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Bioactivity Potential and Chemical Compounds of *Cinnamomum*: Literature Review

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Abstract: *Cinnamon* is a spice commodity that contains chemical compounds and bioactive components that have the potential to be developed as medicinal raw materials in the pharmaceutical industry. Biological activity in cinnamon can increase and stimulate the body's immune system. This study aims to present a summary of the literature review to unify the overall information on bioactivity and chemical compound content in cinnamon. The research method uses the literature review method with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) meta-analysis approach. The literature review of original research articles shows a variety of properties found in cinnamon plants because of alleged chemical compounds including cinnamaldehyde, phenolics, flavonoids, alkaloids, saponins, tannins, polyphenols, triterpenoids as potential bioactivities, namely immunomodulator, antifungal, antioxidant, anti-inflammatory, antibacterial, antidiabetic and A-Glucosidase enzyme activity. From some research results, cinnamon plant parts have been shown to have many pharmacological properties that it can increase the productivity of drugs using natural ingredients.

Keywords: Bioactivity; Chemical Compounds; Cinnamon

Introduction

The pharmaceutical industry has an important role in human life so it has the potential to develop plant diversity in Indonesia by using natural materials. Indonesia is one of the most spice-producing countries in the world with a production of 113, 649 tons with various types of plant species including 400-500 species (Rambey et al., 2021). Chemical drugs that are used in the long term can cause new diseases again so many switches to using natural ingredients and are considered more comfortable than modern medicine because they have relatively no side effects (Puspariki & Suharti, 2019).

Natural ingredients found in Indonesia can be used as medicinal raw materials, one of which is the cinnamon plant (*Cinnamomum*). The cinnamon plant is a spice as well as used as a traditional medicine, the spices obtained are taken from the main part of the bark and other parts that can be used include leaves, twigs, stems, and essential oils (Parmadi et al., 2021). *Cinnamomum* consists of several types of species including *C. burmanni, C. cassia, and C. cullilawan*, but cinnamon that is often found in Indonesia are C. burmanni (Karim & Pratiwi, 2022). Part of the plant is generally dried and can be processed into extracts, powders, essential oils, or oleoresins.

The cinnamon plant has many pharmacological properties due to the presence of chemical compounds of secondary metabolites (Yakhchali et al., 2021). Research by Novendy et al., (2020) eports cinnamon is effective in controlling blood sugar (Farazandeh et al., 2022), explained that cinnamon is useful as a cough medicine, canker sores, eczema, cold decay, sweat decay, and other functions to improve body health including preventing blood clots, anti-cancer, lowering cholesterol, and controlling blood sugar. Therefore, cinnamon has a lot of potential in every part because it is alleged that biological activity is relatively safe for

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consumption and has bioactivity potential (Prasanth et al., 2021).

Cinnamon with therapeutic activity and potential so that it stimulates the body's immune system caused by chemical and bioactive compounds. Bioactive compounds are compounds that provide physiological effects in metabolic processes and prevent degenerative diseases such as cardiovascular, cancer, infections, and other diseases (Mondal et al., 2021). These activity compound's function, among others, as antioxidants, antibacterials, antifungals, and anticancer (Eweys et al., 2022).

The bioactive content of each plant part is different (Błaszczyk et al., 2021). stated that the cinnamon bark contains cinnamaldehyde, linalool, caffeic acid, benzoic acid, trans-cinnamaldehyde, and comfort while the leaves contain eucalyptol and cinnamaldehyde where the bioactive components in the bark are more than the leaves. Bioactive compounds contained in a natural material can decrease due to several factors. Temperature factors can affect stability and damage bioactive compounds (Koch et al., 2020).

The high bioactivity content in cinnamon has a beneficial effect on health and has the potential to be developed in the pharmaceutical industry. Therefore, the article review study aims to provide information related to the potential of chemical compounds and pharmacological bioactivity found in cinnamon plants, so that they can be used as parameters for subsequent researchers and the public.

