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ANALYSIS OF BENEFICIAL MICROORGANISMS IN KOMBUCHA AS ANTIMICROBIAL AGENTS AGAINST SKIN DISEASE-CAUSING MICROORGANISMS

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Abstract

Skin infections caused by pathogenic bacteria, such as Propionibacterium acnes and Staphylococcus aureus, remain a significant health concern, highlighting the need for natural antimicrobial alternatives to reduce the risk of antibiotic resistance. This study aimed to analyze the microorganisms present in kombucha and evaluate their antimicrobial potential against skin pathogenic bacteria based on previously published studies. A narrative literature review with a descriptive qualitative approach was conducted by collecting scientific articles from Google Scholar, ScienceDirect, and PubMed. The collected data were integrated and analyzed descriptively to describe the characteristics of kombucha microorganisms and their antimicrobial activity. The findings indicate that kombucha contains a Symbiotic Culture of Bacteria and Yeast (SCOBY), which is predominantly composed of acetic acid bacteria, lactic acid bacteria, and yeasts. During fermentation, these microorganisms produce various bioactive compounds, including acetic acid, gluconic acid, polyphenols, and flavonoids, which contribute to the inhibition of pathogenic bacterial growth. Previous studies also demonstrate that the antimicrobial activity of kombucha increases with longer fermentation periods, as indicated by the formation of inhibition zones against Propionibacterium acnes and Staphylococcus aureus. Based on these findings, kombucha has the potential to be developed as a natural antimicrobial ingredient in topical formulations for preventing bacterial skin infections.

Keyword: *Antimicrobial, Kombucha, Microbiome, Propionibacterium acnes, Staphylococcus aureus.*

Abstrak

Penyakit infeksi kulit yang disebabkan oleh bakteri patogen, seperti Propionibacterium acnes dan Staphylococcus aureus, masih menjadi salah satu masalah kesehatan yang memerlukan alternatif antimikroba alami untuk mengurangi risiko resistensi antibiotik. Penelitian ini bertujuan untuk menganalisis jenis mikroorganisme yang terdapat pada kombucha serta mengkaji potensi aktivitas antimikrobanya terhadap bakteri penyebab penyakit kulit berdasarkan hasil penelitian yang telah dipublikasikan. Metode yang digunakan adalah studi literatur (narrative review) dengan pendekatan kualitatif deskriptif melalui penelusuran artikel ilmiah pada basis data Google Scholar, ScienceDirect, dan PubMed. Data yang diperoleh selanjutnya diintegrasikan dan dianalisis secara deskriptif untuk memperoleh gambaran mengenai karakteristik mikroorganisme kombucha dan aktivitas antimikrobanya. Hasil kajian menunjukkan bahwa kombucha mengandung kultur simbiotik bakteri dan khamir (Symbiotic Culture of Bacteria and Yeast atau SCOBY) yang didominasi oleh bakteri asam

asetat, bakteri asam laktat, dan khamir. Selama proses fermentasi, mikroorganisme tersebut menghasilkan berbagai senyawa bioaktif, seperti asam asetat, asam glukonat, polifenol, dan flavonoid yang berperan dalam menghambat pertumbuhan bakteri patogen. Berbagai penelitian juga menunjukkan bahwa aktivitas antimikroba kombucha meningkat seiring bertambahnya lama fermentasi, yang ditandai dengan terbentuknya zona hambat terhadap Propionibacterium acnes dan Staphylococcus aureus. Berdasarkan hasil kajian tersebut, kombucha berpotensi dikembangkan sebagai bahan alami yang dapat dimanfaatkan sebagai agen antimikroba dalam formulasi sediaan topikal untuk membantu menghambat pertumbuhan bakteri penyebab penyakit kulit.

Kata Kunci: *Antimikroba, Kombucha, Mikrobioma, Propionibacterium acnes, Staphylococcus aureus.*

A. INTRODUCTION

The skin is the outermost organ of the human body and serves as the primary protective barrier against various environmental factors, including physical impacts, chemical substances, and exposure to microorganisms. Despite its protective function, the skin may still develop disorders when the balance of its natural microbiota is disrupted or when it becomes infected by pathogenic bacteria. Several bacteria commonly associated with skin diseases include *Propionibacterium acnes*, which contributes to acne development, and *Staphylococcus aureus*, which causes various skin infections such as boils, impetigo, and wound infections. These infections are commonly treated with topical or systemic antibiotics. However, inappropriate and prolonged antibiotic use may increase the risk of antibiotic resistance; therefore, safer antimicrobial alternatives derived from natural materials are needed (Wungu, 2024).

