Antimicrobial Activities Assessment of Cinnamon Bark (*Cinnamomum burmannii* Nees & T. Nees) Extract against Caries Factors

Prasetyorini[1], Dian Indah W.[2], Yulianita[2], Novi F. U.[2] and Neng Rani[2]
[1]*Biology Study Program, Faculty of Mathematics and Natural Science, Universitas Pakuan, Bogor, Indonesia*
[2]*Pharmacy Study Program, Faculty of Mathematics and Natural Science, Universitas Pakuan, Bogor, Indonesia*

Keywords: Cinnamon Bark Extract; Streptococcus Mutan, Staphylococus Aureus; Candida Albicans.

Abstract: This research was conducted to test the antimicrobial activity of cinnamon bark (*Cinnamomum burmani* Nees & T. Nees Blume) against *Streptococcus mutans*, *Streptococcus aureus*, and *Candida albicans*. The gradual extraction method was employed using 3 types of solvents which were n-hexane, ethyl acetate, and 70% ethanol. The obtained extracts were dried from their solvents by vacuum-drying and weighed to obtain the extraction yield. The dried extracts were each characterized to gain information about color, aroma, and water content. Further characterization was conducted to qualitatively measure the phytochemical contents such as alkaloids, flavonoids, tannins, and saponin, then followed by growth inhibition tests such as minimum inhibitory concentration (MIC) and inhibition zone test. The result showed that the obtained yields of n-hexane, ethyl acetate, and 70% ethanol were 3.75%, 3.70%, and 32.47%, respectively. All extracts were brown-colored with a distinctive cinnamon aroma. The qualitative phytochemical measurements were as follows: n-hexane extract showed the presence of tannins, ethyl acetate extract showed the presence of flavonoids, while the 70% ethanol extract showed the presence of alkaloids, flavonoids, tannins, and saponin. The MIC test result for n-hexane, ethyl acetate, and 70% ethanol extracts were, in order, 12%, 12%, and 8% against *Staphylococcus aureus*, 2.5%, 2.5%, and 25% against *Streptococcus mutan*, and 2.5%, 2.5%, and 25% against *Candida albicans*. The best inhibition zone test results against *Staphylococcus aureus* were exhibited by n-hexane, ethyl acetate, and 70% ethanol extracts in following concentrations: 50% (3.16 mm), 50% (5.90 mm), and 32% (6.83 mm), respectively. Against *Streptococcus mutan*, the best n-hexane concentration was 2.5% (3.83 mm), while ethyl acetate and 70% ethanol extract exhibited relatively the same results in all of their measured concentrations, which were 2.00 mm and 5.30 mm, respectively. Against *Candida albicans*, the best n-hexane extract concentration was 10% (14.5 mm), and the best ethyl acetate concentration extract was 10% (7 mm). The 70% ethanol extract exhibited relatively same results (1.5 mm) in all measured concentrations.

1 INTRODUCTION

Oral microorganisms that cause dental caries and thrush are *Streptococcus mutans*, *Candida albicans*, and *Staphylococcus aureus* (Brotosoetarno, 1997). Dental caries can cause the quality of life disorders including limited dental function, physical disability, and psychological discomfort. One of the plants that have the potential to improve the dental and oral health is cinnamon bark. Cinnamon is a plant in which bark and branches are contain alkaloids, flavonoids, tannins and essential oils consisting of camphor, safrol, eugenol, sinamaldehid, cinamilacetate, terpenes, cineol, citral, citronellal, polyphenols and benzaldehyde (Perry & Metzger, 1980).

According to Anandito et al. (2012) the main components of cinnamon bark essential oils are sinamaldehid (63.12%), p-Cineole (17.37%), benzyl benzoate (11.65%), linalool (8.57%), α-Cubebene (7.77%), and α-Terpineol (4.16%). According to Bisset & Wichtl (2001), cinnamon bark essential oils contain cinnamicaldehyde, whereas the leaves contain more eugenol. According to Rismunandar & Paimin (2001), in cinnamon bark, there are also chemical components such as dammar, adhesive, tannin, tanners, sugar, calcium oxalate, two types of insecticide cinnzelanin and cinnzelanol, cumarin.

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Cinnamon bark has a sweet and slightly spicy, fragrant and warm nature. Cinnamon contains including essential oils of eugenol, safrole, tannins, calcium oxalate, dammar and tanners.

