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Literature Review

The Potential of Moringa Oleifera Leaf (Moringa oleifera Lam.) as an Antibacterial: Systematic Literature Review

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ABSTRACT

Background: The most common type of disease encountered is infectious disease. Antimicrobial substances are known as antibiotics. Misuse of antibiotics can lead to a number of negative outcomes, such as worsening of the drug's side effects, microorganisms becoming resistant to antibiotics, and even death.
Methods: Researchers conducted a systematic review that aims to describe the review of the potential of Moringa leaves as antibacterial based on research that has been done. This literature review used six fulltext articles. The literature search technique was carried out on the PubMed and Google Scholar databases.
Results: Moringa leaves contain various metabolite compounds such as flavonoids, alkaloids, saponins and tannins which are effective in inhibiting the growth of Gram-positive and Gram-negative bacteria. Moringa leaves can inhibit the growth of S. aureus, E. coli, P. aeruginosa, B. Subtilis, Proteus vulgaris, S. mutans, Streptococcus mutans, Staphylococcus epidedermis, and Salmonella sp.
Conclusions: Moringa oleifera Lam. is often referred to as the “miracle tree” because all parts of the plant are beneficial for human health. Moringa leaves have antibacterial potential because they contain metabolite compounds that can inhibit bacterial resistance mechanisms, making them highly effective for treating infections.

Keywords : Antibacterial, Moringa leaves, Moringa oleifera Lam

INTRODUCTION

In Indonesia, infectious diseases are the most common type of disease. Based on information from the 2013 Riskesdas National Report, infectious disease transmission is divided into three categories: 1) air, 2) food and drink, and 3) vectors [1]. Diseases classified as infectious diseases are diseases caused by the entry and growth of microorganisms, a category of microscopic creatures consisting of one or more cells, including bacteria, fungi, viruses, and parasites. When the host body is damaged by microbial interactions, this can lead to a variety of symptoms and clinical signs, including infectious diseases. Pathogenic microorganisms, one of which is pathogenic bacteria. Pathogenic microorganisms are microorganisms that infect humans and cause disease [2].

Bacteria that cause infections can belong to Gram-positive or Gram-negative bacteria [3]. Some bacteria that cause infectious diseases are *Staphylococcus aureus, Bacillus cereus, Clostridium perfringens, Clostridium botulinum, Escherichia coli (ETEC, EPEC, EHEC, EAEC, EIEC), Salmonella sp., Shigella sp., Campylobacter sp., Vibrio cholera, Listeria monocytogenes, and Plesiomonas sp* [4]. Skin infections, food poisoning, toxic shock syndrome, tuberculosis, and typhoid fever are some of the human diseases caused by bacteria [3].

Many antimicrobial substances, both cellular and molecular, have long been developed at the organismal level to slow the growth of pathogenic microorganisms. Antibiotics are substances that have antimicrobial properties. Chemicals known as antibiotics are made by bacteria or fungi and have the ability to kill or stop the growth of harmful microorganisms with minimal adverse impact on humans. The class of antibiotics also includes synthetic compounds that have antibacterial properties and derivatives of semi-synthetic materials. When using antibiotics as drugs to treat infectious diseases, rationality, appropriateness, and safety must be done. Overuse of antibiotics can have adverse effects, including increased drug side effects, development of antibiotic resistance in microorganisms, and even death [5].

Moringa oleifera Lam. belongs to the *Moringaceae* family and is a valuable plant found in many tropical and subtropical countries [6]. *Moringa oleifera Lam*. is a nutrient-rich plant and is often called the “miracle tree” because all parts of the *Moringa* plant are very useful for people's lives. The nutritional content is spread over all parts of the *Moringa* plant, starting from the leaves, bark, flowers, fruit (pods) to the roots, and is widely recognized as a medicinal plant [7]. Seed extracts were observed to have protective effects by lowering liver lipid peroxides and being antihypertensive. *M. oleifera* plants from roots, leaves, seeds, fruits, flowers, bark, and young pods are used as heart and circulatory stimulants and contain antipyretic, antiepileptic, antitumor, anti-inflammatory, anti-ulcer, diuretic, antihypertensive, cholesterol-lowering, antidiabet, hepatoprotective, antioxidant, antibacterial and antifungal activities, and are used for the treatment of various diseases in the indigenous system of medicine [6].

