

Borneo Journal of **PHARMACY**

Volume 4 Issue 2 May 2021

*Accredited at SINTA 2 until February 2025
by Ministry of Research and Technology / National Research and Innovation Agency, Indonesia
No: 148/M/KPT/2020.*



Institute for Research and Community Services
Universitas Muhammadiyah Palangkaraya

BORNEO JOURNAL OF PHARMACY

Borneo J Pharm
e-ISSN: 2621-4814

Volume 4 Issue 2 May 2021

Department of Pharmacy
Faculty of Health Sciences
Universitas Muhammadiyah Palangkaraya

EDITOR IN CHIEF

Mohammad Rizki Fadhil Pratama

Universitas Muhammadiyah Palangkaraya, Indonesia
ORCID: <http://orcid.org/0000-0002-0727-4392>

Ahmed Mahal
Chinese Academy of Sciences, China
Lina Perekhoda
National University of Pharmacy, Ukraine
Jyoti Singh
CSIR-CIMAP, India
Shayma Thyab Gddoa Al-Sahlany
University of Basrah, Iraq

Quazi Majaz Ahamed Aejazuddin
Ali Allana College of Pharmacy, India
Nalini Kanta Sahoo
Marri Laxman Reddy Institute of Pharmacy, India
Luis Castillo Henriquez
Universidad de Costa Rica, Costa Rica
Heng Yen Khong
Universiti Teknologi MARA Sarawak, Malaysia
Syahrida Dian Ardhany
Universitas Muhammadiyah Palangkaraya,
Indonesia

MANAGING EDITOR

Khalid Karrouchi
Mohammed V University in Rabat, Morocco
Alaa Kareem Niamah
University of Basrah, Iraq
Neni Frimayanti
Sekolah Tinggi Ilmu Farmasi Riau, Indonesia
Erwin Martinez Fallar
San Pedro College, Philippines
Susi Novaryatiin
Universitas Muhammadiyah Palangkaraya,
Indonesia

REVIEWER

Keni Vidilaseris
University of Helsinki, Finland
Oleh M Koshovy
National University of Pharmacy, Ukraine
Atul Kabra
Raffles University, India
Arthi Venkatesan
ALTEM Technologies, India
Ashraf Ahmed Ali Abdusalam
Sirte University, Libya
Adryan Fristiody
Universitas Halu Oleo, Indonesia
Prayasee Baruah
North-Eastern Hill University, India
Santwana Palai
Odisha University of Agriculture and
Technology, India
Saeful Amin
Sekolah Tinggi Ilmu Kesehatan Bakti Tunas
Husada, Indonesia
Hasyrul Hamzah
Universitas Muhammadiyah Kalimantan
Timur, Indonesia

Nurolaini Kifli
Universiti Brunei Darussalam, Brunei Darussalam
Alexandru Mihai Grumezescu
Politechnica University of Bucharest, Romania
Anna Vladimirovna Kurkina
Samara State Medical University, Russia
A Lalithamma
Karpaga Vinayaga Institute of Medical Sciences, India
Julaeha
Universitas 17 Agustus 1945 Jakarta, Indonesia
Ihsanul Arief
Akademi Farmasi Yarsi Pontianak, Indonesia
Mohammed Gamal
Jouf University, Saudi Arabia
Dian Wuri Astuti
Sekolah Tinggi Ilmu Kesehatan Guna Bangsa
Yogyakarta, Indonesia
Monaj Kumar Sarkar
Shanmugha Arts, Science, Technology and Research
Academy (SASTRA) Deemed University, India
Hafsan
Universitas Islam Negeri Alauddin Makassar,
Indonesia

Mahendran Sekar
Universiti Kuala Lumpur, Malaysia
Punet Kumar
Shri Gopichand College of Pharmacy, India
Rimadani Pratiwi
Universitas Padjadjaran, Indonesia
Ruqiah Ganda Putri Panjaitan
Universitas Tanjungpura, Indonesia
Sutomo
Universitas Lambung Mangkurat, Indonesia
Arnida
Universitas Lambung Mangkurat, Indonesia
Andhika Bintang Mahardhika
Institut Teknologi Bandung, Indonesia
Isna Rasdianah Aziz
Universitas Islam Negeri Alauddin
Makassar, Indonesia
Dhafer Saber Zinad
University of Technology, Iraq
Paula Mariana Kustiawan
Universitas Muhammadiyah Kalimantan
Timur, Indonesia

COVER & LAYOUT DESIGN

Syahrida Dian Ardhany

PUBLISHED BY



Institute for Research and Community Services
Universitas Muhammadiyah Palangkaraya
RTA Milono St. Km. 1,5 Palangka Raya 73111
lp2m@umpalangkaraya.ac.idbjop
<http://journal.umpalangkaraya.ac.id/index.php/bjop>

EDITORIAL WORDS

apt. Mohammad Rizki Fadhil Pratama, S.Farm., M.Si.