Susanti et al. (2013) reported that cinnamon bark essential oil is widely used as raw material for the industry of making fragrance oil, cosmetics, pharmaceuticals, and other industries. The cinnamon essential oil can also be used as a mouthwash and paste, refreshment, aroma soap, detergent, lotion, perfume, and cream (Rismunandar & Paimin, 2001). Kadek (2011) mentioned the ethanol extract compound of cinnamon bark has the antibacterial power of Streptococcus mutans with a Minimum Inhibition Concentration (MIC) of 5% and Inhibition Zone of 5 mm. The content of cinnamon bark extract compounds has the antifungal activity of Candida albicans with a MIC of 1% and an inhibition zone of 25.5 mm. Nuryanti et al. (2015) stated that cinnamon bark extract with n-hexane solvent had greater inhibitory growth of Candida albicans when compared to other solvents. Research by Puspita (2014) stated that 96% ethanol extract of cinnamon can reduce the growth of *Staphylococcus aureus* bacteria with inhibitory zones of 20% (6.14 mm), 40% (13.01 mm), 80% (21, 04 mm), 100% (23.61mm).

Cinnamon bark can be used as an antidiarrheal drug, stomach cramps, and to reduce intestinal secretions. Pharmacological effects of cinnamon are carminative, diaphoretic, antirheumatic, stomachic and analgesic pain relievers. Cinnamon bark can also be used for medicinal ingredients; essential oils can be used in the industry of perfume, cosmetics, pharmaceutical, and food or beverage (Inna et al., 2010; Shekar et al., 2012). Cinnamon bark is known as one of the plants that have active compounds of cinnamaldehyde and eugenol which has antibacterial properties (Inna et al., 2010). In this research, the extraction of active ingredients will use a multilevel maceration method with three different solvents. The first solvent is n-hexane, a type of nonpolar solvent that can dissolve compounds that are nonpolar (Maulida et al., 2010). The second solvent is ethyl acetate, a semi-polar solvent that can dissolve semi-polar compounds in the cell (Harborne, 1996). The third solvent is ethanol, a polar solvent that can dissolve polar compounds such as phenol groups (Kusumaningtyas et al., 2008). The purpose of this study was to obtain cinnamon bark extract with different polarity solvents and test the extract as an anti-bacterial and anti-fungal cause dental caries and canker sores. Extract activity as antibacterial and antifungal will be determined by measuring MIC and inhibition zone on bacteria and fungus test.

2 METHODS

The study used a complete Randomized Design, carried out in March to May 2019 in the Pharmacy Laboratory, Faculty of Mathematics and Natural Sciences at Pakuan University and in the Microbiology Laboratory, Department of Biology, Bogor Agricultural University. The tools utilized include digital scales (LabPRO®, Kern®) grinders (Zeppelin®), autoclaves (All American®), ovens (Memmen®), test tubes (Pyrex®), test tube racks, 10 ml vials, dishes Petri (Pyrex, ose, beaker glass (Pyrex), measuring glass (Pyrex), volume pipette (Pyrex®), incubator (nuve®), stir bar, spirtus burner, Laminar Air Flow (LAF), Vacuum Dry (Ogawa®) , furnace, Waterbath (Memment®), Hot plate stirrer (Termo Scientific Cimarec®), magnetic bars and other glassware. The ingredients utilized are 11000g cinnamon bark, culture of Streptococcus mutans, Staphylococcus aureus and Candida albicans, PDB (Potato Dextrose Broth), BHI (Brain Heart Infusion), 70% Ethanol, N-hexane, Ethyl Acetate, Physiological NaCl, Whatman paper disks, Clindamycin antibiotics, Nystatin, 1% DMSO and other chemicals.

2.1 Extraction

Cinnamon bark used was obtained from the Research Institute for Medicinal Herbs (Balitro) at Jalan Tentara N0.3, Cimanggu, Central Bogor, Ciwaringin, Bogor, West Java 16124 and has been determined at the LIPI Bogoriense Hebarium Bogor. Next, 1100g of cinnamon bark was made into powder simplicia and measured the yield, moisture content, and ash content. Water content is measured by the gravimetric method and ash content is measured by heating the powder simplicia in the furnace at 6000C. 1000g extraction of cinnamon barks powder using a multilevel maceration method with three solvents, n-hexane, ethyl acetate, and 70% ethanol. Initially, 500g of cinnamon powder was macerated using 5 L n-hexane solvent for 3x24 hours, by putting 500g of cinnamon bark powder into a brown bottle with capacity of 5 L, then adding 2.5 L of n-hexane, and shook. The solution allowed to stand for 18 hours while occasionally shaken, then the filtrate and residue are separated by filtering. In the same way, the residue was re-macerated twice of each using the remaining 1.5 L n-hexane.