Moringa oleifera Lam has been used to

isolate various metabolite compounds. The compounds consist of flavonoids, glucosinolates, terpenes, alkaloids, saponins, sterols, fatty acids, and phenolic compounds, as well as vitamins A, B1, B2, B3, C, and E, and minerals such as calcium and iron. *Moringa* plants are claimed to cure asthma, sore throat, fever, urinary tract infections, and diarrhea. It also improves skin health. *M. oleifera* also has antimicrobial, anti-inflammatory, tissue-protective, anti-cancer, and anti-diabetic properties. *Moringa* seed powder can be used as a biosorbent and antibacterial agent for water purification and can be added to food to inhibit the growth of harmful bacteria [8].

In Indonesia, many studies have been conducted on natural materials. This is related to the content of active ingredients as a result of secondary metabolism in plants that can provide many benefits, one of which is found in *moringa* plants, which are efficacious as anti-cancer, anti-bacterial, hypotensive, inhibitors of bacterial and fungal activity [9]. Based on research by Dima (2016), *M. oleifera* leaf extract has antibacterial properties against *Escherichia coli* and *Staphylococcus aureus* bacteria. Therefore, we conducted a systematic review that aims to describe the review of the potential of *Moringa* leaves as antibacterial based on the research that has been done.

METHOD

This study uses a literature review method that begins with collecting journals to be reviewed. The literature search technique was carried out on the PubMed and Google Scholar databases. The selection of journals in this article review has criteria, namely journals published from 2014 to 2024 and journals that are nationally and internationally accredited. Researchers searched with the keywords "Moringa oleifera leaves as antibacterial OR potential of Moringa oleifera leaves as an antibacterial" and obtained 29,600 journals with these keywords. Journals that have been found are then screened for journals that meet the criteria that are eliminated based on a full review of the journal title, abstract, and discussion results. Then, articles that have been selected in accordance with the criteria, namely discussing in detail about the potential of Moringa leaves as antibacterial. Based on the criteria that have been set, six articles have been reviewed.

RESULTS

A total of six full-text articles were used in this literature review. The studies were conducted in 4 different countries, namely India, Nigeria, Sudan, and northern Ethiopia. The characteristics of each article are described in the following table 1.

Table 1. Results of a literature review on the potential of Moringa Oleifera leaves as antibacterials

Solvents and Methods	Results	References
Using ethanol and distilled water	The ethanol extract of *M. oleifera* leaves used in this experiment showed significant antibacterial activity	Malhotra & Mandal., 2018.

Solvents and Methods	Results	References
solvents. The method used is agar well diffusion	against the test pathogens, supporting the fact that the content of *M. oleifera* contains active phytochemicals with broad-spectrum antibacterial activity, capable of inhibiting the growth of gram-positive and negative bacteria.	
Using ethanol and distilled water solvents. The method used is agar well diffusion.	The study revealed that ethanol extract was the extraction solvent and showed better inhibitory activity against bacterial isolates. Moringa leaf ethanol extract can inhibit *S. aureus, P. aeruginosa, E. coli,* and *Salmonella sp.*	Enerijiofi et al., 2021.
Using petroleum ether and methanol. The method used is agar plate diffusion method.	The findings of this study indicate that the methanol extract of Moringa leaves has potential as an antibacterial compound against pathogens and its ability to block or inhibit bacterial resistance mechanisms and eradication of bacterial strains can thus improve treatment.	Tabidi et al., 2018.
Using methanol solvent. The method used is agar well diffusion.	The antibacterial activity of Moringa extracts against bacterial isolates showed that Moringa leaf ethanol extract (MLE) had the broadest spectrum of activity against the test bacteria. The results showed that MLE has antimicrobial activity against bacteria *P. aeruginosa, P. vulgaris, B. subtilis, S. epidermidis,* and *S. mutans*.	Amabye & Tadesse., 2016.
Using ethanol solvent. The method used is agar well diffusion	The secondary metabolites present in Moringa leaves are responsible for the bacterial inhibition observed in this study (against *S. aureus* and *E. coli*) and may also justify its use as an antimicrobial agent.	Unegbu et al., 2020.
Using methanol solvent. The method used is agar well diffusion.	The results of this study showed that Moringa leaf extract exhibited promising antibacterial activity against all bacterial strains used, including *P. aeruginosa* and *Klebsiella pneumoniae* which are usually highly resistant to most antibacterial agents used.	Kwami et al., 2020.