*Editor in Chief
Borneo J Pharm*

Assalamu'alaikum Wr. Wb.

Alhamdulillahirabbil 'alamin. The next edition of **Borneo Journal of Pharmacy** (*Borneo J Pharm*), has been published at May 2021. Starting from this volume, *Borneo J Pharm* increases the frequency of publishing four times a year. This change aims to improve circulation of the best articles published by *Borneo J Pharm*.

Starting in the 2019 edition, *Borneo J Pharm* has been accepted for indexing in **EMBASE** by Elsevier dan **CAS**. This is an acknowledgment of the quality of the publications presented by *Borneo J Pharm*. In addition, *Borneo J Pharm* has also been accredited at **SINTA** in rank **2**. In the future, *Borneo J Pharm* will try to improve the indexing to ESCI by Web of Sciences and SCOPUS. We will ensure this achievement as a start and will continue to improve the quality of *Borneo J Pharm*.

This edition contains ten articles consisting of Pharmacology-Toxicology, Pharmaceutical, Microbiology Pharmacy, and Clinical-Community Pharmacy. This edition includes writings from seven countries including Indonesia, India, Pakistan, Iran, Nepal, Uganda, and Nigeria. The authors come from several institutions, including Sekolah Tinggi Ilmu Kesehatan Borneo Lestari, Bandung Institute of Technology, Universitas Lambung Mangkurat, Universitas Muhammadiyah Banjarmasin, Sekolah Tinggi Ilmu Kesehatan ISFI Banjarmasin, Shri Gopichand College of Pharmacy, Government College University Faisalabad, Islamic Azad University, Sardar Patel College of Pharmacy, Universal College of Medical Sciences, NKBR College of Pharmacy and Research Centre, Universitas Islam Bandung, Oxford College of Pharmacy, ATMS Group of Institutions, Institut Sains dan Teknologi Nasional, Mbarara University of Science and Technology, Kampala International University, Kebbi State University of Science and Technology Aliero, University Institute of Pharma Sciences Chandigarh University, and Laureate Institute of Pharmacy.

Editorial boards are fully aware that there are still room for improvement in this edition, hence with all humility willing to accept constructive suggestions and feedback for improvements to the publication for the next editions. The editorial board would like to thank all editors and reviewers, and contributors of the scientific articles who have provided the repertoire in this issue. We hope that all parties, especially the contributors of the articles, could re-participate for the the publication in the next edition on August 2021.

Wassalamu'alaikum Wr. Wb.

Palangka Raya, May 2021

Editor-in-Chief

Table of Contents

BORNEO JOURNAL OF PHARMACY

Borneo J Pharm – e-ISSN: 2621-4814

Volume 4 Issue 2 May 2021

Sections: PHARMACOLOGY-TOXICOLOGY

***In Vitro* Determination of Sun Protection Factor of Water Extract of *Aerodramus fuciphagus* from Central Kalimantan**

Dita Ayulia Dwi Sandi / Sekolah Tinggi Ilmu Kesehatan Borneo Lestari

Eka Fitri Susiani / Sekolah Tinggi Ilmu Kesehatan Borneo Lestari

I Ketut Adnyana / Bandung Institute of Technology

Pratiwi Wikaningtyas / Bandung Institute of Technology

78 – 83

Combination of Bawang Dayak Extract and Acarbose against Male White Rat Glucose Levels

Aditya Maulana Perdana Putra / Universitas Lambung Mangkurat

Ratih Pratiwi Sari / Universitas Muhammadiyah Banjarmasin

Siska Musiam / Sekolah Tinggi Ilmu Kesehatan ISFI Banjarmasin

84 – 90

Systemic Lupus Erythematosus Disease: An Overview of the Clinical Approach to Pathogenesis, Diagnosis, and Treatment

Saurabh Nimesh / Shri Gopichand College of Pharmacy

Md. Iftekhar Ahmad / Shri Gopichand College of Pharmacy

Shikhka Dhama / Shri Gopichand College of Pharmacy

Pradeep Kumar / Shri Gopichand College of Pharmacy

Muhammad Akram / Government College University Faisalabad

Neda Esmaeili Nejad Hasaroeih / Islamic Azad University

91 – 98

Sections: PHARMACEUTICAL

Formulation and Evaluation of Sustained Release Matrix Tablets of Aceclofenac

Priyanka Singh / Sardar Patel College of Pharmacy

Amit Kumar Shrivastava / Universal College of Medical Sciences

Sachin Kumar / NKBR College of Pharmacy and Research Centre

Manish Dhar Dwivedi / Sardar Patel College of Pharmacy

99 – 109

Identification of the Glimepiride and Metformin Hydrochloride Physical Interaction in Binary Systems

