes* uses the secreted sebum as a substrate for metabolism to promote growth. *Propionibacterium acnes* further increases sebum secretion by increasing diacylglycerol acyltransferase activity and exacerbating pre-existing androgen-related seborrhea. Encourages the development of comedones, where *Propionibacterium acnes* degrades triglycerides and free fatty acids generated by the sebaceous glands. Porphyrins are catalytic lytic agents for the oxidation of squalene, the primary component of sebum, and are secreted by *Propionibacterium acnes*. Free fatty acids and oxidized squalene aid comedogenesis. The preservation of hyperproliferative keratinocytes and corneal cells in the follicular canal leads to the formation of blackheads. Studies have demonstrated that *Propionibacterium acnes* activates the insulin-like growth factor 1 (IGF)/IGF 1 (receptor signaling pathway) pathway to regulate the expression of filaggrin and form biofilms to promote keratin cell adhesion. Integrin levels 3, 6s, and V6 rise due to the regulation of filaggrin expression, which impacts keratinocyte proliferation and differentiation during p-forming. *Propionibacterium acnes* can cause inflammation by binding to Toll-like receptors (TLR) 2 and 4 on the surface of keratinocytes. This causes monocytes and other cells to produce the cytokines and polypeptides IL-1, IL-1, IL-6, IL-8, IL-12, Tumor Necrosis Factor (TNF), interferon, chemoattractant factor, defensins, and other cytokines. Along with increasing vascular permeability and involving chemotactic leukocytes in the inflammatory response, *Propionibacterium acnes* also activates the classical and alternative complement pathways to generate C3a and C5a. Furthermore, *Propionibacterium acnes* stimulates sebocytes and promotes the conversion of T cells into T helper (Th) 17 cells by secreting transform-growth factors β, IL-1β, and IL-6. *Propionibacterium acnes* can also activate the NLRP3 inflammasome to induce the release of IL-1β, IL-8, and TNF-α from sebocytes (Li et al., 2014).

In addition to directly harming hair follicles, sebaceous glands, and the dermal extracellular matrix, *Propionibacterium acnes* also causes certain cells to create matrix metalloproteinases. This further exacerbates inflammation. Although its contribution to the pathogenesis of acne has not yet been established, *Propionibacterium acnes* is thought to be crucial for maintaining healthy skin because it releases free fatty acids through the hydrolysis of triglycerides, which helps to keep the pH of the skin low and prevents the colonization of harmful bacteria like *Staphylococcus aureus* and Streptococcus.

This classification is useful in understanding the relationship between *Propionibacterium acnes* strains present in acne and those present in healthy skin. Strains from clades IA 2 (especially RT4 and RT5), IB 1 (RT8), and IC (RT5) are strongly associated with acne. Type II strains, including RT2 and RT6, are present on healthy skin without acne.

Strains from clades IA 1, IB 2, and IB 3 have been found in healthy and acne-prone skin conditions. Type III strains are rarely found on the skin of the face but are abundant on the back and have been associated with the skin condition progressive macular pro hypomelanosis (Barnard & Li, 2017), (Barnard & Li, 2017); (Petersen et al., 2017).

Recent research on *Propionibacterium acnes* and the skin microbiota sheds new light on the diverse roles that *Propionibacterium acnes* plays in keeping clear skin and in the development of acne. According to Fitz Gibbon et al.'s research, some *Propionibacterium acnes* strains are usually found in healthy people, whereas others are in acne patients (Fitz-Gibbon et al., 2013). Porphyrins are a class of proinflammatory chemicals that generate inflammation in keratinocytes and worsen tissue damage by creating reactive oxygen species, as demonstrated by Johnson et al., who found that acne-causing strains produce more of these molecules (Johnson, 2016).

How to Treat Acne

The variety of acne treatment options available today reflects the condition's complex nature. Topical medications like benzoyl peroxide and retinoids are used as treatments, as are systemic medications like hormones and antibiotics (Kim & Kim, 2024).

Three main topical retinoid medications are used: tretinoin (available as a cream, gel, or gel microsphere in concentrations of 0.025-0.1%), adapalene (as a 0.1% cream, gel, or lotion, and a 0.3% gel), and tazarotene (as a 0.05% or 0.1% cream, gel, or foam formulation) (Althwanay et al., 2024). Physical treatments have also been used to treat acne in the past forty years, including comedone extraction, chemical peels, microdermabrasion, intralesional corticosteroid injections for acne cysts, photodynamic therapy, laser therapy, and injectable fillers (Aydemir, 2014; (Zaenglein et al., 2016). Macrolides, clindamycin, and tetracyclines are the most frequently given antibiotics for treating acne. However, using synthetic medications often has unfavorable side effects and leads to increased antibiotic resistance in clinical settings (Patel, 2015).

According to Chinese guidelines for the management of acne vulgaris, 2019. Consisting of topical, systemic treatment, physical and chemical modalities, as well as a new treatment in China, namely Traditional Chinese Medicine (TCM). Traditional Chinese Medicine (TCM) therapy for acne consists of: TCM wet compress: A concoction consisting of purslane, violaeherba, and goldencypress, TCM mask: Mask powder (rhubarb powder and sulfur) mixed with water or honey to form a paste and acupuncture (Ju et al., 2019).