DISCUSSION

One type of tropical plant that grows in the Indonesian region is the Moringa plant. Parts of the plant that have anti-inflammatory, antifungal, anticancer, antibacterial, and antioxidant properties are parts of the seeds and leaves that are often used as medicine and show antibacterial

properties. This is because the Moringa plant has a high concentration of bioactive compounds [10]. *M. oleifera* leaves are known to have biocompatible and antibacterial properties in tissues because *M. oleifera* leaf extract contains saponins, flavonoids, tannins, alkaloids, phenolics and triterpenoids so it has antibacterial activity [11].

Research by Malhotra and Mandal (2018), has demonstrated that moringa leaves have antibacterial activity against both gram-positive and gram-negative bacteria. The study extracts bioactive compounds from *M. oleifera* leaves using distilled water and ethanol in order to screen for antibacterial activity and detect phytochemical content. Testing was done on the antibacterial activity of *M. oleifera* leaf ethanol extract against *S. aureus* and *E. coli* bacteria. Using the agar well diffusion method, antibacterial tests were performed on *M. oleifera* ethanol extracts at volumes of 50, 100, 150, and 200 µL/well. The findings demonstrated that the ethanol extract of moringa leaves exhibited activity against the two test bacteria, with a maximum inhibition zone of 25 mm against *S. aureus* and 22 mm against *E. coli*. [12].

Based on research by Enerijiofi et al (2021), revealed that moringa leaves are rich in phytochemical compounds and antimicrobial activity. The yield of Moringa leaves extracted with ethanol and water was 40.75% and 62.87% respectively. Using gas chromatography mass spectrometry, eleven compounds were found in both extracts. 6.25 mg/ml is the minimum inhibitory and bactericidal concentration against the ethanol extract test organisms. At 200 mg/ml the ethanol extract showed the highest zone of inhibition, namely 23 ± 0.02 mm for *S. aureus*, 25 ± 0.51 mm for *P. aeruginosa*, 22 ± 0.48 mm for *E. coli*, and 28 ± 0. 34 mm *Salmonella sp*. At 200 mg/ml the water extract showed an inhibition zone of 26 ± 0.01 mm for *S. aureus*, 5 ± 0.11 mm for *P. aeruginosa*, 8 ± 0.25 mm for *E. coli*, and 5 ± 0.14 mm for *Salmonella sp*. [13].

The results of research by Tabidi et al. (2018), showed that most of the extracts had inhibitory effects on bacteria and isolates. Phytochemical screening revealed the presence of flavonoids, sterols, coumarins, tannins, alkaloids, saponins, triterpenes and anthraquinones. The minimum inhibitory concentration (MIC) ranged between 25 mg/ml and 50mg/ml for all organisms. The zone of inhibition obtained in the preliminary screening of moringa leaves antibacterial activity of the petroleum ether extract showed no inhibition on all the bacteria used in the study (*E. coli., P. aeruginosa, Salmonella typhi, B. subtilis,* and *S. aureus*). The methanol extract of the leaves showed effect against all the standard bacterial species at a concentration of 100mg/ml. The highest values were recorded for *E. coli*, *Salmonella typhi*, and *S. aureus*, namely (15.5±0.29 mm), while the values of *P. aeruginosa* (15.0±0.0 mm) and B. subtilis (14.0±0.0 mm). Zone of inhibition of moringa leaf antibacterial activity from methanol extract of 200ml concentration; the highest values were recorded for *P. aeruginosa* (22.5±0.29 mm) and *E. coli* (21.5±0.29 mm), followed by *Salmonella typhi*, *B. subtilis* and *S. aureus* (18.5±0.29 mm); therefore gram-negative bacteria were more affected than positive bacteria [14].

