UNIVERSITAS
KRISTEN
MARANATHA

Fakultas Kedokteran Gigi

Jl. Prof. drg. Surya Sumantri, M.P.H. No. 65
Bandung - 40164, Jawa Barat, Indonesia
Telp: +62 22-201 2186 / 200 3450, ext. 1905 / 1906
Email: fkg@dent.maranatha.edu
www.maranatha.edu

SURAT TUGAS
No.252/SUT/FKG-UKM/IV/2024

Yang bertanda tangan di bawah ini

Nama : Dr. Ignatius Setiawan, drg., MM.
Jabatan : Dekan Fakultas Kedokteran Gigi Universitas Kristen Maranatha

Dengan ini menugaskan kepada :

Dr. Vinna Kurniawati Sugiaman, drg., M.Kes., PBO – NIK.120005

Melaksanakan publikasi jurnal dengan judul : "*Antibacterial Properties of Citronella Oil Against Streptococcus mutans and Candida albicans by In Vitro Study*" di Jurnal Kedokteran Brawijaya pada tahun 2024.

Demikian agar tugas ini dilaksanakan dengan sebaik-baiknya.

Bandung, 03 April 2024
Dekan Fakultas Kedokteran Gigi
Universitas Kristen Maranatha

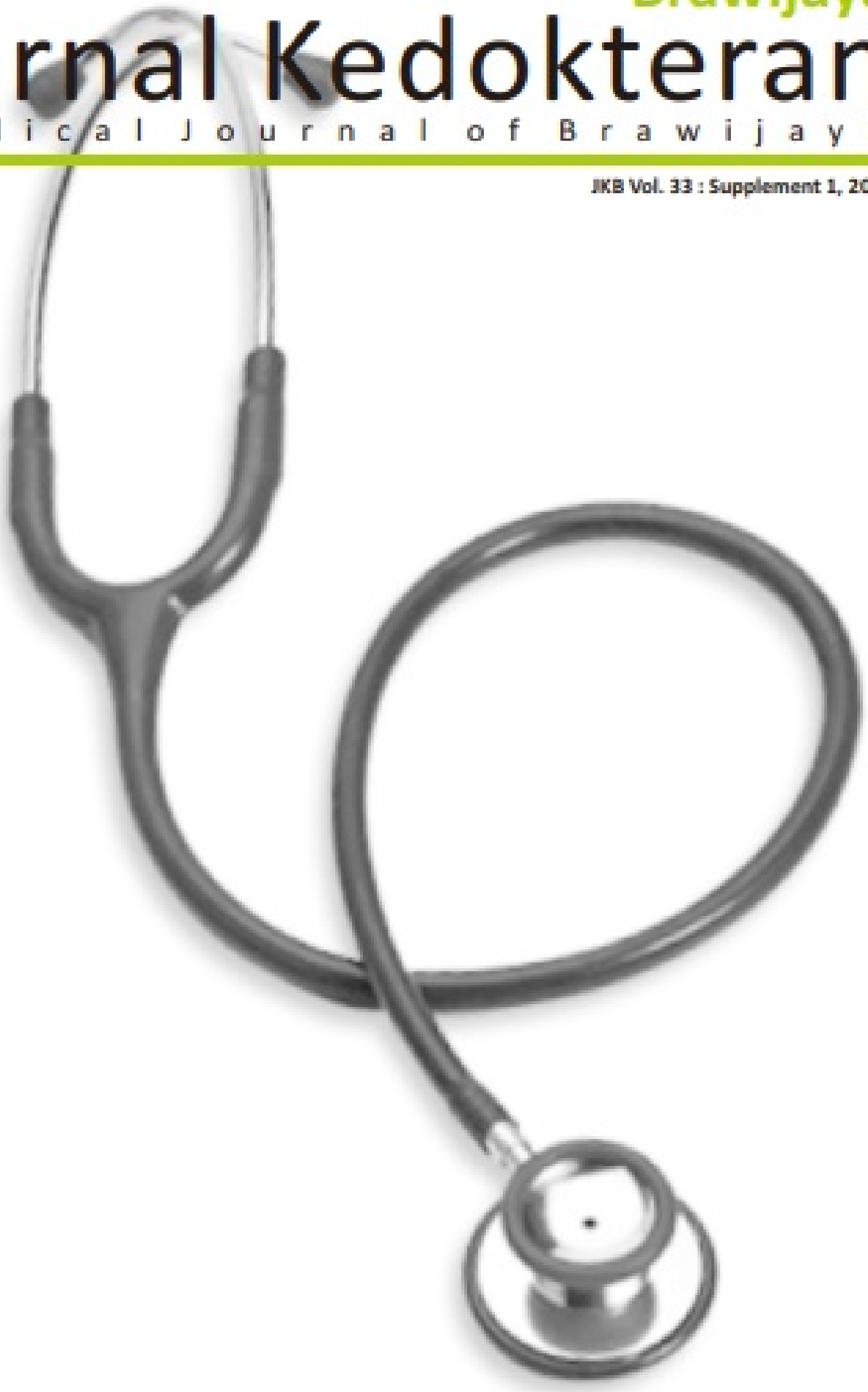
Dr. Ignatius Setiawan,drg., MM..
NIK. 120010

Brawijaya

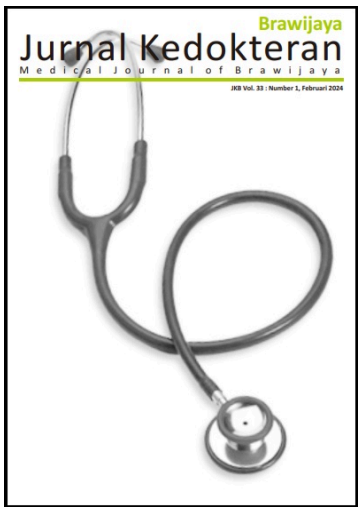
Jurnal Kedokteran

Medical Journal of Brawijaya

JKB Vol. 33 : Supplement 1, 2024



Vol. 33 No. 1 (2024)