The maceration filtrate was collected, poured for ± 24 hours, and the filtrate that had been poured was then concentrated with vacuum dry until a dry extract was obtained, then characterized for the organoleptic character, water content and ash content. Meanwhile, the residue is dried in an oven at 50^0C and then in the same way the residue is re-macerated with different solvents of ethyl acetate and 70% ethanol. Thus, three kinds of extracts will be obtained, namely n-hexane extract, ethyl acetate extract and 70% ethanol extract. The yield of the extract obtained then calculated.

2.2 Phytochemical Test of Extracts

The three types of extracts were carried out by phytochemical screening for alkaloids, flavonoids, saponins, tannins, and steroids/terpenoids. Alkaloids test using Dragendrof reagents, Mayer test and Bouchardat test (Ministry of Health of the Republic of Indonesia, 1995). Flavanoid test using Mg powder with a few drops of 5 M hydrochloric acid and Zn powder with a few drops of 5M hydrochloric acid. The tannin test uses 1% of gelatin in 10% NaCl and with a solution of FeCl3. Tannin test carried out by shaking for 10 minutes. Steroid and terpenoid tests using chloroform of concentrated H2SO4 (Kumoro, 2015).

2.3 Media Making

Weighed 20g for each medium of GDP and BHI, and 23g for NA media, then each of media was dissolved in 1 L of water, then placed in an Erlenmeyer and heated using a hot plate equipped with a magnetic stirrer until boil and clear. Then the media was covered with cotton and aluminum foil (Hidayat & Sutarma, 1999), and sterilized in an autoclave at 121ºC with a pressure of 1 atm for 20 minutes (Waluyo, 2008). After the heat is reduced, near the Bunsen burner was poured in a Petri dish and test tube (tilted) @ 5 ml. After the media has frozen, the sterilization test was done by putting it into a 37ºC incubator for 24 hours before the media is used. Each batch of media that has been tested for sterilization and quality then stored at 5ºC-8ºC (Hidayat & Sutarma, 1999).

2.3.1 Preparation of Bacteria and Fungus

One ose pure Candida albicans culture was inoculated on slanted solid PDB (Potato Dextrose Broth) media, while the pure culture of Streptococcus mutans in BHI (Brain Heart Infusion) media and Staphylococcus aureus was inoculated in slanted solid Nutrien Agar (NA) media. Then each test tube is closed with a plug (Waluyo, 2008). All the media then incubated at 37^0C and 20-25^0C for 24 hours. Bacteria and fungi that have been grown are then stored in a refrigerator at 4^OC as stock. The colonies of bacteria and fungi that have grown on each tilted media then made a suspension on a test tube containing 0.9% NaCl (physiological Na) by using ose, then homogenized. The turbidity of the suspension is likened to the standard solvent of Mc Farland 1 and then dilution is carried out up to 10^{-6}.

2.3.2 Test of Minimum Inhibitory Concentration (MIC)

The MIC test for the three types of extract produced was carried out by the dilution method, the concentration of the extract tested was presented in Table 1, and all treatments were duplicated.

Table 1: Extract concentration treatment (%) in testing the minimum inhibitory concentrations of bacteria and fungi.

Types of extract	Types of Bacteria and Fungus Test											
	Staphylococcus aureus				*Streptococcus mutans*				*Candida albicans*			
N-hexane	1	3	6	12	0,5	1	2,5	5	0,5	1	2,5	5
Ethyl acetate	1	3	6	12	0,5	1	2,5	5	0,5	1	2,5	5
70% ethanol	1	2	4	8	15	20	25	30	15	20	25	30