Fitrianti Darusman / Universitas Islam Bandung

Taufik Muhammad Fakhri / Universitas Islam Bandung

Gina Fuji Nurfarida / Universitas Islam Bandung

110 – 116

Method Development and Characterization of Liposomal Formulation of Isotretinoin

Md. Iftekhar Ahmad / Shri Gopichand College of Pharmacy

Punet Kumar / Shri Gopichand College of Pharmacy

Sangam Singh / Oxford College of Pharmacy

Nitin Kumar / ATMS Group of Institutions

117 – 127

Self-Nanoemulsifying Drug Delivery System (SNEDDS) for Oral Delivery of Cod Liver Oil

Sani Ega Priani / Universitas Islam Bandung

Desti Puspa Rahayu / Universitas Islam Bandung

Indra Topik Maulana / Universitas Islam Bandung

128 - 134

Sections: MICROBIOLOGY PHARMACY

Antimicrobial Activity of Ethanolic Extract of Sempur (*Dillenia suffruticosa* (Griff.) Martelli) Leaves against Pathogenic Microorganisms

Vilya Syafriana / Institut Sains dan Teknologi Nasional

Amelia Febriani / Institut Sains dan Teknologi Nasional

Suyatno / Institut Sains dan Teknologi Nasional

Nurfitri / Institut Sains dan Teknologi Nasional

Fathin Hamida / Institut Sains dan Teknologi Nasional

135 - 144

Antibiotic-Resistant Profiles of Bacteria Isolated from Cesarean and Surgical Patients from Kasese District Hospitals Western Uganda

Abraham Bwalhuma Muhindo / Mbarara University of Science and Technology & Kampala International University

Adamu Almustapha Aliero / Kampala International University & Kebbi State University of Science and Technology

Martin Odoki / Kampala International University

Ibrahim Ntulume / Kampala International University

Emmanuel Eilu / Kampala International University

Joe Mutebi / Kampala International University

Yap Boum II / Mbarara University of Science and Technology

Richard Onyuthi Apecu / Mbarara University of Science and Technology

145 - 156

Sections: CLINICAL-COMMUNITY PHARMACY

An Overview on Patient-Centered Clinical Services

Gaurav Joshi / University Institute of Pharma Sciences, Chandigarh University

Atul Kabra / University Institute of Pharma Sciences, Chandigarh University

Nishant Goutam / Laureate Institute of Pharmacy

Alka Sharma / Laureate Institute of Pharmacy

157 - 170

Author Guidelines

BORNEO JOURNAL OF PHARMACY

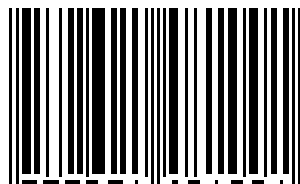
Borneo J Pharm – e-ISSN: 2621-4814

1. Writing is the result of research or review of critical analysis study in the field but not limited to Pharmacology-Toxicology, Pharmacognosy-Phytochemistry, Pharmaceutical, Analytical Pharmacy-Medicinal Chemistry, Natural Product Development, Clinical-Community Pharmacy, Management Pharmacy, and other Pharmacy aspects which have never been published in other scientific publication media.
2. Manuscripts that have been published in the form of a preprint on several platforms such as arXiv, INA-RXiv, SSRN, and ResearchGate are welcome to publish.
3. The manuscript is written in English with Book Antiqua font 10 pt, two-column, density 1.15 spaces, on A4 paper with a top-down margin of 2.5 cm and right-left margins 1.5 cm.
4. The manuscript is typed with MS-Word program using the provided template and saved in .doc or .docx format.
5. The manuscript is typed strictly with the following rules:
 - a. The title, short and clear, written in English. The title length does not exceed 20 words.
 - b. Authors, listed without mention of title or degree, under the name including the affiliation and complete address, and email of the corresponding author. The author's name, which consists of one word, must be repeated twice for first and last names. To author with names of more than two words, the author's last name consists of only one word, the rest is written as the first name.
 - c. Abstract, written in English which is a summary of the article. The abstract is created in one paragraph and a maximum of 250 words with Book Antiqua font 9 pt, single column, and space 1. Points that must be listed in the abstract include the research objectives, methods, results, conclusions, and keywords. The number of keywords is between three and five keywords.
 - d. Introduction, contain background, reasons for the importance of underlying research or hypotheses, general approaches and objectives of the research and relevant literature review. The number of paragraphs not restricted but the contents must include background, objectives, positions on previous research, as well as the novelty of the research. The little theoretical basis which indirectly related to the contents of the article could be included without sub-chapters required. Citation is written in occurrence number on the manuscript (Vancouver style).
 - e. Methodology, Research method consists of 2 sub-chapters including materials and methods. If data analysis is specific, or the way of analysis is novel, then data analysis subchapter could be added. The sub-chapters are written without numbering or bullet.
 - f. Results and Discussion, at least contain three subjects (1) description of results, (2) interpretation or explanation of results, and (3) comparative of results with previous studies results. If the subchapters very length could be made sub-sub-chapters with Arabic numbering. Description of the results can be in the form of tables and figures with a serial number (Table uses a sequence of Roman numerals and placed at the top, while figures using Arabic numeric sequence and placed in the below).
 - g. Conclusion, made in a single paragraph without the citation contains the final conclusion and suggestions for advanced research.
 - h. References, a list of recently selected topics is published last five years (the minimum percentage and a minimum number of references are different for each type of manuscript). The bibliography is written in chronological order with the serial number (Vancouver style) and suggested using a reference management application such as EndNote, Mendeley, Zotero, and other applications.
6. Authors whose manuscripts are published are free of charge for both Publication cost and article processing charge.
7. Authors will get full access to the article published on e-journal of Universitas Muhammadiyah Palangkaraya at the website <http://journal.umpalangkaraya.ac.id/index.php/bjop>.