Method

Research Methods

This research method is the literature review method. The literature review is a research method that the stages of the process of selecting the identified articles can be seen in figure 1.

Evaluates and identifies theories and methods from research results that are relevant to a particular topic. This stage of research collects, identifies and evaluates, and interprets while using the *Preferred Reporting Items for Systematic Review and Meta-Analysis* (PRISMA) approach.

Inclusion Criteria

This study uses inclusion criteria with appropriate articles and journals, then taken for analysis, namely the potential of the chemical compound cinnamon (*Cinnamomum*), the potential for cinnamon bioactivity, articles quoted from national journals written in Indonesian, original research articles or not literature reviews in the last 10 years.

Search Keywords

The articles in this study used keywords and Boolean operators (AND, OR). The search was conducted in January 2023. The database source used Google Scholar, and Crossref, and searched using the google search engine. The data sought includes published articles from 2014-2023 using the following keywords: Cinnamon (*Cinnamomum*), Bioactivity, and Chemical compounds.

Results and Discussion

Based on the results of the literature review conducted aimed at knowing the chemical compounds and bioactivity of cinnamon as pharmacology, 1,194 articles were identified. Furthermore, 1,179 articles were issued and 15 articles were obtained that were relevant to the determination of articles that met the requirements for inclusion criteria. So that 9 selected articles were obtained that met the feasibility.

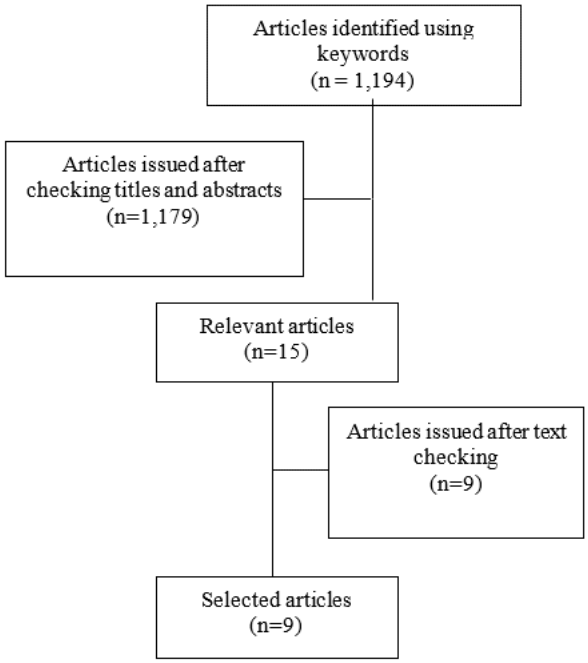

Figure 1. Article Selection Flow

The stages of the process of selecting the identified articles can be seen in figure 1. Based on the results of the literature review of articles that meet the feasibility with systematic reviews in the last 10 years of research. The results of the literature review found that cinnamon contains many chemical compounds and bioactivity. A summary description of the study result data is in table 1.