2.3.3 Test of Inhibition Zone

The inhibition zone test is carried out using the Paper Disc Diffusion method. The active ingredient in the form of an extract is placed in a 6 mm diameter disc aseptically, then placed on a media that has been inoculated with bacteria or fungi. The inhibition zone is measured by measuring the clear zone that occurs around the disc paper. This test is done in duplicate. For the inhibition zone test, the concentrations tested are based on the results of the MIC test. The positive control for Staphylococcus aureus bacteria is 10 ppm amoxicillin, mutant Streptococcus is 10 ppm clindamycin, Candida albicans used Nystatin 100.000 IU/ml, and all negative controls are DMSO 1%. The making of extract test solution is done by making 50% concentrated parent dissolve of each dry extract. The making of the test solution is carried out with a dilution formula based on concentration. The making of the paper disc was done by soaking the Whatman filter paper with a 6 mm diameter in extracts according to concentration for 30 minutes. Then dried in the oven for 24 hours in a Petri dish container at 40-50ºC until dry and ready for use. The concentrations used in the inhibition zones test are presented in Table 2 and each with 3 replications.

Table 2: Treatment of extract concentrations (%) tested on the inhibition zone test of bacteria and fungus.

Type of extract	Testing on Bacteria and Fungus														
	Staphylococcus aureus					*Streptococcus mutans*					*Candida albicans*				
N-hexane	12,5	25	50	K+	K-	2,5	5	10	K+	K-	2.5	5	10	K+	K-
Ethyl acetate	12.5	25	50	K+	K-	2,5	5	10	K+	K-	2.5	5	10	K+	K-
70% ethanol	8	16	32	K+	K-	25	30	35	K+	K-	25	30	35	K+	K-

3 RESULTS AND DISCUSSION

From 1100g cinnamon bark produces 1000g of simplicia cinnamon bark powder, brownish-colored simplicia powder, a slightly spicy-sweet taste with a characteristic aroma of cinnamon. The yield, water content and ash content are all meet the applicable requirements (Table 3).

Table 3: Characterization results of Simplisia Cinnamon Bark Powder.

Examination	Simplisia powder (%)	Requirements (%)	Category	Standard Reference
Yield	91	± 100	qualify	
Water content	8,24	< 10	qualify	Republic of Indonesia Ministry of Health year 2000
Ash content	3,68	< 10	qualify	Indonesian Herbal Pharmacopoeia, 2008

Water content is a quality indicator of the simplicia powder that needs to be known because water is a good medium for microbial growth so that it can result in decreased quality of simplicia. Low water content in simplicia can extend the shelf life of simplicia powder. The ash content of the simplicia powder of cinnamon bark obtained was 5.21%. The qualified determination of ash content was less than 10.5% (Ministry of Health of the Republic of Indonesia, 2008). The determination of ash content aims to determine levels of inorganic substances and minerals contained in simplicia originating from plants or contaminants during the manufacturing process of simplicia (Ministry of Health of the Republic of Indonesia, 1995). Ash levels in cinnamon bark powder simplicia still meet the Indonesian Herbal Pharmacopeia of 2008, which is 3.68% (< 10%).

3.1 Extraction Results

Multilevel maceration was carried out with a simplicia powder of 1000g, using three different solvents namely n-hexane, ethyl acetate and ethanol 70%, each solvent used in a ratio of 1:10. Maceration results obtained 3 filtrates with different solvents, and then each filtrate was vacuum dried until a dry extract of cinnamon bark was obtained. The results of the characteristics of n-hexane extract, Ethyl acetate extract, and 70% ethanol extract of cinnamon bark can be seen in Table 4.

Table 4: Characterization extracts Results of Multilevel Maceration Results of 1000g Simplisia Powder.

Type of Extract	Extract amount (g)	Yield (%)	Water content (%)	Colour	Aroma
N-hexane	37,5	3.75	4,95	Light brown	Typical cinnamon
Ethyl acetate	46,5	4,65	3,95	Light brown	Typical cinnamon
70% ethanol	324,7	32.47	2,90	Light brown	Typical cinnamon

The water content obtained in the n-hexane extract of cinnamon bark was 4.95%, ethyl acetate extract was 3.95% and 70% ethanol extract was 2.90%. The results of the water content of cinnamon bark extract meet the requirements of the dry extract water content of <5%. Different types of solvents affect the amount of extract produced. Ethanol (polar) extract has the highest yield because ethanol has a polar group that is stronger than non-polar groups; this can be seen from the chemical structure of ethanol containing hydroxyl (polar) groups and carbon (nonpolar) groups.