Published: 2024-02-29

Research Article

Antibacterial and Antifungal Properties of Citronella oil Against Streptococcus mutans and Candida albicans by In Vitro Study

Page: p.1-5, Abstract views: 137, PDF downloads: 58

Vinna Kurniwati Sugiaman(1), **Wahyu Widowati**(2), **Hanna Sari Widya Kusuma Widya Kusuma**(3), **Nindia Salsabila**(4), **Rizal Rizal**(5),

(1) Faculty of Densitry Universitas Kristen Maranatha Bandung
(2) Faculty of Medicine Universitas Kristen Maranatha Bandung
(3) Aretha Medika Utama Biomolecular and Biomedical Research Center Bandung
(4) Aretha Medika Utama Biomolecular and Biomedical Research Center Bandung
(5) Biomedical Engineering Department of Electrical Engineering Faculty of Engineering Universitas Indonesia Jakarta
(*) Corresponding Author

PDF

Correlation between the Degree of Psychological Stress with Pain Intensity in Tension-Type Headache Patients

Page: p.6-10, Abstract views: 160, PDF downloads: 64

Pagan Pambudi(1), **Oktaviana Sidabutar**(2),

(1) Faculty of Medicine Universitas Lambung Mangkurat Banjarmasin
(2) Faculty of Medicine Universitas Lambung Mangkurat Banjarmasin
(*) Corresponding Author

PDF

Modification of qSOFA Increases Mortality Prediction Accuracy in Sepsis Patients

Page: p.11-16, Abstract views: 103, PDF downloads: 46

Erik Jaya Gunawan[(1)], **Salmon Charles Pardoman Tua Siahaan**[(2)], **Areta Idarto**[(3)], **Florence Pribadi**[(4)], **Lidya Handayani**[(5)],

(1) Universitas Ciputra Surabaya
(2) Universitas Ciputra Surabaya
(3) Universitas Ciputra Surabaya
(4) Universitas Ciputra Surabaya
(5) Universitas Ciputra Surabaya
(*) Corresponding Author

PDF

The Characteristics of Preeclampsia and Eclampsia Patients at Dr. T.C. Hillers Regional Hospital Maumere

Page: p.17-22, Abstract views: 182, PDF downloads: 72

Bagus[(1)], **Rommy**[(2)], **Advent CT Conterius**[(3)],

(1) Regional Hospital Dr TC Hillers Maumere
(2) Regional Hospital Dr TC Hillers Maumere
(3) Regional Hospital Dr TC Hillers Maumere
(*) Corresponding Author

PDF

The First Experience and Benefits of the 12-week VIVIFRAIL Exercise and Its Workout Music Selection for Elder Adults in the Community of Ardirejo, Kepanjen

Page: p.23-30, Abstract views: 224, PDF downloads: 80

Sri Soenarti[(1)], **Victoria Maya Kurniawati**[(2)], **Fifi Afifatus Zakiya**[(3)], **Marshanda Shella Pramesta**[(4)], **Rita Sulistyaningsih**[(5)], **Harien Lestari**[(6)], **Iftinan Amalia**[(7)], **Silmy Marintan**[(8)],

(1) Division Geriatric Department of Internal Medicine Faculty of Medicine Universitas Brawijaya Malang
(2) Nursing Science Program Faculty of Health Sciences Universitas Brawijaya Malang
(3) Nursing Science Program Faculty of Health Sciences Universitas Brawijaya Malang
(4) Nursing Science Program Faculty of Health Sciences Universitas Brawijaya Malang
(5) Department of Physical Medicine and Rehabilitation Universitas Brawijaya Malang
(6) Department of Physical Medicine and Rehabilitation Universitas Brawijaya Malang
(7) Department of Physical Medicine and Rehabilitation Universitas Brawijaya Malang
(8) Division Geriatric Department of Internal Medicine Faculty of Medicine Universitas Brawijaya Malang
(*) Corresponding Author

PDF

Literature Review

The Potential of Shell Extract as a Hemostasis and Wound Healing Agent: A Literature Review

Page: p.31-39, Abstract views: 153, PDF downloads: 87

Putri Erlyn[(1)], **Irfannuddin Irfannuddin**[(2)], **Krisna Murti**[(3)], **Aldes Lesbani**[(4)],

(1) Department of Pharmacology Faculty of Medicine Universitas Muhammadiyah Palembang
(2) Department of Physiology Faculty of Medicine Universitas Sriwijaya Palembang
(3) Department of Anatomical Pathology Faculty of Medicine Universitas Sriwijaya Palembang
(4) Research Center of Inorganic Materials and Complexes Faculty of Mathematics and Natural Sciences Universitas Sriwijaya Palembang
(*) Corresponding Author

PDF

The Effect of Social Support on Adolescent Mental Health: Literatur Review

Page: p.40-45, Abstract views: 204, PDF downloads: 86

Ana Pujianti Harahap[(1)], **Andi Daramusseng**[(2)], **Risza Choirunissa**[(3)], **Sri Achadi Nugraheni**[(4)],

(1) Doctoral Program in Faculty of Public Health Universitas Diponegoro Semarang
(2) Doctoral Program in Faculty of Public Health Universitas Diponegoro Semarang
(3) Doctoral Program in Faculty of Public Health Universitas Diponegoro Semarang
(4) Nutrition Program in Faculty of Public Health Universitas Diponegoro Semarang
(*) Corresponding Author

