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Effect of Terpenoid Compounds in Coriander Seeds (*Coriandrum sativum L*) as Antibacterial Agent: A Review

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Abstract

Bacterial infections disrupt the balance between bacterial virulence and host resistance. Bacterial infections are easier to treat than viral infections, as the arsenal of antimicrobial agents active against bacteria is broader. Illness is caused by injury to the cells by organisms or the body's immune responses. Terpenoids are compounds derived from plants and are widely reported to have antimicrobial activity inhibitors. These agents can exert direct bactericidal action by blocking bacterial DNA synthesis, inhibiting ATPase activity, inhibiting biofilm formation, or disrupting membrane integrity or permeability. Terpenoids constitute a significant source of bioactive natural products. Due to their lipophilic characteristics, terpenoids have become one of the main antimicrobial agents against various microorganisms. This study aims to determine the effect of terpenoid compounds as antibacterial agents. This writing method is a literature study with literature sources for the last 5 years through search sites such as Google Scholar, PubMed, NCBI, Clinical Key, and Science Direct. These various literature sources indicate that terpenoid compounds are agents that have antibacterial activity. Coriander seeds have antibacterial activity and can inhibit bacterial growth, depending on the concentration. The compound that acts as an antibacterial is a terpenoid, especially the linalool compound.

***Keywords*:** *Antibacterial, Coriandrum sativum L, Infections, Terpenoid*

Abstrak

Pengaruh Senyawa Terpenoid pada Biji Ketumbar (*Coriandrum sativum L*) sebagai Agen Antibakteri. Infeksi bakteri lebih mudah diobati daripada infeksi virus, karena persenjataan agen antimikroba yang aktif melawan bakteri lebih luas. Penyakit dapat disebabkan oleh kerusakan sel-sel tubuh oleh organisme atau respons imun tubuh terhadap infeksi. Salah satu senyawa yang berasal dari tanaman dan telah banyak dilaporkan menjadi penghambat aktivitas antimikroba adalah terpenoid. agen ini dapat melakukan tindakan bakterisida langsung dengan menghalangi sintesis DNA bakteri; menghambat aktivitas ATPase, menghambat pembentukan biofilm, integritas membran, atau permeabilitas. Terpenoid adalah sumber utama produk alami bioaktif. Terutama karena karakteristik lipofiliknya, terpenoid telah menjadi salah satu jenis utama agen antimikroba terhadap berbagai mikroorganisme. Penelitian ini bertujuan untuk mengetahui bagaimana pengaruh senyawa terpenoid sebagai agen antibakteri. Metode penulisan ini adalah studi literatur dengan sumber pustaka 5 tahun terakhir melalui situs pencarian berupa google scholar, Pubmed, NCBI, Clinical Key, dan Science Direct. Hasil yang diperoleh dari berbagai sumber pustaka tersebut yaitu dapat diketahui bahwa senyawa terpenoid merupakan sebuah agen yang memiliki aktivitas antibakteri.

***Keywords*:** *Antibakteri, Coriandrum sativum L, Infeksi, Terpen*

Introduction

Infectious diseases are commonly found in both developed and developing countries. This disease occurs when microorganisms enter and multiply in the body; microorganisms that enter can be bacteria, parasites, fungi, or viruses. These microorganisms can enter the human body in various ways, such as inhalation through the air when breathing, through contaminated food, through blood, or even through sexual activity. Microorganisms that cause human disease are called pathogenic microorganisms, one of which is pathogenic bacteria.[1]

GRAM (*Global Research on Antimicrobial Resistance*) reported that in 2019, 7.7 million deaths occurred due to bacterial infections. Bacterial infections are also among the world's top 8 causes of death. Most bacterial pathogens can affect all ages and Genders. 5 bacteria cause the most deaths, namely, *S. aureus*, *E. coli*, *S. pneumoniae*, *K. pneumoniae*, and *P. aeruginosa*.[2] The word bacteria comes from the Latin "*bacterium,* " one of the most widespread organisms in the environment. Bacteria are unicellular organisms (single-celled) and prokaryotic organisms (the cell nucleus and core membrane are not yet clear and perfect). Bacteria can be found almost everywhere, such as in the air, water, and soil; bacteria can also live in symbiosis with living things and can play a role in pathogenic agents.[3]

