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Literature Review: Antibacterial Activity of Cinnamon Bark Against Various Types of Bacteria

Sandrean Sadewa Hanesta
Universitas Prima Indonesia, Indonesia
Email: Sandreansadewahanesta@gmail.com

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Abstract

Bacterial infections remain a significant public health problem because of their potential to cause organ dysfunction and the increasing prevalence of antibiotic resistance, prompting the exploration of safer natural antibacterial alternatives such as cinnamon bark (Cinnamomum burmannii). This review examines, integrates, and documents the spectrum of antibacterial activity of cinnamon bark against Gram-positive and Gram-negative pathogenic bacteria based on nine primary experimental studies. This literature review employed a descriptive-analytical approach using secondary data, with searches conducted through Google Scholar, PubMed, and the GARUDA Portal. Specific inclusion and exclusion criteria were applied to select studies reporting inhibition zone diameters and minimum inhibitory concentrations (MICs). Cinnamon bark preparations exhibited antibacterial activity ranging from weak to very strong. Pure essential oil (100%, 32 µL/mL) demonstrated the strongest activity, producing an inhibition zone of 44.33 mm against Escherichia coli, while an 8% (w/v) preparation produced an inhibition zone of 28.31 mm against methicillin-resistant Staphylococcus aureus (MRSA). Extracts generally exhibited lower antibacterial activity, potentially because of differences in diffusion characteristics and solvent type, as demonstrated by a 30% aqueous extract against Streptococcus mutans, which produced an inhibition zone of 4.00 mm. Against Gram-negative bacteria, a 10% (w/v) aqueous extract inhibited Salmonella Typhi, Serratia marcescens, and Enterobacter cloacae, producing inhibition zones of 11–12 mm, whereas a 70% ethanol extract achieved 94.31% growth inhibition of Klebsiella pneumoniae. This antibacterial activity is primarily attributed to cinnamaldehyde and eugenol, with additional contributions from alkaloids, tannins, saponins, flavonoids, and triterpenoids. In conclusion, cinnamon bark demonstrates considerable potential as a broad-spectrum natural antibacterial agent, with essential oils generally exhibiting greater antibacterial activity than extracts.

INTRODUCTION

Bacterial infections remain a significant public health problem because they can cause dysfunction in various organs and contribute to the increasing risk of antibiotic resistance. This condition has encouraged the search for alternative antibacterial agents derived from natural materials that may offer safer therapeutic options (Primasari & Ramadhani, 2021). Herbal plants traditionally used as medicinal remedies are widely utilized by communities for the treatment and prevention of various diseases. Many people choose traditional medicines because of their widespread availability and accessibility (Kurama et al., 2020). Cinnamon (Cinnamomum burmannii) is recognized as one of the oldest and most widely used spices and

has been utilized for centuries (Arora et al., 2021). Cinnamon bark can be processed as an additive in foods and beverages, while the leaves can be processed to produce essential oils (Dangeubun et al., 2024). The distinctive flavor and aroma of cinnamon are primarily derived from its aromatic essential oils (Purwakanthi & Rahman, 2021).

Cinnamon (Cinnamomum spp.) is recognized as one of the oldest and most widely used spices (Arora et al., 2021). Cinnamon bark can be processed as an additive in foods and beverages, while the leaves can be used to produce essential oils (Dangeubun et al., 2024). The distinctive flavor and aroma of cinnamon are derived from its aromatic essential oils, particularly cinnamaldehyde, which is a major constituent (Purwakanthi & Rahman, 2021). Previous studies have identified that cinnamon bark (Cinnamomum burmannii) is rich in bioactive compounds, including cinnamaldehyde, eugenol, flavonoids, tannins, saponins, alkaloids, and triterpenoids, which have been reported to possess antibacterial activity (Dangeubun et al., 2024; Sukmayadi et al., 2023; Intan et al., 2021). The antibacterial mechanisms of these compounds involve disruption of bacterial cell membrane permeability, interference with cell wall synthesis, and damage to bacterial DNA, ultimately resulting in the inhibition of bacterial growth or cell lysis (Sukmayadi et al., 2023; Ulanowska & Olas, 2021).