PDF

Promising Anthelmintic Properties of Papaya (Carica Papaya) Extract: A Literature Study

Page: p.46-53, Abstract views: 144, PDF downloads: 108

Syanur An-Nisa[(1)], **Silma Amalia Putri**[(2)], **M Luqman Affandi**[(3)], **Aulia Rahmi Pawestri**[(4)],

(1) Bachelor Study Program of Medicine Faculty of Medicine Universitas Brawijaya Malang
(2) Bachelor Study Program of Medicine Faculty of Medicine Universitas Brawijaya Malang
(3) Bachelor Study Program of Medicine Faculty of Medicine Universitas Brawijaya Malang
(4) Department of Parasitology Faculty of Medicine Universitas Brawijaya Malang
(*) Corresponding Author

PDF

Review of Determinants of Nonmedical Caesarean Section in Indonesia: A Systematic Review

Page: p.54-61, Abstract views: 171, PDF downloads: 71

Sigit Nurfianto[(1)], **Rachmad Suhanda**[(2)], **Ferina Agustia Yuarta**[(3)], **Priska Refani**[(4)], **Thyrister Nina Asarya Sembiring**[(5)], **Dhea Sofiana Mellazulfa**[(6)], **Yoriko Laurentina**[(7)], **Yeni Yeni**[(8)],

(1) 1Department of Obstetrics and Gynecology Faculty of Medicine Universitas Palangkaraya Palangkaraya
(2) Department of Public Health/Community Medicine Faculty of Medicine Universitas Syiah Kuala Banda Aceh
(3) Department of Public Health Faculty of Public Health Universitas Airlangga Surabaya

(4) Yasmin Mother and Child Hospital Palangkaraya
(5) Yasmin Mother and Child Hospital Palangkaraya
(6) Yasmin Mother and Child Hospital Palangkaraya
(7) Yasmin Mother and Child Hospital Palangkaraya
(8) Yasmin Mother and Child Hospital Palangkaraya
(*) Corresponding Author

PDF

Case Report

Conservative Management of Early Grade Unilateral Reinke's Edema with Laryngopharyngeal Reflux

Page: pp.62-64, Abstract views: 107, PDF downloads: 44

Sutji Pratiwi Rahardjo[(1)],

(1) Department of Otorhinolaryngology Head and Neck Surgery Faculty of Medicine Universitas Hasanuddin Makassar
(*) Corresponding Author

PDF

Malaria Falciparum in Pregnancy: A Case Series from an Endemic Area

Page: p.65-69, Abstract views: 166, PDF downloads: 73

Bagus[(1)], **Rommy**[(2)],

(1) RSUD T.C. Hillers Maumere
(2) RSUD T.C. Hillers Maumere
(*) Corresponding Author

PDF

Recurrent Severe Spasmophylia from Hypocalcaemia: A Case Report

Page: p.70-73, Abstract views: 208, PDF downloads: 135

Rizaldy Taslim Pinzon[(1)], **Ruth Vanessa Gloria Sinaga**[(2)],

(1) Department of Neuorology Bethesda Hospital Yogyakarta
(2) Faculty of Medicine Universitas Kristen Duta Wacana Yogyakarta
(*) Corresponding Author

PDF

About JKB

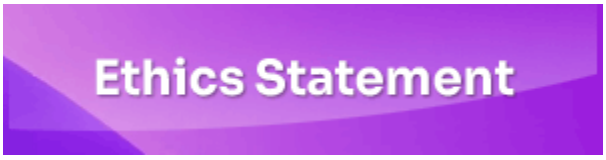
Aim and Scope
Publication Ethics
Visitor Statistic
Contact Us

Information for Author
General Information
Online Submissions
Author Guidelines
The Authors Data
Ethics Statement
Template

Information for Reviewer
Peer Review Process

Make a Submission

TEMPLATES



Editorial Team

Cholid Tri Tjahjono, Department of Heart and Vascular Sciences, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Dearisa Surya Yudhantara, Department of Psychiatric Medicine, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar

Devita Rahmani Ratri, Department of Hospital Management Masters Science, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar

Dewi Kartikawatiningsih, Department of Nursing Sciences, Faculty of Health Sciences, Universitas Brawijaya, Indonesia; Google Scholar

Dewi Santosaningsih, Department of Microbiology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Diadjeng Setya Wardani, Department of Obstetrics, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Diah Priharsari, Faculty of Computer Science, Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Dian Natasya Raharjo, Faculty of Pharmacy, Universitas Surabaya, Indonesia; Google Scholar

Djoko Wahono Soeatmadji, Department of Internal Medicine, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Edi Widjajanto, Department of Clinical Pathology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Efta Triastuti, Department of Pharmacy, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar, ScopusID

Ema Pristi Yunita, Department of Pharmacy, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Eriko Prawestiningtyas, Department of Forensic and Medicolegal Sciences, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar

Eviana Norahmawati, Department of Anatomical Pathology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Nanik Setijowati, Department of Public Health Sciences, Faculty of Medicine, Universitas Brawijaya, Indonesia; Google Scholar, ScopusID

Nashi Widodo, Faculty of Mathematics and Natural Sciences Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Nia Novita Wirawan, Department of Nutrition, Faculty of Health Sciences Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Nikma Fitriasari, Department of Public Health Sciences, Faculty of Medicine, Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Noorhamdani AS, Department of Clinical Microbiology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Novi Arfarita, Faculty of Medicine, Universitas Islam Malang & IRC-MEDMIND, Indonesia; Google Scholar; ScopusID

Novi Khila Firani, Faculty of Dentistry, Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Nur Samsu, Department of Internal Medicine, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Mohammad Saifur Rohman, Department of Heart and Vascular Sciences, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Muhammad Sasmito Djati, Faculty of Mathematics and Natural Sciences Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Putu Eka Sudaryatma, Fish Quarantine and Inspection Agency, Ministry of Marine Affairs and Fisheries Indonesia, Indonesia; ResearchGate; ScopusID