Maintenance therapy reduces and prevents acne recurrence and improves quality of life. Concern is growing over antibiotic resistance among *Propionibacterium acnes* and other skin bacteria. Topical retinoids, combination therapy (topical retinoids + combination therapy, topical antibiotics + combination therapy, topical retinoids + topical antibiotics + combination therapy), and topical retinoids + topical antibiotics + combination therapy are recommended treatments for mild to moderate acne, respectively (Adler et al., 2017) (Adler et al., 2017). The first-line treatment for moderate to severe acne is advised to be a mix of oral antibiotics with combination therapy or topical retinoids (Nast et al., 2016). Oral antibiotic monotherapy is not recommended. For female patients, oral contraceptives or anti-androgens can be an alternative to antibiotics to improve clinical efficacy and reduce antibiotic resistance; avoid macrolides or clindamycin if previously exposed to enhance clinical effectiveness and reduce antibiotic resistance.

Given that a strain of *Propionibacterium acnes* that is resistant to antibiotics was shown to be present in some acne patients. To prevent the prolonged use of ineffective antibiotics, Sinnott et al. advise swabbing, culturing, and testing for resistant bacteria (Bienenfeld et al., 2017; Sinnott et al., 2016). According to Cherno et al. (2017), oral antibiotic treatment for acne should last at least 6 to 8 weeks and no longer than 12 weeks. According to the study, 17.5% of antibiotic treatment programs lasted less than six months, while 7% lasted longer than nine months, with an average treatment period of 125–129 days (Li et al., 2014); Straight et al., 2015).

Antibiotic use over an extended period can dramatically alter the skin's microbiota and increase drug resistance. Psychological anxiety and severe nodular acne are treated with oral isotretinoin. Women of childbearing age should use isotretinoin with extreme caution as it is a teratogen (Reddy & Jain, 2019). Synthetic medication use frequently causes negative effects and raises antibiotic resistance in clinical settings. Additionally, there is a lack of effectiveness in using antibiotics on skin microorganisms due to the extensive distribution of acne drugs offered online and coming from sources that have yet to be discovered. All of the above methods of treating acne vulgaris are beneficial, but there are several problems, including drug resistance and side effects and the high costs associated with some treatments which have led to a tendency to use low-risk methods to prevent and treat many diseases, herbal therapy seems to be the best method. is well tolerated and the results of this treatment have been accepted for a long time, but data regarding its safety and efficacy are limited. agents for use in acne (Shadab et al., 2018; Asnaashari, 2023). This encourages the search for herbal alternatives to conventional acne treatment. The aim of this review is to assess natural remedies for the prevention and treatment of acne.Since ancient times, herbal therapy has been used for the treatment of acne, which includes various herbal extracts, oils and ayurvedic formulations. The introduction of new herbal formulations for the treatment of acne can produce many advantages compared to previous therapies. This herbal medicine is effective against various Gram-positive and Gram-negative bacteria. Sunder Vati, which is an ayurvedic formulation, has been proven to be effective orally and is well tolerated for the treatment of acne vulgaris. Tablet and cream formulations that contain many herbal extracts and have egligible side effects compared to modern treatments, are usually indicated for moderate and severe forms of acne (Shadab et al., 2018).

Figure 1. *Auricularia auricula* judei (A) *Auricularia polytrica* (B), *Agaricus bisporus (C), Lentinus edodes (D)*

One herb that has not been widely studied but has potential as an anti-acne agent is edible mushrooms. Mushrooms have been used as food and medicine since ancient times, especially in China. Its potential as an antimicrobial has also been proven in various studies. However, there are no studies that explain the potential of mushrooms that focus on treating acne-causing bacteria (Xu & Li, 2019). This review's objective is to assess all-natural remedies for acne prevention and treatment.

Mushrooms

Humans have consumed and used mushrooms for food and medicinal purposes for ages. Macroscopic, fibrous fruiting structures known as mushrooms are found growing above the ground. Because fungi are thought to be the ancestors of all plants, studying them, or mycology, is a branch of botany. Despite occasionally being referred to as vegetables, fungi belong to a different kingdom than plants because of their distinct cellular structure. A particular nutritional profile applies to mushrooms. The following are the main distinctions between fungi, plants, and animals: 1. Chlorophyll-containing plants employ photosynthesis to produce their nourishment. 2. Animals consume food. 3. Chlorophyll-free mushrooms can be grown commercially and found in nature in decomposers and on various substrates (Feeney et al., 2014).

Mushrooms are distributed worldwide, with approximately 14,000 species worldwide. Approximately 350 species of mushrooms are consumed worldwide (Niego et al., 2021a)

Ascomycetes and basidiomycetes are the two main categories of edible mushrooms

Infectious infections are among the top causes of death globally, and their incidence is rising quickly. Anti-microbial medications can be difficult because of the overuse of antibiotics, the emergence of adverse effects, the difficulty in discovering new medicines, and, most importantly, the issue of rising resistance. A serious worry for human health, animal productivity, and environmental health is antibiotic resistance, which has increased due to the excessive and inappropriate use of antibiotics in recent years. On the other hand, no medicine on the market can match the pace of infectious illness therapy. The fast rise of microorganisms resistant to antibiotics and the rising mortality from contagious diseases necessitate the development of new anti-microbial medications (Eliuz, 2021).