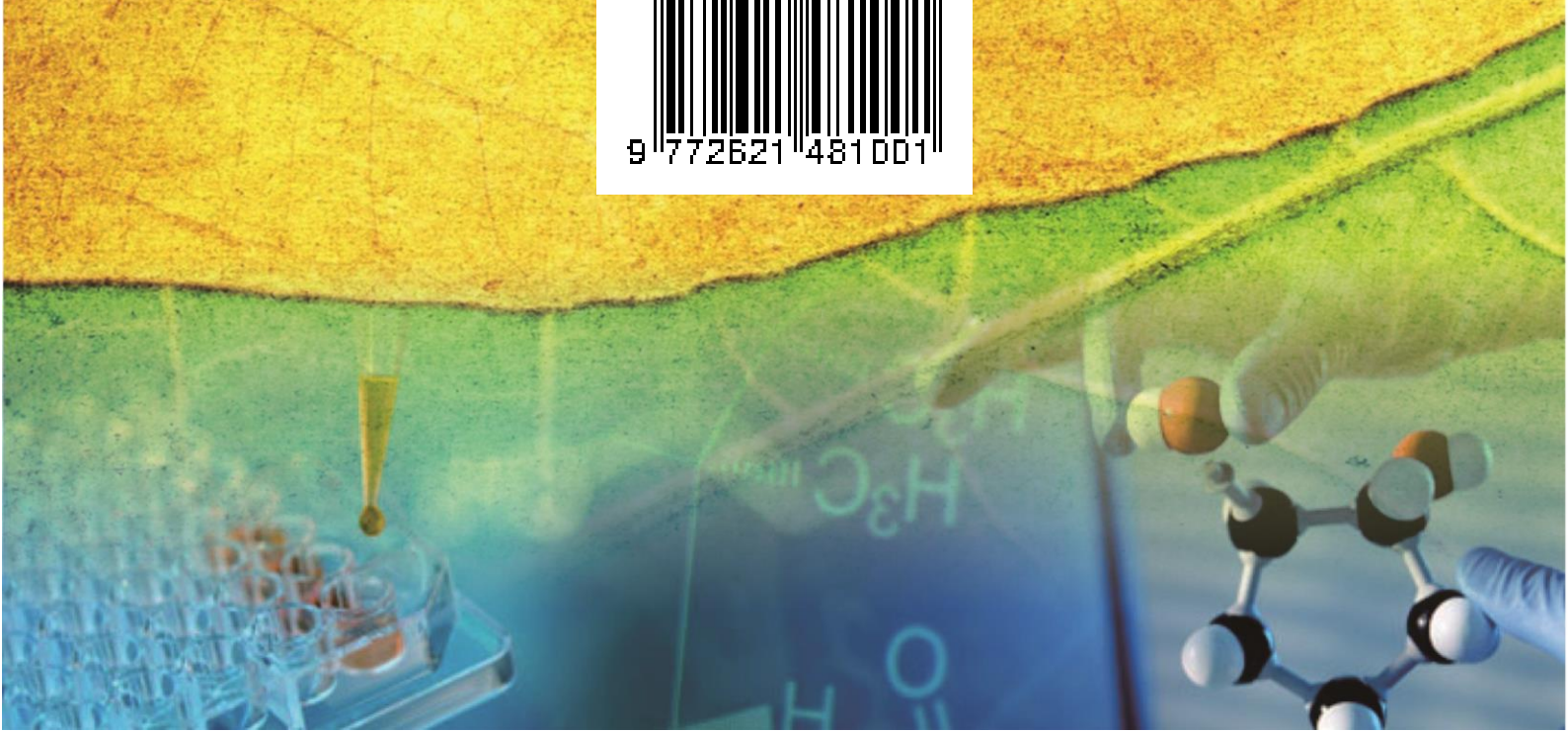
BJOP

Borneo Journal of
.....
PHARMACY

Volume 4 Issue 2 May 2021



9 772621 481001



Research Article

Antimicrobial Activity of Ethanolic Extract of Sempur (*Dillenia suffruticosa* (Griff.) Martelli) Leaves against Pathogenic Microorganisms

Vilya Syafriana*

Amelia Febriani

Suyatno Nurfritri 

Fathin Hamida

Department of Pharmacy, Institut Sains dan Teknologi Nasional, South Jakarta, Jakarta Capital Special Region, Indonesia

*email: v.syafriana@istn.ac.id**Keywords:**Antimicrobial
Dillenia suffruticosa
Ethanol
Maceration
Sempur leaves**Abstract**

Sempur (*Dillenia suffruticosa*) leaves are known as a traditional medicine for the people of Bangka-Belitung Island. The local people empirically utilize the boiled water of *D. suffruticosa* leaves as anti-diarrhea. However, the antimicrobial activity of the ethanol extract of *D. suffruticosa* leaves has not been reported. This study aims to determine the antimicrobial activity of the ethanol extract of *D. suffruticosa* leaves against several microorganisms: *Staphylococcus aureus* as Gram-positive bacteria, *Escherichia coli* as Gram-negative bacteria, and *Candida albicans* as fungi. Extraction was carried out by maceration method with 70% ethanol, then screened for phytochemical constituents. The antimicrobial test was carried out by the disc diffusion method using Nutrient Agar (NA) for bacteria, and Sabouraud Dextrose Agar (SDA) for fungi. The results of phytochemical screening showed that the ethanol extract of *D. suffruticosa* leaves contained alkaloids, flavonoids, tannins, and saponins. The antimicrobial test showed that the extract of *D. suffruticosa* leaves could inhibit the growth of *S. aureus* at concentrations of 10%, 20%, and 40% were 8.35 ± 0.05 ; 9.34 ± 0.32 ; and 10.52 ± 0.22 , respectively. The ethanol extract of *D. suffruticosa* leaves could inhibit the growth of *S. aureus*, whereas *E. coli* and *C. albicans* did not show any activity.

Received: December 4th, 2020Accepted: February 19th, 2021Published: May 30th, 2021

© 2021 Vilya Syafriana, Amelia Febriani, Suyatno, Nurfritri, Fathin Hamida. Published by Institute for Research and Community Services Universitas Muhammadiyah Palangkaraya. This is an Open Access article under the CC-BY-SA License (<http://creativecommons.org/licenses/by-sa/4.0/>). DOI: <https://doi.org/10.33084/bjop.v4i2.1870>