Retty Ratnawati, Department of Physiology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Respati Suryanto Dradjat, Department of Orthopedics and Traumatology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

Safrina Dewi Ratnaningrum, Department of Anatomy Histology, Faculty of Medicine Universitas Brawijaya, Indonesia; Google Scholar; ScopusID

About JKB

Make a Submission

Editorial Office:

Faculty of Medicine, Universitas Brawijaya
Road. Veteran, Malang (65145), East Java, Indonesia
email: jkb@ub.ac.id

Accessed on: http://jkb.ub.ac.id/index.php/jkb/article/view/3410
Jurnal Kedokteran Brawijaya Vol. 33, No. 1, February 2024, pp. 1-5
Article History: Received 10 April 2023, Accepted 29 February 2024

Research Article

Antibacterial and Antifungal Properties of Citronella oil Against Streptococcus mutans and Candida albicans by In Vitro Study

Sifat Antibakteri dan Anti-fungal Minyak Sereh terhadap *Streptococcus mutans* dan *Candida albicans* Secara In Vitro

Vinna Kurniawati Sugiaman[1], Wahyu Widowati[2], Hanna Sari Widya Kusuma[3], Nindia Salsabila[4], Rizal Rizal[5]

[1]Faculty of Densitry Universitas Kristen Maranatha Bandung

[2]Faculty of Medicine Universitas Kristen Maranatha Bandung

[3,4]Aretha Medika Utama Biomolecular and Biomedical Research Center Bandung

[5]Biomedical Engineering Department of Electrical Engineering Faculty of Engineering Universitas Indonesia Depok

ABSTRACT

Streptococcus mutans and Candida albicans are the main microorganisms that cause dental cavities. It can cause infection, damaged tissue around teeth, abscesses, and focal infection to other organs in the body. Natural products are currently widely used as products or as additives in the prevention of dental caries which have more anti-bacterial and anti-fungal activities than antibiotics that can cause resistance. Citronella (Cymbopogon citratus) is abundant and easy to grow. This study was conducted to determine the effectiveness of citronella (Cymbopogon citratus) oil on the growth of S. mutans and C. albicans microorganisms by Minimum Inhibitory Content (MIC) and Minimum Bactericidal Content (MBC). The method of MIC is broth microdilution by making chlorhexidine concentration levels of 100%, 50%, 25%, 12.5%, 6.25%, 3.125%, and 0.2% with 4 replications each. The MIC value was determined based on absorbance spectrophotometry and the MBC value was determined from the agar plate using the spread method. Biofilm eradication test was conducted by crystal-violet staining and measuring the absorbance. The results of MIC and MBC were obtained on S. mutans, namely at concentrations of 25% and 100%, respectively. Meanwhile, the results of MIC and MBC on C. albicans were obtained at concentrations of 50% and 100%, respectively. Furthermore, the citronella oil has antibacterial and antifungal activities.

Keywords: *Antimicrobial, Candida albicans, Minimum Bactericidal Content, Minimum Inhibitory Concentration, Streptococcus mutans*

ABSTRAK

Streptococcus mutans dan *Candida albicans* merupakan mikroorganisme utama penyebab gigi berlubang. Hal ini dapat menyebabkan infeksi, kerusakan jaringan di sekitar gigi, abses dan infeksi fokal ke organ tubuh lainnya. Produk alami saat ini banyak digunakan sebagai produk atau sebagai bahan tambahan dalam pencegahan karies gigi yang memiliki aktivitas anti bakteri dan anti jamur dibandingkan antibiotik yang dapat menyebabkan resistensi. Citronella (*Cymbopogon citratus*) melimpah dan mudah tumbuh. Penelitian ini bertujuan untuk mengetahui efektivitas minyak serai wangi (*Cymbopogon citratus*) terhadap pertumbuhan mikroorganisme *S. mutans* dan *C. albicans* berdasarkan *Minimum Inhibitory Content* (MIC) dan *Minimum Bactericidal Content* (MBC). Metode MIC adalah mikrodilusi kaldu, dengan membuat kadar konsentrasi klorheksidin 100%, 50%, 25%, 12,5%, 6,25%, 3,125%, dan 0,2% dengan masing-masing 4 ulangan. Nilai MIC ditentukan berdasarkan spektrofotometri absorbansi dan nilai MBC ditentukan dari lempeng agar menggunakan metode sebar. Uji eradikasi biofilm dilakukan dengan pewarnaan kristal-violet dan diukur absorbansinya. Hasil MIC dan MBC diperoleh pada *S. mutans* yaitu pada konsentrasi masing-masing 25% dan 100%, serta hasil MIC dan MBC pada *C. albicans* diperoleh pada masing-masing konsentrasi 50% dan 100%. Selain itu, minyak serai memiliki aktivitas antibakteri dan antijamur.