Research evaluating the antibacterial activity of cinnamon has employed various in vitro methods, including the disk diffusion method (Kirby–Bauer method), agar well diffusion method, and broth dilution method for determining the minimum inhibitory concentration (MIC). The tested preparations have also varied, including ethanolic extracts, ethyl acetate extracts, pure essential oils, and formulations combined with other plant extracts (Ilham & Cahyanti, 2026; Fadlilah et al., 2021; Waris & Ambarwanto, 2024). However, despite the numerous studies investigating the antibacterial activity of cinnamon, most have focused on a single bacterial species or a single preparation form (Ezzaky et al., 2023; Nabavi et al., 2015). To date, there has been no comprehensive literature review integrating and comparing the spectrum of antibacterial activity of cinnamon bark against various pathogenic bacteria, including Gram-positive and Gram-negative bacteria as well as specific pathogens associated with the oral cavity, gastrointestinal tract, and respiratory tract (Niazi et al., 2025; Proft & Baker, 2009; Silvestri et al., 2008). Consequently, a knowledge gap remains regarding the comparative effectiveness of different preparation forms, the influence of solvent type on antibacterial activity, and differences in susceptibility among bacterial groups, which have not been systematically synthesized in a single literature review.

The urgency of this research is underscored by the increasing prevalence of antibiotic resistance in Indonesia, including infections caused by methicillin-resistant Staphylococcus aureus (MRSA) and extended-spectrum β-lactamase (ESBL)-producing Klebsiella pneumoniae, which exhibit resistance to various commonly used antibiotics (Fadlilah et al., 2021; Fu'adah et al., 2026). Cinnamon, as an accessible natural material with reported broad-spectrum antibacterial activity, has the potential to serve as a source of novel antibacterial compounds that may be safer and more economical. Furthermore, a comprehensive understanding of effective concentration ranges, the effects of different preparation forms, and the spectrum of antibacterial activity may provide a scientific basis for the development of phytopharmaceuticals and cinnamon-based health products for managing bacterial infections.

The novelty of this literature review lies in its integration of data from nine primary experimental studies encompassing various pathogenic bacteria, diverse testing methods (disk

diffusion and broth dilution), and different preparation forms (crude extracts, pure essential oils, and combination formulations) within a single comparative analytical framework. Unlike previous reviews that have focused on a single bacterial species or group of compounds, this review systematically maps differences in susceptibility between Gram-positive and Gram-negative bacteria, identifies the most effective preparation forms, and evaluates the influence of solvent type and extraction method on antibacterial activity. This approach provides a comprehensive overview of the potential of cinnamon bark as a broad-spectrum natural antibacterial agent (Friedman, 2017; Jaramillo Jimenez et al., 2024; Tian et al., 2025; Wang et al., 2025).

The objective of this literature review is to examine, integrate, and document the spectrum of antibacterial activity of cinnamon bark (Cinnamomum burmannii) against various pathogenic bacteria based on data from nine primary experimental studies, with particular emphasis on comparing the effectiveness of different preparation forms, evaluating differences in susceptibility between Gram-positive and Gram-negative bacteria, and identifying optimal concentrations that produce the strongest antibacterial effects. The expected benefits of this review encompass three main aspects: scientifically, it provides a comprehensive overview of the antibacterial activity of cinnamon that may serve as a reference for future research; clinically, it provides healthcare practitioners with scientific information regarding the potential of cinnamon-derived preparations as complementary antibacterial agents; and pharmaceutically, it provides preliminary evidence to support the development of standardized cinnamon-based antibacterial phytopharmaceutical preparations. Through this literature review, a more comprehensive understanding is expected to be obtained regarding the effective concentration ranges of cinnamon bark preparations, differences in susceptibility between Gram-positive and Gram-negative bacteria, and the preparation forms that exhibit the greatest potential for inhibiting the growth of pathogenic bacteria.

METHOD

This study employed a literature review design with a descriptive-analytical approach based on secondary data. It focused on collecting, mapping, and comparatively assessing previously published in vitro experimental studies investigating the antibacterial activity of cinnamon bark (Cinnamomum spp.) against various bacterial species.

The literature search was conducted using electronic databases, including Google Scholar, PubMed, and the GARUDA Portal. The search terms included “antibacterial activity,” “cinnamon bark extract,” “Cinnamomum burmannii extract,” “Cinnamomum verum,” “inhibition zone,” “minimum inhibitory concentration,” and “pathogenic bacteria.” Based on the search and screening process, nine relevant primary experimental studies were selected for further analysis.