Similar to the rise in antibiotic resistance in the clinical practice of treating acne (Patel, 2015), not to mention the widespread use of acne medications that are sold online and originate from unidentified sources, it's critical to find herbal alternatives to conventional acne treatments, one of which is edible mushrooms, which have activity against the causes of acne (Xu & Li, 2019). Additionally, there is an urgent demand for novel anti-bacterial chemicals due to the global rise of multi-resistant bacterial strains. Strong anti-bacterial substances are thought to be derived from fungi due to the natural living conditions of fungi (life cycle based on the breakdown of dead organic materials) and the necessity to protect against pathogenic organisms in their environment. As seen by the rising demand for fungus medications, there is a renewed interest in traditional medicine.

The primary nutrients in edible mushrooms include carbohydrates, proteins, and minerals (Ca, Na, K, and Mg), depending on the species, age, and production methods. Mannan, glucan, pectin, chitin, and cellulose are the most common polysaccharides that can be digested and create carbohydrates (Kadnikova et al., 2015).

Auricularia auricula **Judai** ***and Auricularia polytricha.***

Auricularia mushrooms, sometimes referred to as jelly ear mushrooms or wood ear mushrooms, are a class of fungi that produce fruiting bodies that resemble jelly. The shape of the Auricularia fruit body is like an ear and is brown or black in color, making it easy to recognize (Asanka R. Bandara, 2019). Tropical, subtropical, and temperate areas are home to nearly all Auricularia species. They rank as the fourth most significant genus of mushrooms and have been harvested, grown, and extensively consumed for centuries in numerous nations, including China, Thailand, Korea, Vietnam, Japan, and New Zealand. For more than a millennium, Chinese people have used the fruit bodies of Auricularia as food and medicinal remedies. More than 90% of the world's Auricularia production comes from China, the world's largest producer. The two most widely grown species are *Auricularia polytricha* and *Auricularia auricula* Judai, which are found in Heilongjiang, Jilin, Shanxi, Zhejiang, Yunnan, and Guangxi provinces in China (Miao et al., 2020). Particularly, recent years have seen the emergence of scientific evidence supporting the possible use of AAJ in medicines, cosmetics, and functional foods (Liu et al., 2021).

The macrofungi *Auricularia auricula* Judai (AAJ) and *Auricularia polytricha* (AP) are members of the Auriculariaceae family and Basidiomycota class (Chiu et al., 2014). The public in European and American societies is familiar with *Agaricus bisporus*, but more about AAJ, a unique variety of mushrooms, is needed. It is particularly well-liked and frequently used in Asia as a component of drugs, fermented foods, noodles, antibiotic oxidants, and other products. Recent research has demonstrated the tremendous therapeutic potential of AAJ. Nutritional science advancements have shown that AAJ has great nutritional value for enhancing human health. In the medical and culinary realms, nutraceuticals including dietary fiber, polysaccharide with monosaccharides composed of glucose (72%), mannose (8%), xylose (10%), and fucose (10%) and containing a pyranose ring) (Zhao et al., 2023), glucan (Kumar et al., 2021), essential amino acid, sodium, potassium phosporus, magnesium, calcium, iron, zink, and selenium (Noreen et al., 2025). Studies have been done on polysaccharides' bioactivity, structural characterization, and isolation. AAJ is currently thought to have potential uses as a novel antioxidant in the food sector. One of the key active components of AAJ was extracted and named the polysaccharide AAJ in earlier investigations. AAJ polysaccharides were found to have antioxidant action both in vitro and in vivo. AAJ is processed into a variety of high-quality goods that are in demand on the market, and it also contains high-quality protein, melanin, dietary fiber, polyphenols, and trace elements (Liu et al., 2021).

To exist in their natural habitat, fungi play a significant role in anti-bacterial and antifungal activity. Anti-microbial substances can thus be extracted from various fungus species for human use. Macrofungi create a lot of metabolites that include anti-bacterial (Sanico & Vicencio, 2019), antifungal, antiviral (Niego et al., 2021b), anticancer (Zhan et al., 2024), hypoglycemic, hypoallergenic, immune-modulating (Kong et al., 2020), anti-inflammatory, hypolipidemic, hepatoprotective (Liu et al., 2022). In this review study, we have compiled the most recent research on the anti-acne-causing properties of *Auricularia auricula*, and *Auricularia polytricha* (Xiang et al., 2021).

The test samples for the ethyl acetate fraction and the n-hexane fraction have the best Minimum Inhibitory Concentration (MIC) values for the bacteria *P. acnes, S. epidermidis, and S.*

aureus, both of which have inhibition of the growth of these bacteria at a concentration of 256 ppm, according to the findings of Sukmawati's research (Sukmawati et al., 2018).

Lentinus edodes

Another fungus frequently consumed is the shitake mushroom (*Lentinus edodes*), a wood mushroom known as Shii-Take in Japan, Shiang-gu in China, and Chinese black mushroom or black forest mushroom on the worldwide market. Shiitake mushrooms are typically used as a culinary ingredient. Shiitake mushrooms are now produced in the third-largest quantities worldwide, behind oysters (Pleurotus) and champignons (Agaricus), thanks to their presence and flavor. Polysaccharides, proteins, fibers, vitamins, minerals, dietary fiber, trace elements, ergosterol, and other nutritious and bioactive ingredients are all present in Lentinus edodes (Zheng et al., 2025). Modern phytochemistry studies have demonstrated that L. edodes is very rich in bioactive polysaccharides, especially the β-glucans (Sheng et al., 2021). Of the eight essential amino acids known to exist, shiitake includes 18 types, 7 of which are essential amino acids. Additionally, this mushroom has been reported to have around 30 different types of enzymes. Originally known as lentisin or lentinasin, one of the distinctive amino acids was later isolated and given the name Eritadenine (Amin et al., 2022).