Kata Kunci: Antimikroba*, Candida albicans, Kandungan Bakterisida Minimum, Konsentrasi Hambat Minimum, Streptococcus mutans*

Correspondence: Wahyu Widowati. Faculty of Medicine Universitas Kristen Maranatha Bandung, Jl. Prof. Drg. Surya Sumantri No. 65, Bandung, West Java, Indonesia Tel. +62022-2102186/+6222-70753665 Email: wahyu_w60@yahoo.com

DOI: http://dx.doi.org/10.21776/ub.jkb.2024.033.01.1

INTRODUCTION

Dental cavities in people have been linked to *Streptococcus mutans* as the main causative agent. The bacterium's capacity to create the biofilm known as dental plaque on teeth surfaces is a crucial aspect of its pathogenicity (1). This organism also has surface proteins that work together to form tooth plaque and cause dental cavities, including glucosyltransferases, numerous glucan-binding proteins, protein antigen C, and collagen-binding protein (2). *Candida albicans* colonization caused significant microbial dysbiosis characterized with distinct microbial composition and structure as compared to the biofilm in the absence of *C. albicans.* These findings is in agreement with previous studies showing that *C. albicans* influenced the microbial composition of saliva biofilms (3). The primary bacterial pathogen in tooth caries, especially in early-childhood caries (ECC), is frequently identified as S. mutans. *Candida albicans* cells are commonly found in plaque biofilms from ECC-affected infants, along with heavy infection by *S. mutans*, suggesting that *S. mutans* may not act alone. Exopolysaccharide (EPS) synthesis is increased by the presence of *C. albicans*, causing cospecies biofilms to accumulate more biomass and contain more live *S. mutans* cells than single-species biofilms (4).

Nowadays, the demand for natural preservatives is solely related to the increasing interest in healthy lives and health issues. Additionally, the use of antibiotics leads to the development of multidrug resistant microorganisms, so research into these natural components has gained more focus in the scholarly community (5). Numerous useful natural compounds derived from various plant species have been found to possess antimicrobial qualities (6). Among them, some essential oils (EOs) have the potential to be useful food stabilizers, making them appealing substitutes for manufactured compounds (7). Additionally, EOs are not too difficult to obtain, ecologically favorable (they degrade rapidly in soil and water), and not too harmful to people (8).

Tropical and subtropical areas of the globe are home to *Cymbopogon citratus*, more commonly known as "Lemon Grass" (9). *C. citratus* is native to Asia (Indochina, Indonesia, and Malaysia), Africa, and the Americas, but is widely cultivated in temperate and tropical regions of the world (10). Alpha citral (geranial), beta citral (neral), and myrcene are the three primary constituents of this *C. citratus* essential oil. While studies have proven the antibacterial activity of alpha and beta citral against gram-positive and gram-negative bacteria as well as fungistatic activity against Candida species, myrcene has not exhibited any antimicrobial activity (11). The therapeutic actions of *C. citratus* include anti-amoebic, antibacterial, antidiarrheal, antifilarial, antifungal, and anti-inflammatory effects. Antimalarial, antimutagenic, anti-mycobacterial, antioxidant, hypoglycemia, and neurobehavioral benefits, among others, have also been researched (12). With all of the benefits of *C. citratus* stated above, this study were to determine the effectiveness of citronella (*C. citratus*) oil on the growth of *S. mutans* and *C. albicans* microorganisms as antibacterial and antifungal activity.

METHOD

Preparation of Citronella Oil

The extraction was carried out at the Pharmaceutical Company PT Indesso Aroma, Baturaden, Purwokerto, Central Java with CoA No Batch. 895850017. The extraction was carried out for the plan to develop standardized herbal medicines from natural ingredients consisting of Citronella extract as an anti-bacterial and anti-fungal. The extraction method started by washing the lemongrass and cutting them to ¼cm x ¼cm x ¼cm. Methanol was used as maceration solvent with ratio of 1:10 between solute and solvent. Maceration was carried out for 10 hours (13). The resulting extract is in the form of oil.

Research on the MIC and MBC tests of citronella oil on the growth of *S. mutans* and *C. albicans* was carried out at the Aretha Medika Utama Bandung Biomolecular and Biomedical Laboratory, with work procedures using the 2012 CLSI (Clinical Laboratory Standard Institute) method with modifications. This research is pure experimental laboratory in vitro by comparing the sample groups containing citronella oil with concentrations 100%, 50%; 25%; 12.5%; 6,25%, and 3.125% and positive control in the form of 0.2% chlorhexidine (Minosep) with 4 replication. Citronella oil dilution was carried out by adding n-hexane. Chlorhexidine was acted as the positive control because it was reported that Chlorhexidine was an antiseptic that could go averse to both types of bacteria, viruses, and facultative aerobes and anaerobes (14). The growth control was used as the negative control.

Antibacterial and Antifungal Assay

The isolates of *S. mutans* and *C. albicans* were obtained by sub culture in MHA media at 37°C for 24 hours. Some of the colonies were inoculated to 10ml MHB. McFarland 0.5 standard was used to adjust the turbidity. Inoculum was obtained by conducting dilution to the solution with physiological solution. Media MHB with ratio of 1:20 was then used to conduct dilution. The inoculum was then obtained in the range of 1-5 x 10^5 CFU/ml. The MIC of Citronella oil against *S. mutans* and *C. albicans* was determined by the broth microdilution method as recommended by the Clinical and Laboratory Standards Institute (CLSI) M07-A9.

At the final concentration, 100µL of Citronella oil was added into 96-well microplate. For the positive control we added 100µl of 0.2% chlorhexidine (Minosep) to the well. The sample of each bacterial and fungal suspension (24h incubated *S. mutans* and *C. albicans*) respectively with a concentration of 1.5 × 106CFU/mL with Mueller Hinton Broth (Himedia, M403-500G) were also added to the wells. The microplate was incubated for 24 hours at 37°C in anaerobic condition then measured the absorbance with Spectrophotometry (Multiskan GO Thermo Scientific 51119300) at 415nm for *S. mutans* and 510nm for *C. albicans.* The MIC was determined as the lowest concentration of Citronella oil in which visible bacterial and fungi growth was inhibited. Also, the quantitative evaluation of microbial growth was determined based on the previous study (15).