Studies were selected according to predefined inclusion and exclusion criteria. The inclusion criteria comprised original in vitro experimental studies investigating cinnamon bark, reporting clearly defined test bacteria, and providing quantitative antibacterial activity measurements, such as inhibition zone diameter or minimum inhibitory concentration (MIC). Studies were excluded if they lacked complete quantitative data on extract concentrations or inhibition zone diameters or investigated only cinnamon plant parts other than the bark without a relevant comparator or combination involving cinnamon bark.

Data were systematically extracted following full-text screening of the nine selected studies. The extracted information included the authors, year of publication, bacterial species, antibacterial susceptibility testing method, preparation type and concentration, positive and negative controls, and mean inhibition zone diameter or MIC, where available. The extracted data were subsequently organized in a data extraction table to facilitate comparison across studies.

The data were grouped according to bacterial characteristics, particularly Gram-positive and Gram-negative classification, and analyzed using a descriptive-comparative approach. Antibacterial activity was compared across studies based on inhibition zone diameters, MIC values, preparation types, and concentrations where applicable. The analysis was used to characterize the antibacterial activity spectrum of cinnamon bark, compare bacterial susceptibility, and identify the preparation types and concentration ranges associated with the greatest antibacterial activity.

RESULTS AND DISCUSSIONS

Based on the established literature search strategy, experimental articles were obtained that tested the antibacterial activity of cinnamon bark extract (*Cinnamomum burmannii*) against various types of test bacteria. Comparative data on the type of bacteria, test method, concentration variation, control, and diameter of the inhibition zone are summarized in table 1.

Table 1. Antibacterial Activity of Cinnamon Bark (Cinnamomum burmannii) Against Various Types of Bacteria

No	References	Types of Bacteria	Solvents	Test Media	Active Substances	Concentration Variations	Largest Inhibition Zone Diameter	Strength of the Buffer Zone
1	(Ilham & Cahyanti, 2026)	Escherichia coli	Aquadest	Mueller Hinton Agar (MHA)	Rosella Flower Extract : Cinnamon Bark Extract	30% : 10% b/f	8.55 ± 0.52 mm	Medium
2	(Mursyida & Wati, 2021)	Escherichia coli	Ethanol 96%	Mueller Hinton Agar (MHA)	Cinnamon Bark Extract	100% b/v	4,85 mm	weak
3	(From Purvakan & Rahman, 2021)	Escherichia coli		Blood Agar	100% Pure Essential Oil	32πl/ml	44,33 mm	very strong
4	(From Purvakan & Rahman, 2021)	Streptococcus pneumoniae		Mueller Hinton Agar (MHA)	100% Pure Essential Oil	32πl/ml	19,59 mm	Strong
5	(From Purvakan & Rahman, 2021)	Pseudomas aeruginosa		Mueller Hinton Agar (MHA)	100% Pure Essential Oil	32πl/ml	19,06 mm	Strong

6	(Fadlilah et al., 2021)	Methicillin Resistant Staphylococcus aureus	Ethanol	Mueller Hinton Agar (MHA)	Essential Oils	8% b/v	28,31 mm	very strong
7	(Waris & Ambarwanto, 2024)	Staphylococcus aureus	Ethanol 70%	Nutrient Agar (NA)	Cinnamon Bark Extract	8% b/v	14,27 ± 0,8 mm	Strong
8	(Intan et al., 2021)	Staphylococcus aureus	DMSO	Mueller Hinton Agar (MHA)	Cinnamon Bark Extract	75% b/v	12,7 mm	Strong
9	(Fu'adah et al., 2026)	Klebsiella pneumoniae	Ethanol 70%	Nutrient Broth (NB)	Cinnamon Bark Extract	70% b/v	Liquid dilution 70%, inhibition percentage 94.31%	very strong
10	(Amran et al., 2026)	Streptococcus mutans	aquadest	Blood Agar	Cinnamon Bark Extract	30% b/v	4,00 mm	weak
11	(Rahmah, 2021)	Salmonella typhi	Air	Nutrient Agar (NA)	Cinnamon Bark Extract	10% b/v	12 mm	Strong
12	(Rahmah, 2021)	Serratia marcescens	Air	Nutrient Agar (NA)	Cinnamon Bark Extract	10% b/v	11 mm	Strong
13	(Rahmah, 2021)	Enterobacter cloacae	Air	Nutrient Agar (NA)	Cinnamon Bark Extract	10% b/v	11 mm	Strong