Based on its structure, bacteria have a basic structure and additional structures. The structure is the bacterial cell wall, which functions as a support, gives the cell shape, and protects the components inside. Bacteria have rigid cell walls that can withstand some osmotic pressure conditions. The rigid cell wall is due to the content of peptidoglycan, which is composed of N-acetyl glucosamine (NAG), N-cetyl muramic acid (NAM), and a peptide consisting of amino acids. The N-acetyl glucosamine polymer is located next to the N-acetyl muramic acid. The N-acetyl muramic polymer has a side chain of four peptides that form cross-links with other N-acetyl muramic peptides.[3]

Bacterial infections result from disrupting the balance between bacterial virulence and host resistance. Bacterial infections are easier to treat than viral infections, as the arsenal of antimicrobial agents active against bacteria is broader. Disease can be caused by damage to cells by organisms or by the body's immune response to infection.[3,4]

Antibacterials are compounds that can be used to control and suppress the reproduction of bacteria. This control aims to prevent the development of a disease and eliminate bacteria in its host. Antibacterial mechanisms can inhibit the synthesis of bacterial cell walls, damage cell walls' integrity, and inhibit the synthesis of proteins and nucleic acids.[5]

Several drugs commonly used as treatments, especially those derived from chemically active compounds, have faced resistance from bacteria. Antibiotic resistances are defined as the ability of microorganisms to resist an antimicrobial agent's mode of action, and this phenomenon occurs when antibiotics lose their efficiency in inhibiting bacterial growth. Biodiversity in Indonesia encourages researchers to look for additional treatment options, especially to overcome drug resistance. Herbal plants are one of the choices due to the ease of accessing the ingredients, and also, the possibility of side effects produced is less than that of chemical-based drugs on the market; one example is coriander seeds.[6]

The name coriander comes from the Greek "*koris*," meaning bedbug, as it has an unpleasant, insect-like odor when its leaves and fruits are green. The plant is native to the Mediterranean and Middle Eastern regions and is widely cultivated in the Middle East and North America. The main components of coriander are fiber, carbohydrates, fatty oils, and proteins. In the ratio of 23-36%, 20%, 16-28%, and 11-17%, respectively. Coriander (*Coriandrum sativum L.*) is a spice or herb plant of the Apiaceae family. *Coriandrum sativum* is native to the eastern Mediterranean and grows in Europe, Africa, and Asia. Coriander seeds are dried, round-shaped, brown-colored fruits. Based on several previous research sources, coriander seeds have several active compounds: flavonoids, saponins, alkaloids, tannins, phenolics, and terpenoids.[7-9]

One compound of plant origin widely reported to be an inhibitor of antimicrobial activity is terpenoids. These agents can exert direct bactericidal action by blocking bacterial DNA synthesis, inhibiting ATPase activity, inhibiting biofilm formation, or disrupting membrane integrity or permeability. Terpenoids are a

significant source of bioactive natural products. Due to their lipophilic characteristics, terpenoids have become one of the main antimicrobial agents that fight various microorganisms.[3,4]

Terpenoids, also known as isoprenoids, are one of the largest groups of natural products, consisting of more than 40,000 primary and secondary metabolites, including monoterpenes (53%), diterpenoids (1%), sesquiterpenes (28%), and others (18%). The basic unit of terpenes is the isoprene unit (C5H8), a simple hydrocarbon. It is the primary precursor and can be modified via the cytosolic mevalonate pathway (MVA) or the methyl erythritol phosphate pathway (MEP). Terpenoids are the primary source of bioactive natural products. Due to their lipophilic characteristics, terpenoids have become one of the main antimicrobial agents that fight various microorganisms.[10]

Methods

The research design used in this study is a literature review that searches and analyzes facts from accurate and valid scientific sources, examining the effect of coriander seeds as antibacterial agents. Scientific sources are obtained from Google Scholar, PubMed, NCBI, Clinical Key, and Science Direct in the form of scientific articles. The literature data obtained were then selected according to the inclusion and exclusion criteria. Literature data included if published in the last 5 years; Literature searches were conducted in October 2024. Sources for conducting this literature review include systematic search studies of computerized databases with keywords used, namely "*Coriandrum sativum L,*" "antibacterial," "terpenoid compounds," and "bacterial infection."