The MBC was considered to be the lowest concentration of Citronella oil which prevented the growth and reduced the

inoculum by >99.9% within 24 hours, irrespective of counts of survivors at higher sample concentrations. For this purpose, 20µL of contents of the well determined as the MIC and also the wells with a concentration of 2 $\times 10^3$CFU/ml were cultured in spread inoculation in the Mueller Hinton Agar by pour plate method (Himedia, M096-500G) and incubated for 24 hours in anaerobic condition with the temperature of 37°C and 5% CO_2 (15). Colony counter was used to count the total colony. The optical density (OD) measurement utilized microplate reader at wavelength of 625 nm. Treatments' OD were compared to Blank's OD.

RESULT

The measurement of optical density of Citronella oil against *S. mutans* results are presented in the table I, that showed Citronella oil 3.125% has the highest average value of absorbance with 0.2613 and lowest in the chlorhexidine control with mean values absorbance 0.0011. On the results of various measurements extract treatment, showed that the average value the highest corrected absorbance is found in the concentration of Citronella oil 100% with the absorbance value is 0.0023, This shows that *S. mutans* can be inhibited by Citronella oil.

The measurement of optical density of Citronella oil against *C.albicans* results are presented in the Table 1. The data showed that Citronella oil 3.125% has the highest average value of absorbance with 0.1192 and lowest in the chlorhexidine control with mean values absorbance 0.0012. Based on the measurement result of various extract treatments, Citronella oil 100% exhibited the highest absorbance value, which is 0.0022. It means that *C. albicans* could be inhibited by Citronella oil. The result of MBC *S.mutans* and *C. albicans* were shown in Table II. It was showed that both Chlorhexidine 0.2% and Citronella oil 100% resulted in zero total colony (0 CFU/ml). It means that Citronella oil 100% exhibited the same result as the positive control. Meanwhile, the highest total colony count came from Citronella oil 3.125% with average 253250 CFU/ml. In *C. albicans*, it is shown that the lowest total colony count at Citronella oil 100% with 0 CFU/ml and the highest at Citronella oil 3.125% with 61750 CFU/ml.

Table 1. Table of optical density of *S. mutans and C. albicans*

Samples	Optical Density (OD)	
	S. mutans	***C. albicans***
Chlorhexidine 0.2%	0.0012 ± 0.0001	0.0012 ± 0.0014
Citronella oil 100%	0.0023 ± 0.0002	0.0012 ± 0.0004
Citronella oil 50%	0.0415 ± 0.0002	0.0337 ± 0.0004
Citronella oil 25%	0.0939 ± 0.0002	0.0567 ± 0.0010
Citronella oil 12.5%	0.1917 ± 0.0003	0.0775 ± 0.0002
Citronella oil 6.25%	0.1961 ± 0.0002	0.1057 ± 0.0007
Citronella oil 3.125%	0.2613 ± 0.0004	0.1192 ± 0.0002

Note: *Data provided as mean ± STD

Table 2. Table of total colony count of *S.Mutans* and *C. albicans*

Samples	Total Colony (CFU/ml)	
	S. mutans	***C. albicans***
Chlorhexidine 0.2%	0 ± 0	0 ± 0
Citronella oil 100%	0 ± 0	0 ± 0
Citronella oil 50%	20250 ± 957	4500 ± 1290
Citronella oil 25%	103750 ± 2500	28750 ± 2217
Citronella oil 12.5%	139500 ± 2380	43500 ± 4434
Citronella oil 6.25%	191500 ± 5447	53500 ± 5322
Citronella oil 3.125%	253250 ± 2217	61750 ± 4645

Note: *Data provided as mean ± STD

Concentration of an antibacterial agent in the lowest value that could inhibit an organism development visually is called MIC (16). In this research, MIC value of Citronella oil against *S. mutans* and *C. albicans* was taken by the concentration of Citronella oil 25% with 75.08% and 53.66% repectively. MBC value was determined by concentration that could inhibit the growth of 99.9% organism (17). In this research, the MBC value of Citronella oil against *S. mutans* and *C. albicans* was taken by the concentration of Citronella oil 100% with 99.38% and 99.04%, respectively (Figure 1).

DISCUSSION

Terpenes, alcohols, ketones, aldehydes, and esters make

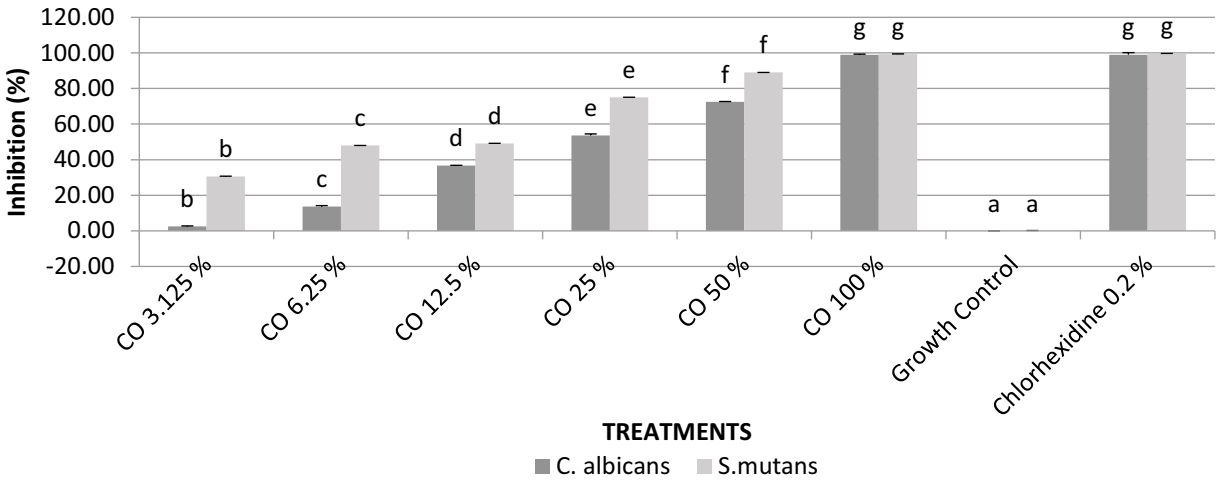


Figure 1. Citronella oil (CO) inhibition against *S. mutans* and *C. albicans*

Note: *Data was presented in mean ± STD. Difference letters (a,b,c,d,e,f,g) were shown significantly difference among treatments in each sample ($p<0.05$) based on Tukey Post Hoc Test.