Source: Data compiled from primary experimental articles (2021–2026)

Antibacterial Activity of Cinnamon Bark

Based on the results of reviews from 9 journals, it is clear that cinnamon bark (*Cinnamomum burmannii*), both in the form of extracts (ethanol, ethyl acetate, and water) and pure essential oils, has antibacterial activity that varies from weak to very strong against various types of pathogenic bacteria. This variation in inhibition is influenced by several crucial factors, including the type of preparation (active substance) used, the concentration of the preparation, the type of solvent, the test medium, and the structural characteristics of the bacterial cell wall itself.

The main active components in cinnamon bark that act as antibacterial agents are bioactive compounds such as cinnamaldehyde and eugenol. The mechanism of action of these compounds involves disruption of the permeability of the bacterial cell membrane, which in turn inhibits cell growth or triggers cell lysis.

From the data from *the article review*, pure essential oils show much greater inhibitory effectiveness compared to the extract form. For example, research using 100% pure essential oil with (From Purvakan & Rahman, 2021) a content of 32πl/ml resulted in a very strong inhibition zone diameter of 44.33 mm in *Escherichia coli bacteria*. On the other hand, the use of cinnamon bark extract in the form of 96% ethanol extract even with a concentration of 100% b/v was carried out by only providing an inhibition zone of 4.85 mm which is included in the weak category against the same type of bacteria, namely (Mursyida & Wati, 2021) *Escherichia coli*. This indicates that the essential oil refining process contains volatile active compounds in

higher and purer concentrations than the results of maceration extraction, thus providing a stronger antibacterial effect on bacterial cells.

The very strong effectiveness of essential oils was also shown in studies on (Fadlilah et al., 2021) *Methicillin Resistant Staphylococcus aureus* (MRSA) bacteria, where essential oil preparations with a relatively small concentration of 8% b/v were able to produce an inhibition zone of 28.31 mm. This provides a great opportunity for the use of cinnamon essential oil as an alternative therapy to overcome resistant bacterial infections such as MRSA which has been a major challenge in the medical world.

In the Gram-Positive bacterial group, strong to very strong sensitivity is found in *Staphylococcus aureus*, MRSA, and *Streptococcus pneumoniae*. The study was conducted by observing an inhibition zone of 14.27 mm in (Waris & Ambarwanto, 2024) *Staphylococcus aureus* with ethanol extract of 70% concentration of 8% b/v, while recording an inhibition zone of 12.7 mm at an extract concentration of 75% b/v using DMSO solvent. This difference indicates that the selection of solvents also affects the solubility and diffusion of active compounds in agar media. The study actually showed that Gram-Positive bacteria (Intan et al., 2021) (Amran et al., 2026) *Streptococcus mutans* (oral cavity pathogens) had a weak sensitivity, namely having an inhibition zone of 4.00 mm at an extract concentration of 30% b/v with aquadest solvent. This low inhibition is most likely influenced by the use of *aquadest mariners* that are less than optimal in attracting non-polar compounds such as sinamaldehyde, as well as the nature of *the bacteria Streptococcus mutans* that is able to form a protective biofilm.

In the Gram-Negative Bacteria group, the variation in the inhibition spectrum is also very wide. Although *Escherichia coli* showed a weak response to the ethanol extract form, the use of essential oils provided a remarkable resistance of 44.33 mm. Other Gram-Negative bacteria such as *Pseudomonas aeruginosa* were also successfully inhibited with a strong category of 19.06 mm using pure essential oils. In addition, the test using water extract against gastrointestinal bacteria and opportunistic pathogens such as (Rahmah, 2021) *salmonella typhi* is 12 mm, *Serratia marcescens* is 11 mm, and *Enterobacter cloacae* is 11 mm at a fairly low concentration of 10% b/v which is included in the strong category. This proves that the active components of cinnamon bark retain the ability to penetrate the outer membrane of lipopolysaccharides of Gram-Negative bacteria if administered in the right type of preparation or formulation. Very strong effectiveness on Gram-Negative bacteria was shown in a study on (Fu'adah et al., 2026) *Klebsiella pneumoniae* using the liquid dilution method, obtaining a very high percentage of bacterial growth inhibition, which reached 94.31%. This liquid dilution method provides a more accurate quantitative picture of the penetration capacity of the active substance directly in the liquid medium without being obstructed by the molecular diffusion barrier factor in the solid medium.