Ethanol can extract phytochemical compounds in higher amounts. The high yield in the ethanol solvent shows that the solvent was able to extract more bioactive components that have higher polarity properties. This is probably because the cinnamon bark component contains many polar compounds. The yield of ethyl acetate solvent is smaller than the ethanol solvent but larger than the n-hexane solvent; it is suspected that there is a methoxy group contained in the chemical structure of ethyl acetate. The presence of the methoxy group in the hydrogen bond sample formed in the ethyl acetate solvent is weaker than the hydrogen bond formed in the ethanol solvent; so that it can affect the yield of less solvent of the ethyl acetate.

3.2 Phytochemical Screening

This test was conducted to determine the class of compounds contained in extracts of n-hexane, ethyl acetate and ethanol of cinnamon bark after extraction. Tests carried out are alkaloid, flavonoid, tannin, and saponin. Phytochemical test results of n-hexane extract, ethyl acetate and ethanol of cinnamon bark can be seen in Table 5.

Table 5: Results of Qualitative Phytochemical Tests of Extracts.

Compound	N-Hexane Extract	Ethyl Acetate Extract	Ethanol Extract
Alkaloids	-	+	+
Flavonoids	-	-	+
Tannin	+	-	-
Saponin	-	-	+

+ = contain, - = not contain

Phytochemical test results indicate the presence of tannin compounds in n-hexane extract. The tannins contained in the n-hexane solvent are hydrolyzed tannins because it has a polyester structure that is easily hydrolyzed by acids or enzymes, and as a result of its hydrolysis is a polyphenic acid and simple sugar (Maldonado, 1994). Hydrolyzed tannins are present in non-food ingredients (Makkar et al., 1993). The positive ethyl acetate extract contains alkaloids because alkaloids can dissolve in semi-polar solvents. Alkaloids in plants are generally in the form of salts so that only soluble in inorganic solvents (chloroform, ethyl acetate, acetone, benzene, alcohol, ethanol, and methanol). In the 70% ethanol extract contains alkaloid, flavonoid and saponin compounds because the 70% ethanol is polar in nature so that it can attract polar compounds. From these results, it can be seen that there are other compounds that have efficacy as antimicrobials other than essential oils revealed by the research of Kadek (2011).

Alkaloids are the largest group of secondary metabolites and are mostly sourced in plants (Ningrum et al., 2016). Alkaloid compounds which have basic groups containing nitrogen will react with amino acid compounds that make up bacterial cell walls and bacterial DNA. This reaction results in changes in the structure and composition of amino acids. So it will cause changes in genetic balance in the DNA chain that will be damaged and encourage bacterial cell lysis that will cause death in bacterial cells. Flavonoids are polar compounds that are usually spread in plants and belong to the phenol group. Flavonoids are polar so it is easier to penetrate the peptidoglycan layer which is also polar in gram-positive bacteria than in the nonpolar lipid layer (Dewi, 2010). The mechanism of action of flavonoids as antimicrobials is by binding to extracellular proteins and dissolved proteins so that they lose their normal function, deactivate enzymes, and damage cell walls and bacterial cell membranes. Some flavonoids are bactericidal, bacteriostatic, fungicidal, and deactivate the lipophilic virus. Saponin is a secondary metabolite compound that functions as an antiseptic so that it has the ability as an antibacterial. The presence of these antibacterial substances will inhibit the formation or transport of components to the cell wall which results in the weak structure of the cell wall accompanied by loss of cell walls and release of cell contents which will ultimately kill or inhibit the growth of the bacterial cell. In addition, saponin compounds cause a decrease in cell surface tension and cause cells to become lysis.

3.3 Test Results of MIC

Test results on Streptococcus mutans and Candida albicans showed that n-hexane and ethyl acetate extracts had the same MIC at 2.5% concentration, and at 70% ethanol extract had 25% higher marked by the absence of a growing bacterial colony. In Staphylococcus aureus, on the contrary, n-hexane extract and ethyl acetate have the same MIC (12%), but the concentration is higher than ethanol extract, 8% ethanol extract in Staphylococcus aureus has shown no bacterial colonies. The results of the MIC test for 70% ethanol on Staphylococcus aureus get lower concentrations compared to n-hexane and ethyl acetate because the ethanol extract contains alkaloids, flavonoids, and tannins. Whereas in ethyl acetate and n-hexane the concentration used is higher because in ethyl acetate only contains flavonoid compounds and in n-hexane only contains tannin compounds. The MIC values for each microorganism are presented in Table 6.