up the majority of the substances found in *Cymbopogon citratus*. Essential oils that contain Citral, Nerol Geraniol, Citronellal, Terpinolene, Geranyl acetate, Myrcene, and Terpinol Methylheptenone are a few of the documented phytoconstituents. The plant is also said to contain phenolic substances like luteolin, isoorientin 2'-O-rhamnoside, quercetin, kaempferol, and apigenin as well as flavonoids. Numerous pharmaceutical actions, including anti-amoebic, antibacterial, antidiarrheal, antifilarial, antifungal, and anti-inflammatory characteristics, have been linked to *Cymbopogon citratus*, according to studies. Antimalarial, antimutagenic, anti-mycobacterial, antioxidant, hypoglycemia, and neurobehavioral benefits, among others, have also been researched (12).

Citronellal compounds, citronellol, geraniol, geranyl acetate, and citronellyl acetate were terpenoids. In order to reduce the permeability of the bacterial cell wall and cause the cells to lack nutrients, inhibit bacterial growth, or die, terpenoid compounds damage the membranes of lipophilic compounds by forming strong polymer bonds and harming porins (18). Monoterpene substances work as an antibiotic by having a toxic impact on the composition and operation of bacterial cell membranes. Since monoterpenes are lipophilic, they transition from the polar phase to the non-polar bacterial cell membrane structure (19).

Luteolin's ability to block DNA topoisomerase I and II activity, which led to a reduction in the production of nucleic acids and proteins, is what gives it its antibacterial properties (20). An important flavonoid compound, called quercetin has a wide range of medicinal effects. Numerous studies examine its antibacterial effects and potential mechanisms of action. It has been demonstrated that quercetin prevents the development of various Gram-positive and Gram-negative bacteria, fungus, and viruses. The method of its antimicrobial action involves mitochondrial failure, cell membrane injury, altered membrane permeability, suppression of protein and nucleic acid synthesis, downregulation of virulence factor expression, and prevention of biofilm formation. A powerful antimicrobial agent against drug-resistant strains, quercetin, has also been shown to suppress the development of a number of drug-resistant microorganisms (21). Kaempferol targets the stability of the bacterial membrane to produce its antibacterial properties (22).

Secondary compounds of plants with antifungal action include flavonoids by denaturing the extracellular proteins of the fungus cell walls, flavonoids cause harm to the fungal cell walls and block the activity of enzymes. Denatured proteins disturb the process of how cells are made, resulting in modifications to the protein structure and an increase in cell membrane porosity. This rise results in intracellular material leaks, cellular ATP shortage, metabolism disturbance, growth suppression, and cell lysis (23). Although the exact method by which terpenoid compounds prevent the growth of fungus is still unknown, the existence of lipophilic or hydrophobic characteristics in terpenoid compounds causes cell coagulation and cytoplasmic membrane damage in fungal cells (24).

Based on the antibacterial and antifungal assay, Citronella oil 100% showed the best inhibition than any other concentrations. In addition, Citronella oil showed better inhibition to *S. mutans* in overall concentrations. However, the MIC obtained at concentration of 25% for both *S. mutans* and *C. albicans.* Previous study showed that *C. nardus* essential oil exhibited *S. mutans* activity at 25% (25). Meanwhile, inhibition of *C. albicans* was showed at concentration of 6.25%. This means that the result of this study is comparable to prior study. This study was hindered by some limitations, one of which is that the characterization of citronella oil has not been able to be conducted, thus restraining the ability to know the exact compound that is responsible for these bioactivity.

Citronella oil has the potency for antibacterial and antifungal treatment, through inhibit *S. mutans* and *C. albicans* growth.

ACKNOWLEDGEMENT

We are gratefully acknowledging Aretha Medika Utama, Biomolecular and Biomedical Research Center, Bandung, West Java, Indonesia, that had sponsored, facilitated, and supported this research. We also appreciate PT Indesso Aroma, Baturaden, Purwokerto, Central Java, for preparing the Citronella extract.

REFERENCES

1. Hamada S and Slade HD. *Biology, Immunology, and Cariogenicity of Streptococcus mutans*. Microbiological Reviews. 1980; 44(2): 331-384.
2. Matsumoto-Nakano M. *Role of Streptococcus Mutans Surface Proteins for Biofilm Formation.* Japanese Dental Science Review. 2018; 54(1): 22-29.
3. Du Q, Ren B, He J, *et al. Candida albicans Promotes Tooth Decay by Inducing Oral Microbial Dysbiosis*. International Society for Microbial Ecology. 2021; 15(3): 894-908.
4. Falsetta ML, Klein MI, Colonne PM, *et al. Symbiotic Relationship between Streptococcus Mutans and Candida Albicans Synergizes Virulence of Plaque Biofilms In Vivo*. Infection and Immunity. 2014; 82(5): 1968-1981.
5. Quinto EJ, Caro I, Villalobos-Delgado LH, Mateo J, De-Mateo-Silleras B, and Redondo-Del-Río MP. *Food Safety through Natural Antimicrobials*. Antibiotics. 2019; 8(4): 1-30.
6. Munekata PES, Rocchetti G, Pateiro M, Lucini L, Domínguez R, and Lorenzo JM. *Addition of Plant Extracts to Meat and Meat Products to Extend Shelf-Life and Health-Promoting Attributes: An Overview. Current Opinion in Food Science*. 2020; 31: 81-87.
7. Ekpenyong CE and Akpan EE. *Use of Cymbopogon Citratus Essential Oil in Food Preservation: Recent Advances and Future Perspectives*. Critical Reviews in Food Science and Nutrition. 2017; 57(12): 2541-2559.
8. Dhakad AK, Pandey VV, Beg S, Rawat JM, and Singh A. *Biological, Medicinal and Toxicological Significance of Eucalyptus Leaf Essential Oil: A Review.* Journal of the Science of Food and Agriculture. 2018; 98(3): 833-848.