Results and Discussion

After searching for data and analyzing it on Google Scholar, six articles met the inclusion criteria suitable for this research review. The characteristics of the article can be seen in Table 1. The results of the study conducted by Hasanah et al. (2019) showed that the phytochemical test conducted showed that in coriander seed extract, there were alkaloid, saponin, tannin, phenolic, flavonoid, triterpenoid, and glycoside compounds. The concentration of ethanol extract of coriander seeds at concentrations of 50% and 75% could inhibit *Shigella dysentery* bacteria, which is included in the weak category, because it had an average of less than 5 mm. At a concentration of 100%, it could be hindered in the moderate category because it had an average of 6-10 mm. The inhibitory power of the use of cotrimoxazole, which is usually used for the treatment of *Shigella dysentery,* is 15.29 mm. So, it can be concluded that coriander seeds are pretty effective but not as effective as cotrimoxazole in eliminating *Shigella dysentery* bacteria.[11]

The study conducted by Sitanggang et al. in (2021) also proved that the ethanol extract of coriander seeds contains phenols, flavonoids, alkaloids, saponins, tannins, and terpenoids/steroids. The concentration of 100% coriander seed extract produced an inhibition zone of 8.20 mm in *Pseudomonas aeruginosa* bacteria. While at a concentration of 50%, an inhibition zone of 6.64 mm was obtained. In this study, researchers suspect the presence of terpenoid compounds as antibacterial compounds that affect the study results. So, it can be concluded that the larger the inhibition zone produced, the higher the concentration applied.[12]

The study's results by Meilina et al. (2021) explained that the administration of ointment from coriander seed extract had a healing effect on treated mice, where the mice experienced wound infections by *Streptococcus aureus*. This study conducted observations for 14 days on mice infected with *Streptococcus aureus* by giving coriander seed extract ointment (concentrations ranging from 0 grams, 4 grams, 6 grams, and 8 grams) and hydrocortisone ointment daily. Based on the average wound length value in each wound healing group of treatment on day 1 to day 14, the average wound length value in the 8-gram and hydrocortisone concentration groups was better than that of the 4-gram and 6-gram groups. In contrast, the average wound length value of the 0-gram group was lower compared to the average wound length value of the other groups. The comparison between the average wound length values for each treatment group was the best at concentrations of 8 grams, 6 grams, and 4 grams. The most effective ointment concentration for healing wounds due to *Streptococcus aureus* infection is a concentration of 8 grams.[13]

Table 1. The result from several references on the effect of coriander seeds as an antibacterial

References	Research Title	Study design	Result
Hasanah and Dori, 2019[11]	Daya Hambat Ekstrak Biji Ketumbar (*Coriandrum sativum L*) terhadap Pertumbuhan Bakteri *Shigella dysenteriae* Metode Cakram	Laboratory experiment with two repetitions of the test using the disc diffusion method.	The 70% ethanol extract is positive for containing secondary metabolites of alkaloids, saponins, tannins, flavonoids, phenolics, triterpenoids, and glycosides. It was found that 50% concentration produced an average of 3.275 mm, 75% concentration had an average of 4.57 mm, and 100% concentration had an average of 8.7 mm. The largest zone was found at 100% concentration.
Sitanggang et al., 2021[12]	Daya Hambat Ekstrak Etanol Biji Ketumbar (*Coriandrum sativum L.*) terhadap Pertumbuhan Bakteri *Pseudomonas Aeruginosa*	Posttest Only Control design with diffusion method discs	Coriander seeds effectively inhibit the growth of *Shigella dysenteriae* bacteria with moderate inhibition. 1. There are phenols, flavonoids, alkaloids, saponins, tannins, and terpenoids/steroids in coriander seed extract (*Coriandrum sativum L.*) *2.* The diameter of the broadest inhibition zone formed on *Pseudomonas aeruginosa* by ethanol extract of coriander seeds (*Coriandrum sativum L.)* is 8.20 mm. P in each extract concentration found a difference of 0.000, showing a significant difference in each treatment group on the diameter of the inhibition zone on *Pseudomonas aeruginosa.* 3. The most effective concentration of coriander seed ethanol extract in inhibiting the of Pseudomonas aeruginosa is 100% concentration.
Meilina et al., 2021[13]	Aktivitas Penyembuhan Luka Salep Ekstrak Biji Ketumbar (*Coriandrum sativum L.)* pada Mencit (*Mus musculus L.*) yang Terinfeksi *Staphylococcus aureus*	Laboratory experiments were conducted by making ointment preparations with different concentrations, which were then given to mice with *Staphylococcus Aureus* infection and observed for 14 days.	Coriander seed extract ointment preparation (*Coriandrum sativum L.*) improves wound healing in mice infected with *Staphylococcus aureus* bacteria. The most effective formulation in wound healing is with coriander seed extract content of 8 grams.
Handayani et al., 2019[14]	*Coriandrum sativum l. (Apiaceae) and Elettariam Cardamomum (l.) maton (zingiberaceae) for antioxidant and* Gram-positive and gram-negative bacteria tested. The antimicrobial protection	Laboratory Experiment using Gas Chromatography-Mass Spectroscopy (GC/MS) for essential oil extract the antioxidant activity of the oil extract is almost the same. The clear zone diameter of DPPH method. While to assess the inhibition of *Staphylococcus aureus* and *Escherichia coli* was tested by paper disc method.	Results show antimicrobial test clear zone was formed in the positive control (tetracycline 15 µg/ml), coriander at concentrations of 500 µg/mL and 1000 µg/ml both on gram-positive *S. aureus* bacteria and gram-negative bacteria, E. coli. Meanwhile, in cardamom, the diameter of the clear zone is relatively very low, namely 0 to 0.94 + 0.096 mm. In coriander, the clear zone formed on 1000 µg/ml