One natural material that has been widely explored as a potential antimicrobial source is kombucha. Kombucha is a fermented tea beverage produced through the activity of a Symbiotic Culture of Bacteria and Yeast (SCOBY). During fermentation, the microorganisms within SCOBY work synergistically to convert sugars into various bioactive compounds, including acetic acid, gluconic acid, glucuronic acid, as well as increased levels of tea-derived polyphenols and flavonoids (Khamidah et al., 2020; Sari et al., 2026). These compounds are known to exhibit antimicrobial and antioxidant activities that may inhibit the growth of pathogenic bacteria.

Several studies have demonstrated that kombucha can inhibit the growth of various pathogenic bacteria, including *Propionibacterium acnes* and *Staphylococcus aureus*. This activity is influenced by fermentation-derived compounds, particularly organic acids, which reduce the environmental pH and create unfavorable conditions for pathogenic bacterial growth. In addition, polyphenols and flavonoids may contribute by disrupting bacterial cell structures, thereby inhibiting bacterial growth processes (Sreeramulu et al., 2000; Yan et al.,

2023). These findings indicate that kombucha has potential to be developed as a natural ingredient for the prevention and management of bacterial skin diseases.

Although numerous studies have investigated the antimicrobial activity of kombucha, their findings remain dispersed across various publications and have not yet provided a comprehensive overview of the characteristics of kombucha-associated microorganisms and their relationship with antimicrobial activity against skin disease-causing bacteria. Furthermore, studies summarizing the effect of fermentation duration on the ability of kombucha to inhibit the growth of *Propionibacterium acnes* and *Staphylococcus aureus* remain limited. Therefore, a literature review is needed to integrate the available findings and provide more comprehensive information.

Based on these considerations, this study employed a narrative review method to examine previous studies on the microorganisms present in kombucha and their antimicrobial activity against bacteria that cause skin diseases (Hermanto et al., 2025; Joevanda et al., 2024). This study aimed to analyze the characteristics of microorganisms found in kombucha and evaluate its potential antimicrobial activity based on variations in fermentation duration. The findings of this review are expected to provide scientific information and serve as a basis for future research on the development of kombucha as a natural ingredient in topical formulations to help inhibit the growth of bacteria responsible for skin diseases.

B. RESEARCH METHOD

This study employed a literature review method, specifically a narrative review, using a descriptive qualitative approach. The method involved collecting, reviewing, and analyzing various literature sources related to microorganisms in kombucha and their potential as antimicrobial agents against bacteria causing skin diseases. The references included national and international scientific journals, research articles, books, and other scientific publications discussing the kombucha fermentation process, the characteristics of its constituent microorganisms, and its antimicrobial activity.

The literature search was conducted using academic databases, including Google Scholar, ScienceDirect, and PubMed. Selected literature was aligned with the research topic and met the criteria of relevance, source credibility, and consistency with the study objectives. Each article was reviewed to obtain information regarding the types of microorganisms present in kombucha, microbial identification results, antimicrobial activity against skin

disease-causing bacteria, and the effect of fermentation duration on antimicrobial effectiveness.

The collected data were subsequently integrated and analyzed descriptively by comparing findings from various studies. This process aimed to provide a comprehensive overview of the characteristics of microorganisms in kombucha, the mechanisms underlying its antimicrobial activity, and the potential application of kombucha as a natural material for inhibiting the growth of bacteria that cause skin diseases.

C. RESULTS AND DISCUSSION

Kombucha is a fermented tea beverage produced through the activity of a symbiotic culture of bacteria and yeast, commonly referred to as the Symbiotic Culture of Bacteria and Yeast (SCOBY). During fermentation, microorganisms within the SCOBY work synergistically to convert sucrose into various metabolites, including acetic acid, gluconic acid, glucuronic acid, vitamins, enzymes, and other bioactive compounds that contribute to antimicrobial activity. The presence and composition of these microorganisms are key factors determining fermentation quality and the biological capacity of kombucha to inhibit the growth of pathogenic microorganisms.