Table 1. Summary of data descriptions

Heading	Author	Method	Result
Antibacterial Activity of Cinnamon Extract (*Cinnamomum burmannii*) Against the Growth of *Enterococcus Faecalis*	(Mubarak et al., 2016)	Standard Plate Count Method	The results showed that cinnamon extract (*Cinnamomum burmannii*) with a concentration of 1.5% namely 299.3 x 104 CFU / ml showed the most inhibitory power of colony growth E. faecalis while the least is found at a concentration of 7.5% which is 6 x 104 CFU/ml.
Isolation of Sinamaldehid Compounds from Cinnamon Sticks (*Cinnamomum Burmanii*) by Column Chromatography Method.	(Wasia et al., 2017)	An exploratory method with Gas Chromatography-Mass Spectroscopy (GC-MS).	The results showed that cinnamon stick extract contains cinnamaldehyde which was identified with a fraction of 1.36% with a molecular weight of 132 g / mol using the solvent dichloromethane.
Antidiabetic Activity Test of cinnamon bark infusion (*Cinnamomum burmannii*) on male white mice invivo.	(Arrafi & Amanatie, 2018)	In Vivo Method	The results of the study showed an anti-diabetic effect that affected reducing blood sugar levels of male mice induced by alloxan.
The Immunomodulatory Effect of Cinnamon (*Cinnamomum Burmanii*) bark extract on the C-Reactive Protein (CRP) Level, Leukocyte Count and Leukocyte Type Count of Wistar Rats Exposed to Staphylococcus Aureus.	(Utomo et al., 2020)	Metode post-test only control group design.	The results showed that by administering *C. burmanii* bark extract with C-Reactive Protein (CRP) examination, there was a significant difference in the number of neutrophils and lymphocytes between the CBE-100 group and the other groups.
The potential of Cinnamon (*Cinnamomum burmannii*) Bark Reflux Extract as Antifungal of Candida albicans and Canida tropicalis	(Djarot et al., 2021)	Dilution method	The results showed that cinnamon bark extract has inhibition of *Candida albicans* and *Canida tropicalis* fungi by using n-Hexan extract with inhibition zone parameters so that it shows cinnamon bark has the highest fungal inhibition zone of 16.300 mm against *C. albicans* and 15.66 mm against *C. tropicalis* with a concentration of 8%.
Antibacterial Activity of Cinnamon (*Cinnamomum burmanii*) against Staphylococcus aureus Growth	(Intan et al., 2021)	In vitro method by diffusion (*Kirby-Bauer*).	The results showed that cinnamon has antibacterial potential in inhibiting the growth of *Staphylococcus aureus* with the best potential in an extract with a concentration treatment of 65%, 70%, and the best is 75%.
Inhibitory Activity of α-Glucosidase Infusa of Cinnamon (*Cinnamomum verum* J. Presl) Turmeric (Curcuma domestica Val) Rhizome and Their Combination.	(Utari & Nasution, 2021)	In vitro method.	The results showed that infuse of cinnamon bark in formula I 10 g/100 mL had the highest percent inhibition of 97.21%.
Anti-inflammatory Activity Test of Cinnamon Leaf Ethanol Extract (*Cinnamomum Burmanni*) On Male White Mice.	(Astika, 2022)	Experimental Method with post-test only control group design approach.	The results of the study on cinnamon leaves obtained a percent inhibition power of 79.80% at a concentration of 20% given topically to male mice having anti-inflammatory activity characterized by a decrease in the amount of exudate volume, the diameter of inflammation and the number of types of leukocytes which include segment neutrophils, stem neutrophils and monocytes. Results (+) phytochemical screening tests: alkaloid compounds, flavonoids, saponins, tannins, steroids/triterpenoids and phenols.

Heading	Author	Method	Result
Antioxidant and Antidiabetic Activity In Vitro Water Extract of Cinnamon Bark (*Cinnamomum burmannii*) From Jambi City.	(Maulana & Safithri, 2022)	The extraction method of inundation technique with a spectrometer.	The results of the study reported cinnamon bark water extract (*Cinnamomum burmannii*) with antioxidant activity test with the first repeat extract of 9,012 mg AAE g-1. The highest total phenolic test was obtained in the second re-extraction of 100.374 GAE g-1, while the highest α-glucosidase enzyme inhibition activity test was found in the first replay extraction of 99.650%.