INTRODUCTION

Indonesia is an archipelago country consisting of more than 17.000 islands. Indonesia's geographic and historical conditions make this country one of the countries with high biodiversity, otherwise known as mega biodiversity^{1,2}. This immense biodiversity has the potential for nutritious and medicinal plants. The World Conservation Monitoring Centre from the UN has reported that Indonesia is an area where various types of medicinal plants are found, with 2.518 species of plants that have been used³.

One of the medicinal plants known in Indonesia is the Dilleniaceae family. Dilleniaceae is native to tropical and warm-temperate regions such as Asia, Australia, and the Indian Ocean Islands^{4,5}. Dilleniaceae are known for their edible fruit and medicinal applications, such as for arthritis, dysentery, diabetes, gastrointestinal disorder, and wound healing⁶. The most investigated species for its potential as medicinal plants from this family is *Dillenia indica*. At the same time, there are many other species that also potential. One of it is *Dillenia suffruticosa*^{4,7}.

Dillenia suffruticosa has few local names such as *sempur*, *simpur*, *simpoh*, *simpur air*, and *simpur bini*^{4,8-11}. The name *sempur* is derived from the hissing sound when the trunk

tree is cut⁴. However, most residents in Indonesia call it *sempur*. *Dillenia suffruticosa* is a native Asian plant that grows in tropical forests from Malaysia, Indonesia, the Philippines, and Brunei Darussalam. *Dillenia suffruticosa* in Indonesia can be found in Sumatra and Kalimantan (Borneo) Islands. Local societies in Brunei and Malaysia are used *D. suffruticosa* leaves to promote wound healing, treat fever, and relieve rheumatism^{8,9}. The people in Bangka-Belitung, Sumatra, usually used the boiled water of *D. suffruticosa* leaves to treat diabetes mellitus¹⁰. Besides that, the local community also used boiled water of *D. suffruticosa* leaves as an anti-diarrhea. However, the study of this potential plant against pathogenic microorganisms is still underreported, and none of the studies reported using ethanol solvents.