			concentration was superior to 500 µg/mL The results also showed that the concentration of coriander essential oil began to have antioxidant activity starting at a concentration of 500 µg/ml. The antioxidant and antimicrobial activity can be attributed to the essential oil compounds of coriander and cardamom.
Kodariah et al., 2024[15]	*Antibacterial activity of coriander seed extract (Coriandrum sativum) against the growth of Streptococcus mutans*	Laboratory experiments by making coriander extract with various concentrations ranging from 0.75%, 1.5%, and 3%, then of *Streptococcus mutans* bacteria to assess its effectiveness	Coriander seed extract (*Coriandrum sativum*) has antibacterial activity, which is indicated by the formation of an inhibition zone against the growth of *Streptococcus mutans* bacteria. The average diameter of the clear zone produced is: 0.75% concentration does not form a clear zone, 1.5% concentration forms a clear zone with an average of 1.5 mm, and 3% concentration forms a clear zone with an average diameter of 3.7 mm. The lowest concentration of coriander seed extract that can be used to inhibit *Streptococcus mutans* is a concentration of 1.5%. The higher the concentration of coriander seed extract, the higher the effect caused by the extract.
Nurmayani and Galaupa, 2024[16]	Efektivitas Rebusan Biji Ketumbar dan Rebusan Daun Sirsak terhadap Masalah Keputihan Pada Wus di Wilayah Kerja Puskesmas Sukatani Kabupaten Bekasi	A quasi-experimental design with pretest-posttest and control group design was used. Samples with purposive sampling technique. The intervention was given 1 x 250 g daily for 7 days—bivariate analysis using paired sample t-test and independent t-test.	The results of the paired sample t-test test showed a p-value of 0.000 <0.05 before and after giving a decoction of coriander seeds or betel leaves, so it can be concluded that there is an effect of providing a decoction of coriander seeds or betel leaves on the problem of vaginal discharge in WUS in the Sukatani Health Center Working Area, Bekasi Regency. The results of the independent t-test test showed a p-value of 0.000 <0.05 after coriander seed decoction and soursop leaf decoction. Thus, it can be concluded that there is a difference in the effect of coriander seed decoction and soursop leaf decoction on the problem of vaginal discharge. Soursop leaf decoction on the problem of vaginal discharge in WUS in the Sukatani Health Center Working Area, Bekasi Regency. Where the administration of coriander seed decoction is more effective against vaginal discharge problems in WUS than soursop leaf decoction in the Sukatani Health Center Working Area, Bekasi Regency.

The results of the study by Handayani et al. (2019) showed that the results formed a clear zone. In the positive control (tetracycline 15 μg/ml), coriander at a concentration of 500 μg/mL and 1000 μg/mL in both gram-positive *S. aureus* and gram-negative bacteria. *E. coli*. Meanwhile, in cardamom, the diameter of the clear zone is relatively very low, namely 0 to 0.94 + 0.096 mm. The clear zone formed in gram-positive and gram-negative bacteria is almost identical to that of coriander. The diameter of the clear zone at a concentration of 1000 μg/ml is superior to that at 500 μg/ml. The study's results also showed that the concentration of coriander essential oil began to have antioxidant activity starting at a concentration of 500 μg/ml. The antioxidant and antimicrobial activities can be associated with the essential oil compounds of coriander and cardamom. So, it can be concluded that the essential oil of coriander has good antimicrobial activity based on the results of the activity index on gram-negative bacteria *E. coli* and gram-positive bacteria *S. aureus*. In comparison, cardamom has poor antimicrobial activity and tends to be active against gram-positive bacteria. Cardamom has more potent antioxidant activity than coriander. Therefore, the essential oil of *Coriandrum sativum L.* (*Apiaceae*) can be explored for its antimicrobial activity. At the same time, *Elettaria cardamomum L. Maton* (*Zingiberaceae*) has the potential to be a source of antioxidants.[14]