Based on research conducted by Amabye & Tadesse (2016), phytochemical analysis of moringa leaves using water and ethanol solvents. Phytochemical screening on both extracts showed the presence of

flavonoids, tannins, steroids, alkaloids, saponins, and others. The well diffusion method was used to assess the antibacterial effect of the extracts against microorganisms. The outcomes demonstrated that the methanol extract of moringa leaves exhibited antimicrobial activity against five bacterial isolates and a broad spectrum of activity against the test bacteria. *P. vulgaris* (03 nm), *B. subtilis* (04 nm), *S. epidermidis* (03 nm), *P. aeruginosa* (05 nm), and *S. mutans* (06 nm) [15].

Based on research conducted by Unegbu et al. (2020), phytochemical analysis was carried out using ethanol and water solvents. Agar well diffusion method was used to test the antibacterial properties of the plant extracts. Phytochemistry showed that the extracts had different concentrations of terpenoids, phenols, flavonoids, glycosides, tannins, saponins, alkaloids, steroids, and anthraquinones. The antibacterial activity of ethanol and water extracts of Moringa leaves showed the diameter of the inhibition zone of *S. aureus* at different extract responses ranging from 9 mm to 20 mm. while *E. coli* between 7 mm and 19 mm. The results of this study showed larger inhibition zones produced by ethanol extracts (10-20 mm) of Moringa leaves at all concentrations used compared to those produced by aqueous extracts (9-15 mm) [16].

Based on research conducted by Kwami et al (2020), Moringa leaves were extracted using 80% methanol. Agar well diffusion method was used to measure the antibacterial activity. In this study, moringa leaf extract showed the highest antibacterial properties against *S. aureus*, *Streptococcus feacalis*, *E. coli*, *Klebsiella pneumonia*, *P. aeruginosa*, Proteus mirabilis, and Salmonella typhi. The highest antibacterial activity was against *S. aureus* which had a diameter of 22 mm, while the minimum inhibition zone was against *Salmonella paratyphi* B strain ATCC0650 which had a diameter of 12 mm [17].

The antibacterial mechanism of action of the metabolite compounds present in Moringa leaves is different. Alkaloids cause bacterial cells to lose their ability to form a complete cell wall layer because they disrupt the peptidoglycan component, this ultimately leads to cell death. In order to disrupt the bacterial cell membrane and release intracellular compounds, flavonoids will combine with extracellular proteins to form complex compounds. Saponins have the ability to cause leakage of proteins and enzymes in bacterial cells [18]. The antibacterial effect of tannins comes from their interaction with cell membranes, inactivation of enzymes, and inactivation of genetic material functions. Tannins have the ability to inhibit reverse transcriptase and DNA enzymes, thus preventing bacterial growth. Steroids act as antibacterial agents by damaging the lipid membrane and causing liposome rupture. Porin damage occurs when terpenoids react with porins (transmembrane proteins) on the outer membrane of the bacterial cell wall and form strong polymer bonds. This will reduce the permeability of the bacterial cell wall, deprive the bacteria of nutrients, and slow or stop bacterial growth [19].

CONCLUSION:

Based on literature studies that have been conducted, Moringa leaves have potential as antibacterials because they contain terpenoids, phenols, flavonoids, glycosides, tannins, saponins, alkaloids, steroids, coumarins, triterpenes and anthraquinolones. These compounds have antimicrobial qualities and are very

important in the treatment of various infection-related diseases. Secondary metabolite compounds prevent bacterial growth by first causing damage to the bacterial cell wall.

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