Various studies have shown that kombucha cultures are predominantly composed of acetic acid bacteria, such as *Acetobacter xylinum*, *Acetobacter aceti*, and *Acetobacter pasteurianus*, as well as lactic acid bacteria, including *Lactobacillus fermentum* and *Lactobacillus acidophilus*. In addition, yeasts such as *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe* have also been identified. These yeasts play a role in converting sugars into ethanol, which is subsequently utilized by acetic acid bacteria to produce various organic acids that contribute to the antimicrobial activity of kombucha.

Figure 1. SCOBY layer formed during the kombucha fermentation process.

Source: Al-Mohammadi et al. (2021).

The presence of SCOBY not only serves as a growth medium for microorganisms but also indicates that the fermentation process is proceeding properly. The interaction between bacteria and yeasts within the SCOBY produces complementary bioactive metabolites, making the antimicrobial activity of kombucha more effective than that produced by a single type of microorganism alone.

After identifying the microorganisms involved in kombucha fermentation, the next step is to observe their colony morphology. Morphological observation is conducted to obtain preliminary information regarding the types of microorganisms that grow before further identification using microbiological methods. Colony characteristics are important indicators because each group of microorganisms exhibits different shapes, sizes, colors, and textures.

Research findings indicate that acetic acid bacterial colonies are generally circular, with smooth surfaces, white to cream coloration, and relatively small sizes. In contrast, yeast colonies tend to be larger, with thicker textures and shiny surfaces. These differences are influenced by the types of microorganisms present and the fermentation conditions used. Observing colony morphology is an initial step that helps distinguish bacterial and yeast groups before microscopic identification is performed.

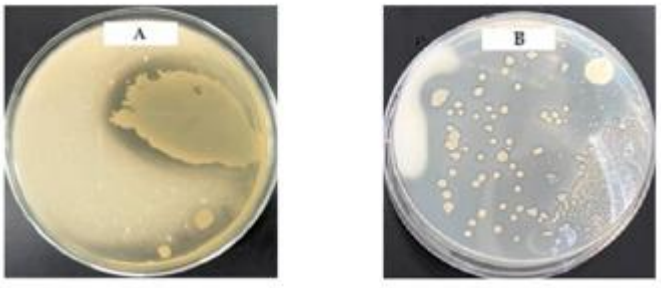

Figure 2. Colony morphology of microorganisms isolated from kombucha culture on agar media.

Source: Al-Mohammadi et al. (2021).

Morphological observations indicate that kombucha cultures exhibit considerable microbial diversity. This diversity supports the establishment of a balanced microbial ecosystem during fermentation, thereby enabling the optimal production of various bioactive metabolites. In addition to the type of starter culture, morphological variation is influenced by fermentation duration, temperature, tea type, and sugar concentration, which serves as a nutrient source for microorganisms.

Colony morphology observation provides preliminary information regarding the characteristics of microorganisms present in kombucha cultures. However, this identification

should be supported by microscopic observation using the Gram staining method to determine bacterial cell wall characteristics and differentiate between Gram-positive and Gram-negative bacteria. This method is widely used in microbiological studies because it provides more specific information about the microorganisms involved during the fermentation process.

Identification results indicate that kombucha-associated microorganisms include rod-shaped Gram-negative bacteria from the acetic acid bacteria group, such as *Acetobacter xylinum*, *Acetobacter pasteurianus*, and *Acetobacter aceti*. In addition, Gram-positive bacteria from the lactic acid bacteria group, including *Lactobacillus fermentum* and *Lactobacillus acidophilus*, have also been identified. Yeasts with oval-shaped cells, such as *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*, were also identified in the same culture and play a role in fermenting sugars into ethanol.

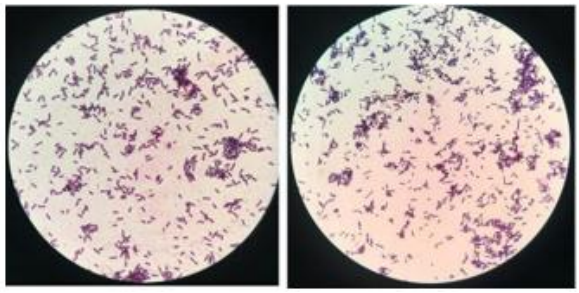

Figure 3. Identification of kombucha microorganisms based on Gram staining.
Source: Al-Mohammadi et al. (2021).

The presence of both Gram-negative and Gram-positive bacteria within the same culture indicates a mutually supportive symbiotic relationship during fermentation. Yeasts produce ethanol and carbon dioxide through sugar fermentation, whereas acetic acid bacteria utilize the ethanol to produce acetic acid and other organic acids. This process decreases the pH of kombucha, thereby inhibiting the growth of various pathogenic microorganisms. In addition to the activity of acetic acid bacteria, the reduction in pH is also supported by the formation of other bioactive metabolites produced during fermentation.