Bioactive compounds from *Lentinula edodes* can reduce the risk of hypertension, hypercholesterolemia, diabetes mellitus cancer (Nam et al., 2021)and antibacterial(Hirasawa et al., 1999)*L. edodes* extract was proven to inhibit the six bacterial strains tested, namely Staphylococci (*S. aureus* and MRSA), and *Pseudomonas aeruginosa (Pabasara et al., 2025)*.

Eritadenine is found in shiitake fruit bodies at 400-700 mg/kg dry matter, according to research. Enman discovered erytadenine levels of 3.2–3.6 mg/g in the dried form of shiitake in 2007, indicating the relevance of the mushroom as a bioactive agent. In previous research, the amount of erytadenine detected in the fruiting bodies of shiitake mushrooms was higher in the pile caps (0.5-0.7 mg/g) than in the stems (0.3-0.4 mg/g) (Amin et al., 2022). Additionally, *Mycobacterium Tuberculosis* and *L. monocytogenes* have been successfully inhibited by lentinan, a potent anti-microbial drug. Shiitake metabolites generated during growing in subsurface culture for 1-3 weeks demonstrated a considerable ability to inhibit *E. coli*, *B. subtilis*, and *S. aureus* in anti-bacterial testing. A concentrated filtrate of *L. edodes* with a concentration of 1 g/mL can prevent the development of *S. aureus*, *B. subtilis*, and *E. coli* with inhibition zones of 9.55 mm, 10.05 mm, and 9.1 mm, respectively. While this was happening, Aryantha (1998) found that the ammonium sulfate component of 30–60% from the subsurface growth medium inhibited *S. aureus* as large as 9 mm in diameter. As demonstrated by the creation of an inhibitory zone with a diameter of 15 mm in prior investigations, the hot water extract of A. auricula exhibited anti-bacterial activity against S. aureus at a concentration of 100 g/mL. An instance where the antibiotic farnesyl hydroquinones (Ganomycin A and B) derived from Ganoderma pfeifferi were discovered to suppress the growth of methicillin-resistant *S. aureus* is used to support this theory (Mothana et al., 2000). This review's primary objective is to improve on earlier evaluations to determine whether fungi have anti-bacterial activity against the most dangerous infectious diseases.

Lentinan has also been studied as an effective anti-microbial agent to inhibit *Mycobacterium tuberculosis* and Listeria monocytogenes. As an anti-viral agent, Lentinan is reported to be able to inhibit the replication of adenovirus type 12, Abelson virus and VSV-encephalitis virus. A protein compound with a BM of 27.5 KD has been reported to have anti-fungal (Amin et al., 2022). In this review study, we have also collected the latest research on the anti-acne properties of fungi, including *Lentinula edodes* (Xiang et al., 2021).

Agaricus bisporus

Agaricus bisporus is the mushroom with the highest global production yield (Kexin Zhang, 2018). One of the mushrooms used as an antibacterial is the button mushroom (*Agaricus bisporus*). This mushroom is one of the traditional medicines and is one of the oldest mushrooms in the world. In western society, button mushrooms are often consumed by adding them to food. Consuming these mushrooms is beneficial for health because button mushrooms contain many good nutrients, rich in vitamins, carbohydrates, protein and fat (Ramos et al., 2019; Usman et al., 2021).

Button mushrooms have various benefits, including anticancer, antidepresan, antidiabetic, antimicrobial (Al-Dbass et al., 2022) antioxidant (Senthilkumar et al., 2016), hemostatic (Öztaş et al.,

2024) hepatoprotective, antiobesity (Yuan et al., 2023) anti-inflammatory, antitumor, anticholinesterase (Öztürk et al., 2011) and body immunity (Muszyńska et al., 2017). Thin Layer Chromatography (TLC) has been used for the phytochemical screens and chemical compound analysis of *Agaricus bisporus* n-hexan, ethyl acetat, and ethanol extracts. Terraced maceration was used for the extraction procedure, and thin-layer chromatography was used to identify the bioactive ingredient. According to the results of the Thin Layer Chromatography test, n-hexane extract contains steroid, flavonoid, coumarin, and therpenoid. Therpenoid, coumarine, and flavonoid are present in ethyl acetate extract. Flavonoids, alkaloids, polyphenols, coumarins, and terpenoid are all present in ethanol extract (Jeong et al., 2010; Suhaenah & Nuryanti, 2017).