Table 6: Test Results of MIC Extract (%) on Staphylococcus aureus, Streptococcus mutans, and Candida albicans.

Type of extract	Testing on Bacteria and Fungus		
	Staphylococcus aureus	*Streptococcus mutans*	*Candida albicans*
N-hexane	12	2,5	2,5
Ethyl acetate	12	2,5	2,5
70% ethanol	8	25	25

3.4 Test Results of Inhibiton Zone

Antimicrobial testing was carried out to see the concentration of each extract that had the greatest antimicrobial activity. This test is carried out using the Paper Disc Diffusion method. This method is used because it is more sensitive to new antimicrobial compounds whose activity is unknown. The inhibition of growth in the method is shown by the wide clear area (inhibition zone) that forms around the paper disk (Brander et al., 1999). (Davis & Stout, 2009) divides the strength of antibacterial power into four categories, namely inhibition weak (<5mm), moderate (5-10mm), strong (10-20mm), and very strong (> 20mm).

3.5 Staphylococcus aureus

Inhibition zone test results of ethanol extract, ethyl acetate and n-hexane extract in Staphylococcus aureus bacteria can be seen in Table 7.

Table 7: Average Test Results of Inhibition Zone (mm) Extracts on Staphylococcus aureus Bacterial Growth.

Type of extract	Concentration (%)	Average ZoI (mm) ±SD	Category
N-hexane	12,5	1,30±0.23	Weak
	25	2,33±0.23	Weak
	50	3,33±0.23	Weak
	K+	8,50±0,00	Medium
Ethyl acetate	12,5	1,86±1.8	Weak
	25	4,33±0.23	Weak
	50	5,90±0.40	Medium
	K+	8,50±0,00	Medium
70% ethanol	8	2,33±0.23	Weak
	16	3,50±0.40	Weak
	32	6,83±0.23	Medium
	K+	8,50±0,00	Medium

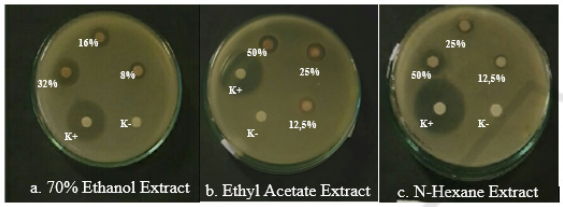


Figure 1: Inhibition Zone Test Results of Cinnamon bark extract against bacteria Staphylococcus aureus.

The results showed ethanol extract was an extract with inhibition zone results that were stronger than ethyl acetate extracts and ethyl acetate showed inhibition zone results that were stronger than n-hexane. Among the three solvents, extract with 70% ethanol solvent produced an average inhibition zone that was closer to positive control at 32% extract concentration. From the observations, it can be seen that the antibacterial activity of n-hexane extract produces a weak inhibitory power at the three concentrations used against *Staphylococcus aureus*. These results indicate that n-hexane extract has less antibacterial activity compared to ethyl acetate and 70% ethanol solvent. In observing the antibacterial activity of ethyl acetate extract at a concentration of 50%, it produces an inhibition zone with a moderate category of 5.9 mm, but when compared with 70% ethanol extract with a concentration of 32% it produces an inhibition zone of 6.83%. These results showed that extracts with 70% ethanol solvent had better antibacterial activity on *Staphylococcus aureus* than ethyl acetate or n-hexane solvents. According to other research conducted shows that the difference in the level of the polarity of the solvent affects the antibacterial properties. The research of *S. muticum* extract on *S. aureus* has the highest antibacterial properties in extracts using 96% ethanol solvent followed by ethyl acetate and n-hexane solvents according to the decrease in polarity. The higher the level of polarity, the better the antibacterial activity (Hidayah, 2016).

3.6 Staphylococcus mutans

The inhibition zone test results on Streptococcus mutans can be seen in Table 8 and in Candida albicans fungus can be seen in Table 9.

Table 8: Test Results of Inhibition Zone (mm) Cinnamon Bark Extract against Streptococcus mutans Bacteria.