Research on the activity of *D. suffruticosa* leaves against pathogenic microorganisms was reported by Wiart *et al*¹². They reported that methanol extract of *D. suffruticosa* leaves was inhibited the growth of *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Candida albicans*. However, it did not affect the growth of *Escherichia coli* and *Staphylococcus aureus*. Otherwise, Yakop *et al*¹¹ reported that the methanol extract of *D. suffruticosa* leaves could inhibit *S. aureus* but did not affect *B. subtilis*, *E. coli*, and *P. aeruginosa*. Another research showed an antifungal activity from *D. suffruticosa* leaves extract with methanol, acetone, and chloroform against *Colletotrichum gloeosporioides*¹³. According to Goh *et al*⁹, the cytotoxic activities of this plant could be attributed to the presence of phytochemicals such as saponins, triterpenes, sterols, and polyphenols compounds. However, more studies should be performed to validate their traditional uses for such diseases fully.

This research was conducted to explore the antimicrobial activity of *D. suffruticosa* leaves extract against several pathogenic microorganisms. This research used 70% ethanol as a solvent since its lower toxicity than

methanol¹⁴. The tested microorganisms were *S. aureus* (Gram-positive bacteria), *E. coli* (Gram-negative bacteria), and *C. albicans* (Fungi).

MATERIALS AND METHODS

Materials

The materials used include *D. suffruticosa* leaves, Nutrient agar (NA), Sabouraud Dextrose agar (SDA), distilled water (Brataco), 70% ethanol (Brataco), FeCl₃ (Merck), Wagner's reagent, Mayer's reagent, Dragendorff's reagent, ammonia (Merck), acetic acid anhydride (Merck), NaNO₂ (Merck), AlCl₃ (Merck), HCl (Merck), chloroform (Merck), H₂SO₄ (Merck), DMSO, immersion oil, crystal violet (Merck), safranin, Lugol's iodine, 0.9% NaCl, blank antimicrobial susceptibility discs (Oxoid), and the antibiotic susceptibility discs of nystatin (Oxoid) and amoxicillin (Oxoid). The main instruments used in this study were analytical balance (Excellent), oven (Memmert), blender (Phillips), autoclave, incubator, vacuum rotary evaporator, hot plate, and laminar airflow.

Methods

Preparation and extraction of *D. suffruticosa* leaves

Dillenia suffruticosa leaves were obtained from Pedindang Village, Pangkalan Baru, Central Bangka District, Bangka-Belitung Island. The sample was identified in the Research Center for Plant Conservation and Botanic Gardens, Indonesian Institute of Sciences, Bogor, with report number B-848/IPH.3/KS/VII/2020. The fresh leaves of the *D. suffruticosa* plant were weighed as much as 6 kg were cleaned with clean water from the tap. The leaves were dried for several hours under the sun to avoid moisture after shipping, so it was not easily contaminated by the fungus. After that, the leaves were sorted and chopped (about 2-3 cm) to speed up the drying process. The leaves were dried with a wind-dried method for 15 days^{10,15}.

The dried leaves then being crushed using a blender and followed by sieving using mesh 60. The sieving produces simplicia of *D. suffruticosa* leaves powder. This procedure was to gain a homogeneous size of simplicia, so the interaction between the *D. suffruticosa* leaves powders and the solvent would be optimal. Besides, homogeneous size particle could optimize the extraction process¹⁶.

The *D. suffruticosa* leaves powder was weighed as much as 100 g then extracted with the maceration method using 70% ethanol as a solvent with a ratio of 1 : 10. The maceration was done for 24 hours and re-macerated twice with the same procedure. The maceration results were filtered with filter paper. The filtrate was evaporated using the vacuum rotary evaporator until it produces a thick extract¹⁷.

Organoleptic observation

The organoleptic observation of ethanolic extract of *D. suffruticosa* leaves aimed to determine the physical form of color, smell, shape, and taste using the senses. This observation includes color checking by looking at the evaporated extract visually, checking the odor by smelling the evaporating extract on filter paper, and checking the taste by dropping extract on the tip of the tongue and then discarding it¹⁸.