DISCUSION

The edible mushrooms possess a variety of bioactive compounds that contribute to their pharmacological activity (Table I). *Auricularia auricula*-judae contains alkaloids, tannins, flavonoids, phenols, proteins, and β-glucan polysaccharides, which have been reported to possess antibacterial, antioxidant, antifungal, antiviral, and immunomodulatory effects (Sukmawati, 2018; Singh, 2008; Oli, 2020). Similarly, *Auricularia polytricha* exhibits potent antimicrobial, antioxidant, and immunomodulatory activities, primarily due to the presence of tannins, glycosides, steroids, and exo-biopolymers (Bandara, 2019; Sanico & Vicencio, 2019). Furthermore, *Lentinula edodes* is rich in β-D-glucan, lentinan, and heteroglucan proteins, which have been associated with antitumor, antiviral, antifungal, antimicrobial, and immunomodulatory effects (Amin et al., 2022; Bisen et al., 2010). Meanwhile, *Agaricus bisporus* is known for its proteins, carbohydrates, fiber, alkaloids, and phenolic compounds, which primarily contribute to its antibacterial properties (Ramos et al., 2019). Collectively, these findings highlight that edible mushrooms are an important source of pharmacologically active constituents with broad-spectrum therapeutic potential.

Antibacterial activity of *Auricularia auricula* Judei, *Auricularia polytricha*, *Lentinus edodes* and *Agaricus bisporus* (Table II, III, IV and V). Research results show that all mushrooms have antiacne activity.

The anti-acne activity of *Auricularia auricula* Judei can be seen from inhibiting the growth of *Staphylococcus aureus* and *Propionibacterium acne* as bacteria that cause acne, although testing against *Propionibacterium acnes* still limited (Table II).

Chitosan is an organic polymer and linear polysaccharide that is sold commercially. It is made of D-7-glucosamine and N-acetyl-D-glucosamine and treats various illnesses, such as obesity and hypercholesterolemia. The deacetylation level of chitosan from species of the genus Auricularia is higher than that of the commercially accessible forms, according to current research. The significant deacetylation capability of Auricularia chitosan was demonstrated to restrict the development of *E coli* and *S aureus*, further demonstrating the antibacterial potential of Auricularia polysaccharides (Chang et al., 2019). Chitosan, which has a low molecular weight and a positive charge, can be combined with *Auricularia auricula* Judei polysaccharides to create special polyelectrolyte complex nanoparticles that have a protein drug delivery system that can deliver activity (Xiong et al., 2016).

Auricula-judae's crude polysaccharides were recovered using hot water extraction, alcohol precipitation, and testing for antibacterial effects. The antimicrobial efficacy of the fungus was demonstrated by inhibiting *Staphylococcus aureus* activity with polysaccharides made from *Auricularia auricula* Judei, (Cai, 2015).

Antiacne activity was assessed with well agar diffusion method. Screening for antibacterials activities in which methanol extract and hexane extract showed higher antimicrobial activity against S. aureus. compared to other extracts. Methanol extract *Staphylococcus aureus* indicating a larger zone of inhibition 25.3 mm followed by hexane extract with an inhibition zone of 22 mm against *Staphylococcus aureus* (Singh & Tripathi, 2018)

Auricularia polytrica has good antibacterial action due to its polyphenols, melanin, and polysaccharides (Liu et al., 2021). The mushroom extract was further examined for its antibacterial activity against gram-positive *S. aureus* strains using the Kirby-Bauer disc diffusion method. It showed moderate inhibition (10–15 mm) (Wong et al., 2013). The *Auricularia polytrica* ethanol extract has antibacterial action, with the smallest inhibition zone measured against *Staphylococcus aureus* measuring 9.6 0.8 mm (Avci et al., 2016). Using well-diffusion techniques, researchers have looked into how well *Auricularia polytircha* silver nanoparticles kill a number of pathogenic species.

Table I. Compounds and Pharmacological Activities *Auricularia auricula* Judei and *Auricularia polyticha*

Mushroom Name	Bioactive Components	Therapy Effect	Reference
Auricularia auricula Judei	Alkaloid, Tanin Steroid	Antibacterial	(Sukmawati., 2018)
	Flavonoids	Antioxidant,Antivirus, antiinflammatory	(Singh., 2008)
	Protein	Imunomodulator, Antivirus, Antifungal, Antibacterial	(Oli., 2020)
	Polisakarida β-glucan	Imunomodulator	(Nwachukwu & zoeto., 2010)
	Phenols	Antioxidant Antibacterial	
	β-karoten	Antioxidant Antibacterial	(Singh & Tripathi., 2018a).
	lycopene	Antioxidant Antibacterial	
	Asam askorbat	Antioxidant Antibacterial	(Singh & Tripathi., 2018a).
	Adenosine	Antiplatelet	(Bandara., 2019)
	Exo-biopolymers Proteins	Antihyperlipidemia	
Auricularia polyticha	Tannins, Glycosides	Immunomodulatory	(Sanico & Vicencio., 2019; S. Singh & Tripathi, 2018b)
	Steroids	Antibacterial	
Lentinula edodes	Lentinan (β-D-glucans), KS-2-α-mannan-peptide, LEM,LAP (heteroglucan-protein), EP3	Antitumor	(Amin et al., 2022)
	Lentinamicin	Antimicrobial	(Bisen et al., 2010)
	Lentinan, LEM, JLS-18, EP3, EPS4	Antivirus	
	Mannoglucan, polysaccharide protein complex, glucan, Lentinan, polysaccharide L-II, (1-3)-β-D-glucan.	Immunomodulation	(Amin et al., 2022; Bisen et al., 2010)
	LEM, Lenthionine, chloroform and ethylacetate extracts	Antibacterial	
	Lentin	Antifungal	
	Eritadenine, lentinacin, lentysine	Cardiovascular, Hypolipidemic	(Amin et al., 2022)
	Lentinan, LEM, hot-water extraction and ethanol extraction	Hepatoprotective	(Amin et al., 2022; Bisen et al., 2010)
	Lectin	Hemaglutination	
Agaricus bisporus	Protein (alanine, aspartic acid, glutamic acid, arginine, leucine, lysine, phenylalanine, serine, proline, tyrosine, and threonine	Antibacterial	(Ramos et al., 2019)
	Carbohydrate and Fiber	Antibacterial	
	Alkaloid	Antibacterial	
	Fenol dan Polifenol	Antibacterial	

Note: MIC: Minimum Inhibitory Concentration; - absent.