Extract Type	Concentration (%)	Average ZoI (mm) ±SD	Category
N-hexane	2,5	3,83±3,01	Weak
	5	1,66±0,57	Weak
	10	1,66±0,57	Weak
	K+	13,00±0,00	Medium
Ethyl acetate	2,5	2,00±1,00	Weak
	5	2,00±1,00	Weak
	10	2,00±1,00	Medium
	K+	13,00±0,00	Medium
70% ethanol	25	5,30±2,36	Weak
	30	5,30±2,36	Weak
	35	5,30±2,36	Medium
	K+	13,00±0,00	Medium

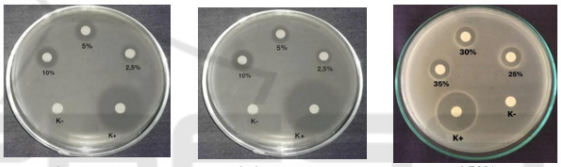


Figure 2: Inhibition Zone Test Results on Streptococcus mutans bacteria.

The statistical analysis results of the inhibition zone test on Streptococcus mutans showed that n-hexane and ethyl acetate extracts for all concentrations tested did not have a significant effect. For the n-hexane and ethyl acetate extracts, all the concentrations had inhibitory power with weak categories (<5mm). While the ethanol extract of all concentrations has inhibition in the medium category (5-10mm). This might be caused by the compounds contained in ethanol extracts including alkaloids, flavonoids, and saponins.

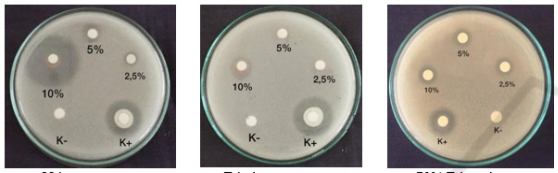
3.7 Candida albicans

The results of the inhibition zone test on *Candida albicans* showed that n-hexane extract at a concentration of 2.5% and 5% had inhibition zone of the weak category (<5 mm), and the concentration of 10% is very strong that is 14.50mm (10-20mm). The ethyl acetate extract with a 10% concentration has inhibition zone with a medium category of 7 mm (5-10 mm) equal to the positive control. The inhibition

zone test on ethanol extract of all concentrations tested has a weak inhibition power of 1.5 mm. The results of inhibition Test of cinnamon bark extract against the fungus *Candida albicans* are presented in Table 9.

Table 9: Test Results of Inhibition Zone (mm) on Cinnamon Bark Extract against Candida albicans.

Type of extract	Concentration (%)	Average ZOI (mm) ±SD	Category
N-hexane	2,5	1,00±0,00	Weak
	5	3,60±1,44	Weak
	10	14,50±0,86	Weak
	K+	7,00±0,00	Medium
Ethyl acetate	2,5	0,00±0,00	Weak
	5	0,00±0,00	Weak
	10	7,00±0,00	Medium
	K+	7,00±0,00	Medium
70% ethanol	25	1,50±0,00	Weak
	30	1,50±0,00	Weak
	35	1,50±0,00	Medium
	K+	7,00±0,00	Medium



N-hexane extract Ethyl acetate extract 70% Ethanol extract

Figure 3: Inhibition Zone Test Results in Candida albicans.

Statistical test results showed that there were no significant differences in extract concentration on the inhibition zone. Quantitatively showed that inhibition zone extract of n-hexane 10% against the fungus *Candida albicans* was greater than the positive control, which is 14.5mm (2 times of the positive control). This might be due to the tannin content in n-hexane extract. Tannin is a complex organic compound that acts as an antimicrobial. The presence of tannin as an antibacterial will disrupt the synthesis of peptidoglycan so that the formation of cell walls becomes less perfect. Circumstances that caused the bacterial cells to become lysis were due to osmotic and physical pressure so that bacterial cells became dead. In addition tannin compounds work by binding to protein walls so that the formation of bacterial cell walls is inhibited (Fahria & Muktiana, 2007).

4 CONCLUSION

From this study can be concluded:

1. Different solvents produce different antimicrobial effects. The effectiveness of cinnamon bark extract against the antibacterial Staphylococcus aureus and Streptococcus mutans respectively are ethanol extract, ethyl acetate extract, and n-hexane extract.
2. The effectiveness of cinnamon bark extract against fungus Candida albicans respectively is n-hexane extract, ethyl acetate extract, and ethanol extract.
3. The 10% concentration of n-hexane ethanol extract of cinnamon bark has strong antimicrobial power against Candida albicans with an inhibition zone of 14.50 mm over the positive control.

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