Cinnamon Bark Extract Compounds as Antibacterial

Based on research that has been carried out by phytochemical tests, it is known that cinnamon extract contains alkaloids, tannins, saponins, flavonoids, and triterpenoids. Flavonoid compounds and their derivatives have two physiological functions, namely as antibacterial and antiviral for plants. (Dangeubun et al., 2024)

Flavonoids are the largest group of natural phenol compounds and are polar, so they will be soluble in polar solvents. Most of the flavonoid groups are soluble in hot water. The hydroxyl

group contained in the structure of flavonoid compounds results in a toxic effect on bacteria. Flavonoids will damage the bacterial cell wall so that the compound can enter the bacterial cell nucleus and damage the bacteria's DNA, causing the bacteria to become inflamed and die. Tannins can precipitate proteins and damage cell walls, saponins can increase membrane permeability, while alkaloids and triterpenoids can interfere with the synthesis of bacterial cell components. The combination of these compounds makes cinnamon bark extract not only effective antibacterially, but also potentially more stable because its effects are not as strong as a single compound. (Sukmayadi et al., 2023) (Intan et al., 2021)

Sinamaldehyde is the main compound in cinnamon that has antibacterial activity against Gram-Negative bacteria, so it has the potential to be developed as an antibacterial active ingredient in pharmaceutical preparations. (Primasari & Ramadhani, 2021)

In addition to synmaldehyde, eugenol works by damaging bacterial cell membranes, so that the cell contents leak and bacteria lose their ability to live. In Gram-negative bacteria, eugenol can penetrate the lipopolysaccharide layer due to its hydrophobic nature, and then disrupt the structure of the inner cell. Eugenol can also reportedly inhibit certain enzymes, trigger the formation of intracellular ROS, and suppress biofilm growth. (Ulanowska & Olas, 2021)

CONCLUSION

Based on the review of nine scientific articles, cinnamon bark (Cinnamomum burmannii) demonstrated considerable antibacterial potential, with activity ranging from weak to very strong against Gram-positive and Gram-negative pathogenic bacteria. This antibacterial activity was primarily attributed to the bioactive compounds cinnamaldehyde and eugenol, which can disrupt bacterial cell membrane permeability. The reviewed studies indicated that pure essential oil preparations generally exhibited greater antibacterial activity than crude extracts. This was demonstrated by 100% pure essential oil (32 µL/mL), which produced a very strong inhibition zone of 44.33 mm against Escherichia coli. In addition, an 8% (w/v) preparation produced an inhibition zone of 28.31 mm against methicillin-resistant Staphylococcus aureus (MRSA), while extracts prepared with DMSO at a concentration of 75% (w/v) produced inhibition zones of 14.27 mm and 12.7 mm against Staphylococcus aureus, respectively, and were classified as having strong antibacterial activity. However, antibacterial activity was weaker against Streptococcus mutans, with a 30% (w/v) aqueous extract producing an inhibition zone of only 4.00 mm, potentially because of limitations in the diffusion of active compounds and the protective properties of bacterial biofilms. Considerable variation in susceptibility was also observed among Gram-negative bacteria. In addition to the strong activity of essential oil against Pseudomonas aeruginosa, which produced an inhibition zone of 19.06 mm, a 10% (w/v) aqueous extract inhibited Salmonella Typhi, Serratia marcescens, and Enterobacter cloacae, with inhibition zones of 12, 11, and 11 mm, respectively. Meanwhile, broth dilution testing of a 70% ethanol extract at a preparation concentration of 70% (w/v) demonstrated substantial activity against Klebsiella pneumoniae, with 94.31% growth inhibition. These findings also indicated that broth-based quantitative assays can characterize antibacterial activity without the agar diffusion limitations that may influence inhibition zone measurements in solid media.

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