Table II. Antiacne activity from *Auricularia auricula* Judei

Extraction methode	Extraction solvents	Activity Test Method	Bacteria	Results			References
				Concentration	Inhibition Zone Diameter (mm)/(mm±SD)	MIC	
Tris buffer extraction	Tris buffer protein extract	Agar well method	*S. aureus*	-	10.66	5	(Oli., 2020)
Warm aqueous extraction	Warm aqueous protein extract	Agar well method	*S. aureus*	-	10.66	5	(Oli., 2020)
Boild	Water extract (wild strain)	Agar well method	*S. aureus*	-	5.5	-	(Abikoye., 2019)
	Water extract the mutant	Agar well method	*S. aureus*	2 µg /mL	5.0	-	(Abikoye., 2019)
	Synthesized silver nanoparticles +wild strain (EW1)	Agar well method	*S. aureus*	2 µg /mL	7.0	-	(Abikoye,. 2019)
	Synthesized silver nanoparticles + the mutant (EW1M1)	Agar well method	*S. aureus*	2 µg /mL	8.5	-	(Abikoye., 2019)
Maseration	Methanol Extract	Agar well method	*S. aureus*	100 mg/mL	25.3	3.125	(Singh et al., 2008)
	Hexane extracts		*S. aureus*	100 mg/mL	22	6.25	(Singh & Tripathi, 2018)
Destilasi	Ethyl acetate	Paper disc technique	*S. aureus*	-	10	-	(Sanico & Vicencio, 2019)
Maserasi ultrasonik	85% ethanol	Difusi cakram	*P.acnes*	25 mg/mL	6.3	-	(Jia et al., 2022)
Extracted with hot water for 4 hours at 90 oC. And re-extracted using NaOH 1M (alkali solvent)	Water soluble of crude polysaccharides	Disc diffusion method	*S. aureus (mm)*	100 mg/mL 50 mg/mL 25 mg/mL	7.07 7.03 6.90		(Elfirta.,2020)
	Alkali soluble of crude polysaccharidesrude polysaccharides		*S. aureus (mm)*	100 mg/mL 50 mg/mL 25 mg/mL	9.18 7.75 6.93		
Fraction	n-hexane fraction	Microdilution	*S. aureus*	-	-	128 µg/mL	(Sukmawati., 2019)
	Ethyl acetate fraction,	Microdilution	*S. aureus*	-	-	64 µg/mL	
	Methanol water fraction,	Microdilution	*S. aureus*	-	-	2048 µg/mL	

Note: MIC: Minimum Inhibitory Concentration; - absent.

Table III. Antiacne activity from *Auricularia polytricha*able II. Antiacne activity from *Auricularia auricula* Judei

Extraction method	Extraction solvents	Activity Test Method	Bacteria	Results			References
				Concentration	Inhibition Zone Diameter (mm)/ (mm±SD)	MIC	
Maceration	Chloroform extract (mg/mL)	Microdilusi	*S. aureus* (ATCC 25923)	-	-	2.00±0.0 mg/mL	(Gebreyohannes et al., 2019)
	70% Ethanol Extract (mg/mL)		*S. aureus* (ATCC 25923)	-	-	1.00±0.0 mg/mL	(Avci et al., 2016)
	HWE: hot water extract (mg/mL)		MRSA (ATCC 33591)	-	-	0.83±0.29 mg/mL	
Soxhlet	Ethanol extract	Disc Diffusion	*S. aureus*	1.5 mg/mL	9.6	-	(Gebreyohannes et al., 2019)
	Water extract			-	Not determinate	-	
Maseration	Ethanol	Agar well method		-	7.42	-	(Singh & Tripathi, 2018b)
	Methanol Extract			100 mg/mL	28.6	0.78	
	Hexane extracts			100 mg/mL	25.3	0.78	

Table IV. Antiacne activity from *Lentinula edodes*

Extraction Method	Solvent Extraction /Fraction	Activity Test Method	Test Bacteria	Results			References
				Concentration	Inhibition Zone Diameter (mm)/(mm±SD)	MIC	
Ultrasonic maceration	85% ethanol		*P. acnes*	25 mg/mL	13.4	-	(Jia., 2022)
Maceration	95% ethanol and 1;20 ethyl acetate	Disc diffusion	*S. epidermidis* ATCC12228	100 mg/mL	15.33	0.5	(Jia.,2022; Tan & Bhate., 2015)
			P.acnes DMST14916		12.67	0.5	
Maceration 24 hours	Ethanol	Microdilution	*S. aureus*	100-400	21.3%	-	(Tamrakar., 2017)
			P. acnes	1 g/mL	21%	-	
Maceration	Ethanol 96%	Microdilution	*P. acnes*	-	-	>512	(Sukmawati,, 2018)
Liquid-liquid extraction	Water Methanol		*S. epidermidis*	-	-	>512	
			S. aureus	-	-	>512	
	Ethyl acetate		*P. acnes*	-	-	256	
	N Hexane	Mikrodilusi	*S. epidermidis*	-	-	256	
			S. aureus	-	-	256	

Note: MIC: Minimum Inhibitory Concentration; - absent.