The results of research by Kodariah et al. (2024) found that the content of coriander seeds during phytochemical tests consisted of saponin, terpenoid, flavonoid, and alkaloid compounds. Giving coriander seed extract with various concentrations has various effects on inhibiting the growth of *Streptococcus mutans* bacteria. A concentration of 0.75% showed no inhibition zone formed. Then, a concentration of 1.5% formed an inhibition zone diameter of 1.5 mm. Meanwhile, a concentration of 3% formed a diameter of 3.7mm. So, it can be concluded that coriander seed extract affects inhibiting bacterial growth with a minimum concentration of 1.5%.[15]

The results of the study by Nurmayani and Galaupa (2024) showed that there was an effect before and after giving boiled coriander seeds and soursop leaves on vaginal discharge problems in the Sukatani Health Center Work Area, Bekasi Regency. Researchers assume that there is an effect on vaginal discharge problems because it is caused by the content of flavonoids, tannins, and triterpenoids, where according to expert researchers, each of these contents functions as an antimicrobial and antifungal. So, it can be concluded that there is an effect of giving boiled coriander seeds and boiled soursop leaves on vaginal discharge problems in WUS in the Sukatani Health Center Work Area, Bekasi Regency. However, giving boiled coriander seeds is more effective.[16]

In the literature above, it is stated that terpenoid compounds are found in coriander seeds. The method of destroying microbes by terpenoids is generally divided into five methods; the first is the destruction of cell membranes, where terpenoids use their lipophilic properties to destroy microbial cell membranes, which can penetrate the phospholipid bilayer of bacteria. The second is the anti-quorum-sensing mechanism, a communication mechanism between cells that terpenoids can inhibit. The third is the inhibition of ATP and its enzymes; terpenoids can work on cell membranes, resulting in differences in ATP concentrations inside and outside cells that interfere with microbial cell activity. The fourth is an inhibitor of protein synthesis, and the last can provide a synergistic effect that can penetrate other protective functions, so that other antibacterial functions given will be more optimal. Based on these five methods, terpenoids can be one of the choices of compounds that function as antibacterials.[10]

The main components of substances contained in the essential oils of coriander seeds include Linalool (67.7%), α-pinene (10.5%), γ-terpinene (9.0%), geranyl acetate (4.0%), camphor (3.0%), geraniol (1.9%), and less than 2% of the components. In addition to essential oils and extract components, coriander seeds contain protein, carbohydrates, phenolic compounds, tannins, and flavonoids.[11]

Linanool, as one of the terpenoid compounds in coriander seeds, has the highest content in coriander seed essential oil, with a percentage of 68%. Linalool, the main component of essential oils, has antibacterial properties by damaging cell walls and membranes, disrupting cellular function, and causing metabolic dysfunction[17]:

1. Damage to the cell walls and membranes: Linalool can damage the structure and function of cell walls and membranes, causing leakage of intracellular substances.

2. Metabolic dysfunction: Linalool can inhibit energy synthesis and cellular respiration and reduce enzyme activity.
3. Disruption of cellular function: Linalool can disrupt cellular function, causing a decrease in membrane potential and the release of macromolecules such as DNA, RNA, and proteins.
4. Cell death: Linalool can cause cell death.

Linalool has many biological activities because it has antioxidant, anti-inflammatory, antimicrobial, cardioprotective, neuroprotective, sedative, anxiolytic, anticonvulsant, and anticancer effects. Regarding its antibacterial activity, linalool is reportedly sensitive to gram-positive and gram-negative bacteria. However, further research is still required on its antibacterial activity.[18]

Conclusions

Based on the study's results and review of six articles, it was found that coriander seeds have antibacterial activity and can inhibit bacterial growth. However, the ability depends on the concentration of compounds in coriander seeds; in this case, the compound that acts as an antibacterial is "terpenoid," especially the linalool compound. This literature also found that the higher the concentration, the better the bacterial growth inhibition zone.

Conflict of Interest

The authors declare no conflict of interest.

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