Phytochemical screening and antimicrobial activity tests

The extract was tested for phytochemical screening in Lux Chemicals Laboratory (Chemicals Product and Chemical Analysis Service), Depok. The screening test included alkaloids (with Mayer's, Wagner's, and Dragendorff's reagents), flavonoids, saponins, tannins, steroids, and triterpenoids¹⁹. The extract also tested for antimicrobial activity using the Kirby-Bauer Disk Diffusion Susceptibility Test method in Testing Laboratory of Biotechnology Center, Agency for the Assessment and Application of Technology, Serpong²⁰. The microorganisms tested were *S. aureus* ATCC 25923

(representative of Gram-positive bacteria), *E. coli* ATCC 25922 (representative of Gram-negative bacteria), and *C. albicans* ATCC 10231 (representative of fungi). The *S. aureus* and *E. coli* were incubated for 24 hours, while *C. albicans* for 48 hours. The differences in incubation time were based on the optimum growth of the microorganisms. Our previous study also used incubation time of 18-24 hours for *S. aureus* and *E. coli* as well as 48 hours for *C. albicans*²¹⁻²³.

RESULTS AND DISCUSSION

Preparation and yield extract of D. suffruticosa leaves

Dillenia suffruticosa leaves were categorized as broad leaves (15-35 cm) in a plant⁴. Due to its enormous size, the leaves were chopped into smaller pieces and consumed about 15 days to gain dried leaves (**Figure 1**). The leaves were dried without direct contact with the sun to avoid damaging compounds, such as thermosensitive polyphenols²⁴. According to some references, *D. suffruticosa* leaves contain polyphenols^{9,10,15,25,26}. This dried method was suitable with Priamsari *et al.*²⁷, which stated that the total flavonoid content was higher in wind-dried leaves than the oven method. It also corresponded with Rivai *et al.*²⁸, which proved that the wind-dried method was the optimum method to gain phenolics.

The wind-dried method also had another advantage: retaining chlorophyll, so the sample still looks greenish, not brown²⁹. The *D. suffruticosa* leaves powder in this research was showed a greenish color (**Figure 2**). However, this method had limitations, such as time-consuming²⁷⁻²⁹. This could be seen from the drying time, which took more than two weeks. The wind-dried method could take time about 3-7 days to months and up to a year, depending on the types of samples dried²⁴.

The extraction method in this research was done by maceration with 70% ethanol as a solvent. Solvents with high polarities, such as ethanol, were pretty efficient to

attract active compounds from plants³⁰. Maceration was chosen because it was a straightforward method and could be used to extract thermolabile compounds^{31,32}. Hasnaeni *et al.*³³ also reported that the maceration method produced a higher yield than reflux and soxhlet extraction.

The yield of ethanol extract of *D. suffruticosa* leaves was about 65.5% (Table I). Yield extract showed some active compounds that are trapped during the extraction process^{27,33}. The high percentage yield indicates the high content of the active compounds in a sample. The ethanol extract of *D. suffruticosa* leaves showed a high yield (more than 50%). This was probably due to the influence of the solvent used. The higher the solvent polarity, the yield obtained will also increase³⁴.



a



b

Figure 1. Wide fresh leaves (a) and chopped dry leaves (b) of *D. suffruticosa*



Figure 2. *Dillenia suffruticosa* leaves powder showed greenish color with a wind-dried method

Table I. Yield of ethanol extract of *D. suffruticosa* leaves

<i>Dillenia suffruticosa</i> leaves powder (g)	Thick extract (g)	Yield (%)
100	65.5	65.5

Organoleptic observation

The organoleptic observation involved eight respondents. Each respondent was asked to observe the shape and color of the extract. Other than that, respondents were also asked to smell and taste the extract (Figure 3). The respondents agree that the extract was in thick, blackish-green color, had a distinctive smell of *D. suffruticosa* leaves, and had an astringent taste (Table II). The findings of organoleptic observations have never been published, so this article was a preliminary report for future studies as a guide.

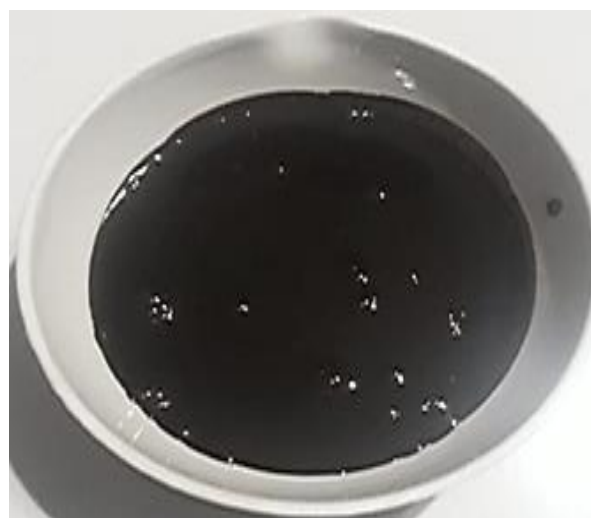


Figure 3. Thick extract of *D. suffruticosa* leaves

Table II. Organoleptic observation of *D. suffruticosa* leaves extract

Organoleptic indicator	Observation
Shape	Thick
Color	Blackish-green
Odor	Distinctive odor
Taste	Astringent