Table V. Antiacne activity from *Agaricus bisporus*

Extraction Method	Solvent Extraction /Fraction	Activity Test Method	Test Bacteria	Results			References
				Concentration	Inhibition Zone Diameter (mm)/ (mm±SD)	MIC	
Maceration	Methanol extracts	Disc diffusion	*B. subtilis*	200 µg/mL	19	-	(Öztürk., 2011)
			B.s subtilis	-	-	5µg/mL	(Atila, 2017)
	Aqueous extract	Dilution	*S.aureus*	50 g/mL	16	-	(Tambekar, 2006)
			S. epidermidis	100 g/mL	16	-	
Aceration	Ethanol extracts	Disc diffusion		0.4 mg/mL	8.4		(Eliuz, 2021)

The synthesized silver nanoparticles showed more antibacterial activity than the mushroom extract. This demonstrates that tested human diseases can be treated with silver nanoparticles as an antibacterial agent. In contrast to the control, all of the microorganisms utilized in the study developed zones of inhibition, demonstrating the efficacy of AgNPs as a treatment. Mushroom extract from the mutant strain exhibited greater antibacterial activity than the natural variety (Abikoye, 2019)

Agar-well diffusion was used to measure antimicrobial activity. One way to fight *Staphylococcus aureus* germs is to screen antibiotic activity. The antibacterial activity of methanol extract was stronger against all pathogenic strains than hexane extract when both extracts were tested side by side. The methanol extract of *Auricularia polyticha* had a larger zone of inhibition (28.6 ± 0.47 µM) against *Staphylococcus aureus*. With an MIC of 0.78 mg/ml, *Auricularia polytricha* hexane extract shows antibacterial activity against *Staphylococcus aureus* (Singh & Tripathi, 2018b). Because *Staphylococcus aureus* is more resistant to the antibacterial effects of *Auricularia polytrica* (Mont) extract, it can be used as an alternative natural treatment for acne caused by bacteria (Sanico & Vicencio, 2019).

Staphylococcus aureus responded to the tris-buffered protein extract. With a DIZ of 3.66 ± 0.53 mm, warm water extract was the most efficient against *E. coli* and *S. aureus*. Although the protein extract produced a larger inhibitory zone diameter against the examined pathogens than the antibiotics ciprofloxacin and fluconazole, this difference was not statistically significant (p-value> 0.05). For all pathogens, including S. aureus, the protein MIC of *Auricularia polytrica* extract was equal to 5 g/mL. 2020 (Oli et al., 2020).

More than any other antibacterial, the chloroform, ethanol, and hot water extracts of the Auricularia species showed the ability to kill *Staphylococcus aureus*. The MBC activity against *Staphylococcus aureus* (ATCC 25923) produced by the hot water extract of Auricularia was the highest. *Staphylococcus aureus* (ATCC 25923) fungal antimicrobial activity statistics have dramatically changed in response to chloroform extract. The bottom line is that extracts from Auricularia spp. are typically efficient against *Staphylococcus aureus* (gram-positive bacteria) (Gebreyohannes et al., 2019).

According to Tamrakar's research from 2017, the fungus *Lentinula edodes* inhibited *S. aureus* by 21.3% and *P. acne* by 21%. (2017) Tamrakar et al. Xiao Jia's research findings (2022) showed that *Lentinus edodes* had a 13.4 mm suppression of *P. acnes*. (Sukmawati et al., 2018; Tamrakar et al., 2017).

Then, to determine the significance of the Minimum Kill Concentration (MKC), samples that demonstrate the ability to kill bacteria are the n-hexane fraction with a concentration of 512 ppm against *Staphylococcus aureus* bacteria and the ethyl acetate fraction with a concentration of 512 ppm against *Staphylococcus aureus* and *Staphylococcus epidermidis*. This is evident from taking samples of the outcomes of the minimum inhibition. Additionally, contact bioautography testing was done on the test sample to qualitatively identify the sample and determine whether any chemicals might have antibacterial activity. Contact bioautography was the technique utilized for bioautography. One spot with an Rf value of 0.56

was found during this monitoring, and it was demonstrated that this spot inhibited the development of the test bacteria.

Based on the phytochemical screening results, the areas that can stop the growth of these bacteria are thought to have antibacterial alkaloids, flavonoids, steroids, triterpenoids, and tannins from the shiitake mushroom group. Using a Scanning Electron Microscope (SEM), researchers found that when *Propionibacterium acnes* was exposed to the ethyl acetate fraction at a concentration of 256 ppm, the shape of its bacterial cells changed. This was shown by the presence of incomplete and damaged bacterial cells, bacterial cell walls that were shrunken, and lumps on the bacterial cell wall. The substances found in the ethyl acetate fraction, such as alkaloids, flavonoids, steroids, triterpenoids, and tannins, which have antibacterial activity, are likely to be the cause of *Propionibacterium acnes* morphological alterations (Sukmawati et al., 2018).