9. Victor IA, Adegoke AM, Olugbami JO, Gbadegesin MA, and Odunola OA. *Lead-Induced Toxicities in Wistar Rats: Mitigating Effects of Ethanol Leaf Extract of Cymbopogon Citratus Stapf*. Archives of Basic and Applied Medicine. 2020; 8(2): 123-129.
10. Lawal OA, Ogundajo AL, Avoseh NO, and Ogunwande IA. *Cymbopogon Citratus.* Medicinal Spices and Vegetables from Africa. Dschang, Cameroon: Academic Press; 2017; pp. 397-423.
11. Chaves-Quirós C, Usuga-Usuga JS, Morales-Uchima SM, Tofiño-Rivera AP, Tobón-Arroyave SI, Martínez-Pabón MC. *Assessment of Cytotoxic and Antimicrobial Activities of Two Components of Cymbopogon Citratus Essential Oil*. Journal of Clinical and Experimental Dentistry. 2020; 12(8): e749-e754.
12. Shah G, Shri R, Panchal V, Sharma N, Singh B, Mann AS. *Scientific Basis for the Therapeutic Use of Cymbopogon citratus, Stapf (Lemon grass)*. Journal of Advanced Pharmaceutical Technology & Research. 2011; 2(1): 3-8.
13. Ariyani F, Setiawan LE, and Soetaredjo FE. *Ekstraksi Minyak Atsiri dari Tanaman Sereh dengan Menggunakan Pelarut Metanol, Aseton, dan N-Heksana*. Widya Teknik. 2008; 7(2): 124-133.
14. Garg J, Manjunath S, Sinha S, Ghambhir S, Abbey P, and Jungio MP. *Antimicrobial Activity of Chlorhexidine and Herbal Mouthwash Against the Adherence of Microorganism to Sutures After Periodontal Surgery: A Clinical Microbiological Study.* Cureus. 2022; 14(12): 1-9.
15. Chitsazha R, Faramarzi M, Sadighi M, *et al*. *Evaluation of Antibacterial Effect of Concentrated Growth Factor on Aggregatibacter Actinomycetemcomitans and Porphyromonas Gingivalis.* Journal of Family Medicine and Primary Care. 2022; 11(6): 2865-2869.
16. Kowalska-Krochmal B and Dudek-Wicher R. *The Minimum Inhibitory Concentration of Antibiotics: Methods, Interpretation, Clinical Relevance*. Pathogens. 2021; 10(2): 1-21.
17. Parvekar P, Palaskar J, Metgud S, Maria R, and Dutta S. *The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of Silver Nanoparticles Against Staphylococcus Aureus.* Biomaterial Investigations in Dentistry. 2020; 7(1): 105-109.
18. Rahayu YC, Setiawatie EM, Rahayu RP, *et al. Effects of Cocoa Pod Husk Extract (Theobroma Cacao L.) on Alveolar Bone in Experimental Periodontitis Rats*. Trends in Sciences. 2023; 20(6): 1-8.
19. Wang Q and Xie M. *Antibacterial Activity and Mechanism of Luteolin on Staphylococcus aureus*. Wei Sheng Wu Xue Bao: Acta Microbiologica Sinica. 2010; 50(9): 1180-1184.
20. Sari I, Misrahanum M, Faradilla M, Ayuningsih CM, and Maysarah H. *Antibacterial Activity of Citronella Essential Oil from Cymbopogon nardus (L.) Rendle) Against Methicillin-Resistant Staphylococcus aureus.* Indonesian Journal of Pharmaceutical and Clinical Research. 2022; 5(1): 16-22.
21. Nguyen TLA and Bhattacharya D. *Antimicrobial Activity of Quercetin: An Approach to Its Mechanistic Principle.* Molecules. 2022; 27(8): 1-13.
22. Wu T, He M, Zang X, *et al*. *A Structure-Activity Relationship Study of Flavonoids as Inhibitors of E. Coli by Membrane Interaction Effect*. Biochimica et Biophysica Acta (BBA)-Biomembranes. 2013; 1828(11): 2751-2756.
23. Br. Tarigan BMC, Lelyana S, and Sugiaman VK. *Kadar Hambat Minimum dan Kadar Bunuh Minimum Ekstrak Etanol Daun Oregano terhadap Pertumbuhan Candida Albicans*. JITEKGI: Jurnal Ilmiah dan Teknologi Kedokteran Gigi. 2021; 17(2): 55-62.
24. Rao A, Zhang Y, Muend S, and Rao R. *Mechanism of Antifungal Activity of Terpenoid Phenols Resembles Calcium Stress and Inhibition of the TOR Pathway*. Antimicrobial agents and chemotherapy. 2010; 54(12): 5062-5069.
25. Kamal HZA, Ismail TNNT, Arief EM, and Ponnuraj KT. *Antimicrobial Activities of Citronella (Cymbopogon Nardus) Essential Oil Against Several Oral Pathogens and Its Volatile Compounds.* Padjajaran Journal of Dentistry. 2020; 32(1): 1-7.