Based on literature review studies, data obtained from several studies that have been proven by testing compounds and bioactivity include:

Immunomodulatory Activity

Cinnamon plants (*C. burmannii*) have the potential as immunomodulators. Immunomodulators are drugs that can modulate activity by increasing the function of the immune system (Kotala & Kurnia, 2022). Research Utomo et al., (2020) on cinnamon extract exposed to *Staphylococcus Aureus* with the examination of CRP levels showed differences in the number of leukocytes and the number of types of leukocytes. leucocytes and the number of types of leucocytes. In the test of CBE-100 administration: the group was given *Cinnamomum burmannii* 100 mg/kgBB, CBE-200: 200 mg/kgBB and CBE-400: the group given *Cinnamomum burman*i 400 mg/kgBB. Neutrophils are one type of leukocyte that functions in the innate immune system while lymphocytes are a subtype of leukocytes that function in the adaptive immune system. adaptive immune system. The solvent used in C. *burmanii* extract is 70% ethanol so it has an effect that affects the final content of the active substance.

Antifungal Activity

Another biological activity found in cinnamon is the potential for antifungal activity, one of which causes candidiasis (Djarot et al., 2021). stated that the fungi Candida albicans and Canida tropicalis, several kinds of solvents used in testing antifungal activity including n-Hexan, ethyl acetate and 96% ethanol. The results showed that the inhibition zone of n-Hexan extract had greater inhibition power with the best KHM (Minimum Inhibition Concentration) value of 2% and the best LDH (Width of Inhibition Area) at a concentration of 8% with an average value of 16.30 mm ± 0.28 against the growth of *C. albicans* and 15.66 mm ± 0.28 against C. *tropicalis*. hexane extract is most dominant in producing bioactiv components contained in cinnamon bark which are volatile. Research (Sahrul, 2020) also states that it can inhibit the growth of *Malassezia furfur* fungi with a concentration of 0.075%. This is due to the higher the concentration of the extract the greater the inhibition, as the bioactive compounds contained are essential oils, flavonoids, polyphenols, saponins, and tannins. Research by Wasia et al., (2017) proves that isolated cinnamon has a chemical component of sinamaldehyde, that the percentage fraction is 71.36% with a molecular weight of 132 g / m which indicates the presence of sinamaldehyde compounds by maceration produces iamaserat.

Antibacterial Activity

Cinnamon also shows antibacterial activity. Antibacterial is a substance produced in organisms that functions as killing and damaging bacteria. Research by Mubarak et al., (2016) showed cinnamon bark with phytochemical tests showed positive results due to the presence of chemical compounds in the form of alkaloids, saponins, tannins, polyphenols, flavonoids, and triterpenoids. The role of the compound will affect the osmotic pressure of bacteria in their environment such as alkaloid properties. Saponins have the ability and hemolyze the blood. tannins react with cell membranes, polyphenols are compounds of the phenol group that plays a role in damaging the cytoplasmic membrane of bacteria producing cinnamon can inhibit the growth of Enterococcus faecalis with the best concentration of 1.5% which is 299.3 x 104 CFU / ml. Based on the results of other literature reviews, research similar to the results of previous research reviews conducted by (Intan et al., 2021), namely cinnamon (*Cinnamomum verum*) also showed that the inhibitory power of Staphylococcus aureus bacteria at a concentration of 75% can inhibit the inhibitory zone by 12.7 mm. Thus, the concentration of the solvent affects the zone of inhibitory power of antibacterial activity.

Antidiabetic Activity

Cinnamon has bioactivity as an antidiabetic. The results of the relevant research by Arrafi & Amanatie, (2018) in vitro proved the intraperitoneal infusion of cinnamon bark with alloxan (a diabetic substance) induced intraperitoneally with effectiveness at 30.60 minutes, and 120 doses of 0.5gr / kgBB, dose 1gr / kgBB, dose 2gr / kgBB the occurrence of a decrease in blood sugar levels in mice. Research conducted by Sari et al., (2023) looked at the effect of cinnamon (*Cinnamomum cassia*) on Diabetes Mellitus 2 patients so that it could

reduce blood glucose levels with respondents 273.3 mg/dl + 69.2 (p-value 0.050) and mean glucose levels 260.4 mg/dl + 53.7 (p0.588), 235.8 mg/dl + 91.0 (p 0.264), and 230.8 mg/dl + 82.0 (p 0.625) Ikhwan et al., (2021) stated that plants that have antidiabetic activity are caused by the content of flavonoid compounds, saponins, and alkaloids. This shows that standard dose treatment is very influential in reducing blood sugar levels because high doses can provide hepatotoxic effects.