Antimicrobial effects of methanol extract of *Agaricus bisporus* tested against *Bacillus subtilis*, an inhibition zone of 19 mm was obtained with an MIC of 5μg/mL. For testing *Agaricus bisporus* water extract against *Staphylococcus aureus* and *Staphylococcus epidermidis* at concentrations of 50 g/mL and 100 g/mL, an inhibition zone of 16 mm was obtained. The test results of 0.4 mg/mL ethanol extract showed inhibitory power with an inhibition zone of 8.4 mm.

One of the main limitations observed in the reviewed studies is the variability of different research methodologies using different extraction techniques, dosages, and testing methods to evaluate the effects of mushroom compounds. These inconsistencies make it difficult to compare results between studies and may lead to differences in reported results, such as differences in zones of inhibition or antimicrobial potency. By discussing these limitations, this review highlights the need for a more standardized approach in future research, larger clinical trials, and consistency in experimental design to validate the effectiveness of edible mushrooms in the treatment of acne.

Possibility of Using Mushrooms to Create Acne Treatments Future Possibilities

Natural remedies made from plant, animal, and mineral sources can be used to cure a variety of human illnesses. If the drug is used for a prolonged period, the acne-causing bacteria will resist it. Herbal medicines are gaining acceptance since they are less toxic and have fewer adverse effects than allopathic ones. Allopathic treatment mainly treats acne's symptoms, such as inflammation, redness, and stain-related stains, but natural systems of medicine concentrate on the complete body and address the core cause of acne (Nasri et al., 2015; (Reddy & Jain, 2019). Herbal remedies are being looked into for treating acne because they have few side effects. Future interest in using herbal treatments to treat various ailments comes. from dermatologists, cosmetologists, researchers, educators, businesspeople, and even teachers. Herbal acne treatments can be applied internally, topically, or both ways. Due to their ease of use and potential for bad taste when taken internally, topical application of herbs is the preferred treatment method. Because they are harmless and beneficial, herbs are frequently employed in cosmetic formulations and anti-acne treatments.

One of the ingredients in mushrooms that has the potential to maintain and improve skin health, including repairing the skin barrier, maintaining skin moisture, modulating the immune system, and maintaining the balance of the microbiome, is being studied for use in cosmetic products. Typically, topical-dose formulations of acne medicines are produced. Products for topical acne therapy on the market include creams, gels, and emulsions (Leksono et al., 2022). Along with beauty science's dynamic and quick growth, researchers are looking for other substances to combine with current ones to create a more potent preparation to address socially necessary health issues, such as treating acne. Studies have demonstrated the effectiveness of natural compounds in treating acne, including shiitake mushrooms (*Lentinus edodes*) and others, against *P. acnes, S. epidermidis*, and *S. aureus*.

The method for processing mushrooms as a topical preparation must be well thought out, considering the product's safety, advantages, and quality. Mushrooms can create topical medicines such as patches, liposomes, creams, emulsions, and lotions containing nanoparticles. Numerous bioactive substances, such as terpenoids, selenium, phenolics, polyphenols, vitamins, polysaccharides, and volatile chemical compounds, are known to be present in mushrooms. Due to their qualities, oil-soluble and water-soluble mushroom extracts are employed in several cosmetic and personal care products. Many cosmetic businesses worldwide include a variety of mushrooms as useful "do-good" components in their compositions. The mushroom extract is used in commercial products with the functional claims of having anti-aging, anti-oxidant, anti-wrinkle, skin-lightening, moisturizing, anti-acne, and anti-dandruff (AD) properties.

CONCLUSION

Based on the results of the literature review above, it can be concluded that mushrooms have good potential as anti-acne by inhibiting the growth of acne-causing bacteria, namely *Staphylococcus aureus*, *Staphylococcus epidermidis, Bacillus subtilis* and *Propionibacterium acnes*. bioactive compounds in mushrooms, such as terpenoids and polysaccharides, may serve as an effective and natural alternative to conventional acne therapy. Methanol extract and hexane extract of the fungus *Auricularia auricula* Judei showed activity against *Staphylococcus aureus* bacteria at a concentration of 100 mg/mL with inhibition zones of 25.3 mm and 22 mm respectively with an MIC of 3.125 µg/mL and 6.25 µg/mL. Methanol extract and hexane extract of the fungus *Auricularia polytricha* showed activity against *Staphylococcus aureus* bacteria at a concentration of 100 mg/mL with inhibition zones of 28.6 mm and 25.3 mm respectively with the same MIC value of 0.78 µg/mL. Shiitake mushroom ethanol extract showed activity against *Propionibacterium acnes* bacteria at a concentration of 25 mg/mL with an average zone of inhibition of 13.4 mm. while n hexane and ethyl acetate extracts had MIC values of 256 µg/mL against *Propionibacterium acnes*, *Staphylococcus aureus* and *Staphylococcus epidermidis*. *Agaricus bisporus* methanol extract showed activity against *Bacillus subtilis* bacteria at a concentration of 200 µg/mL with an inhibition zone of 19 mm. Data on fungal testing results for *Propionibacterium acnes* is still limited, therefore it must be further improved to obtain more comprehensive data. We recommend that future research focus on identifying the types of fungi and dosages that are most effective for the treatment of acne.

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CONFLICT OF INTEREST

"The authors declare no conflict of interest".

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