Microbial identification also indicates that successful kombucha fermentation is not determined by a single type of microorganism but rather by the interaction of all microorganisms present in the SCOBY. These mutually beneficial interactions create a stable fermentation environment while enhancing the production of antimicrobial compounds. Therefore, microbial diversity in kombucha cultures is one of the factors influencing

fermentation quality and the effectiveness of its antibacterial activity against skin disease-causing bacteria.

The presence of various microorganisms in kombucha cultures contributes to the production of secondary metabolites with antimicrobial activity. During fermentation, bacteria and yeasts act synergistically to produce various bioactive compounds, including acetic acid, gluconic acid, glucuronic acid, ethanol, flavonoids, polyphenols, and other metabolic products. The combination of these compounds contributes to the ability of kombucha to inhibit the growth of pathogenic bacteria, including bacteria that cause skin diseases.

One of the bacteria most frequently investigated is *Staphylococcus aureus*, as it is responsible for various skin infections, including boils, impetigo, folliculitis, and wound infections. Based on the studies reviewed, fermented kombucha exhibits greater antibacterial activity than unfermented kombucha. This activity is indicated by the formation of inhibition zones around the test medium, demonstrating the ability of kombucha bioactive compounds to suppress bacterial growth.

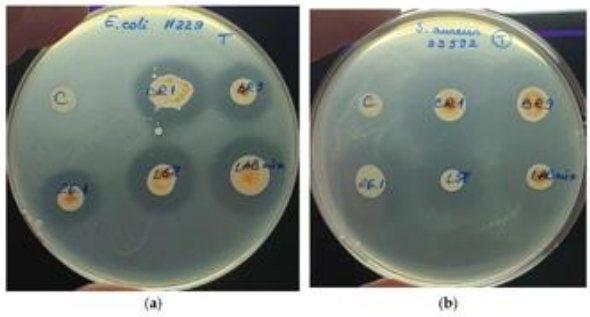

Figure 4. Antibacterial activity of kombucha against *Staphylococcus aureus* using the disk diffusion method.

Source: Muhsinin et al. (2023).

The diameter of the inhibition zone reflects the effectiveness of a material's antibacterial activity. A larger inhibition zone indicates a greater ability of antimicrobial compounds to inhibit bacterial growth. This activity is influenced by several factors, including the type of tea used, fermentation duration, microbial composition of the SCOBY, and the concentration of bioactive compounds produced during fermentation. Kombucha fermented for an optimal duration generally exhibits higher antibacterial activity because it contains greater amounts of organic acids and bioactive metabolites than kombucha that has not undergone complete fermentation.

In addition to inhibiting *Staphylococcus aureus*, several studies have shown that kombucha can inhibit the growth of other pathogenic bacteria, such as *Escherichia coli*, *Salmonella typhimurium*, and *Bacillus cereus*. These findings suggest that kombucha has a relatively broad antimicrobial spectrum and potential for development as a natural ingredient in health and cosmetic applications. Nevertheless, its effectiveness remains influenced by the fermentation process, the type of microbial culture used, and storage conditions after fermentation.

Based on the overall findings of the reviewed studies, kombucha antimicrobial activity is influenced not only by its acidity but also by the synergistic interactions among various fermentation-derived metabolites. Therefore, kombucha has considerable potential as a natural antimicrobial source that may be used to inhibit the growth of bacteria responsible for skin diseases and support the development of health products based on natural ingredients.

D. CONCLUSION

Based on the findings of this literature review, kombucha contains various microorganisms that play important roles during fermentation, particularly acetic acid bacteria, lactic acid bacteria, and yeasts that form the Symbiotic Culture of Bacteria and Yeast (SCOBY). Interactions among these microorganisms produce various bioactive compounds, including acetic acid, gluconic acid, polyphenols, and flavonoids, which contribute to its antimicrobial activity.

The review findings also indicate that kombucha can inhibit the growth of skin disease-causing bacteria, particularly *Staphylococcus aureus*. This antimicrobial activity is influenced by the types of microorganisms present in the culture, fermentation duration, and the concentration of bioactive compounds produced during fermentation. The more optimal the fermentation process, the greater the ability of kombucha to inhibit the growth of pathogenic bacteria.

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