Antioxidant Activity

Cinnamon also has antioxidant activity. Antioxidants are compounds that can inhibit and delay the oxidation reaction of a molecule in the body. Research by Maulana & Safithri, (2022) reported that cinnamon stick water extract (*C. burmannii*) obtained results that tend to decrease from each level of extraction, The first extraction of cinnamon bark has the highest capacity against ascorbic acid, namely 9,012±0.039 mg AAE g-1 crude extract Sari et al., (2021) research also proves that antioxidants found in the cinnamon extract can reduce the body's MDA levels because they can inhibit radicals. On the other hand, Antasionasti & Jayanto, (2021) also proved that cinnamon ethanol excavation has very strong antioxidant activity. This is due to the content of various chemical compounds with total phenolic and total flavonoids of cinnamon ethanol extract in high quantities so it has the potential to be an antioxidant. Flavonoid compounds provide antioxidant effects through the mechanism of catching free radicals due to oxidative stress, inhibiting the formation of ROS (Reactive Oxygen Species) and triggering cell regeneration β-pancreas.

Anti-inflammatory Activity

Cinnamon leaves also have the potential to be anti-inflammatory. Anti-inflammatory compounds are compounds that inhibit infection or inflammation by inhibiting the action of enzymes that cause inflammation (Emelda et al., 2023). Research by Astika, (2022) shows that cinnamon simplicia dry powder extract is mixed using ethanol solvent 70% concentration of 5%, 10%, and 20% with parameters of measuring exudate volume, inflammation diameter, and calculating the number of leukocyte cells. The results showed that the best concentration in overcoming inflammation was a concentration of 20% with an inhibition percent of 78.80% which was close to a positive control drug. The phytochemical testing on cinnamon leaves contains alkaloids, flavonoids, saponins, tannins, steroids/triterpenoids, tannins, alkaloids, and phenols. This is due to the presence of chemical compounds that provide a synergistic effect on the concentration of the extract so that it can reduce the inflammatory response.

a- Glucosidase Enzyme Activity

Cinnamon has α-glucosidase enzyme activity. Analysis of the α-glucosidase enzyme serves to determine the decrease in the activity of the α-glucosidase enzyme in breaking down carbohydrates so that it can reduce carbohydrate digestibility (Attahmid et al., 2021). The results of the study Utari & Nasution, (2021) prove that the cinnamon plant has α-glucosidase enzyme activity with a very high inhibitory power compared to other plants, namely turmeric plants. So that cinnamon provides a synergistic effect in inhibiting the α-glucosidase enzyme due to the high concentration of cinnamon and soluble substances of bioactive components of secondary metabolites contained, one of which is flavonoids, saponins which are natural glycosides.

Bioactivity testing and chemical compound analysis have been widely reported with qualitative and quantitative analysis. Cinnamon has other parts that have different activity values (Ashfaq et al., 2021). Therefore, it is necessary to pay attention to the factors that affect the bioactive components, namely the analysis method, variations in concentration, temperature, type of solvent, extraction, veritas, and site conditions.

Conclusion

Cinnamon has been shown to contain many chemical compounds of secondary metabolites and bioactive components including cinnamaldehyde, phenolics, flavonoids, alkaloids, saponins, tannins, polyphenols, and triterpenoids. It has pharmacological properties with biological activity as an immunomodulator, antifungal, antioxidant, anti-inflammatory, antibacterial, antidiabetic, and A-Glucosidase enzyme activity.

Autor Contributions

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, methodology, and data analysis, Putri Wulandari and Elsa Yuniarti; writing—original draft preparation, Putri Wulandari.; resources, writing—review and editing, funding acquisition, Elsa Yuniarti. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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