Phytochemical screening

Phytochemical screening was an essential step in uncovering the potential of medicinal plant resources as antibiotics, antioxidants, and anticancer. The compounds contained in the extract were analyzed qualitatively based on the color change reaction with several reagents³⁵. The screening results from **Table III** showed that the ethanol extract of *D. suffruticosa* leaves contained alkaloids, flavonoids, tannins, and saponins. Meanwhile, the test for steroids and triterpenoids showed a negative result.

The positive tests of flavonoids, tannins, and saponins were similar to those obtained by Yuningtyas *et al.*¹⁰. The presence of flavonoids and tannins indicates that the ethanol extract of *D. suffruticosa* leaves contains polyphenols³⁶. Ethanol was known as a solvent that was best for extracting polyphenols from plants³⁷. Besides the flavonoids and tannins, the extract also contains saponins. Saponins were triterpene glycosides that had polar tendencies in their glycosidic bonds³⁸. Based on the law of similarity and intermiscibility (like dissolves like), a solvent with a polarity near the polarity of the solute was likely to perform and vice versa³². This explains why ethanol as a polar solvent could attract saponin from *D. suffruticosa* leaves.

Another compound found in *D. suffruticosa* leaves extract was alkaloids. This research using three different reagents to test the alkaloid compounds. Two of the tests were showed positive results (Wagner's and Dragendorff's), while Mayer's showed a negative result. Based on Surbakti *et al.*³⁹, a sample could contain alkaloids if there were at least two positive qualitative test

results. Meanwhile, Yuningtyas *et al.*¹⁰ reported the opposite; their extract showed negative at alkaloid test. This difference in result probably due to regional differences in sample acquisition. The *D. suffruticosa* leaves were obtained from Pedindang Village, Pangkalan Baru, Central Bangka District, while Yuningtyas *et al.*¹⁰ obtained their sample from Jebus Village, West Bangka District. According to Verma *et al.*⁴⁰, plants from the same species might have differences in the concentration of a particular secondary metabolite. The main factor affecting this phenomenon was the abiotic stress in the plant environment. Different season or different environmental condition could encourage plants to produce specific compounds to survive in the unfavorable condition and to protect against extinction.

Table III. Phytochemical screening of *D. suffruticosa* leaves extract

Phytochemical	Results	Conclusion	
Alkaloids	Wagner's	A brown precipitate was formed	Positive
	Mayer's	No sediment formed	Negative
	Dragendorff's	A thick red precipitate was formed	Positive
Flavonoids		A red solution formed	Positive
Tannins		A greenish black solution formed	Positive
Saponins		Formed a stable foam after shaking	Positive
Steroids		No blue or green color formed	Negative
Triterpenoids		No red color formed	Negative

Antimicrobial activity

The antimicrobial activity was done using a Kirby-Bauer disk diffusion method. This method was used to determine the sensitivity or resistance of pathogenic microorganisms to various antimicrobial compounds. The clear zone that appears around the disk was measured as the inhibition zone^{20,41}. The results of the antimicrobial activity showed in **Table IV**.

The results in **Table IV** showed that the *D. suffruticosa* leaves extract did not affect the growth of *E. coli* and *C. albicans*. It only affected *S. aureus* growth at concentrations 10%, 20%, and 40%. The result of this study against *S. aureus* was the same as Yakop *et al*¹¹. Thus, the result against *E. coli* was the same with Yakop *et al*¹¹. and Wiart *et al*¹². However, the result against *C. albicans* was inconsistent with Wiart *et al*¹², in which their research showed a growth inhibition zone, while this study did not. The antibacterial activity against *S. aureus* showed a higher inhibition zone along with higher concentrations. The higher the extract concentration, the active substance in the extract increases so that the antibacterial activity would be greater⁴².

The antibacterial activity against *S. aureus* was presumed due to the synergistic mechanisms among chemicals compounds found in extract ethanol of *D. suffruticosa* leaves. Based on the literature, alkaloids were known could intercalate with DNA. In general, alkaloids work with interfering the DNA synthesis⁴³. Flavonoids and saponins were work by disrupting the bacterial cell membrane of microorganisms⁴⁴. Meanwhile, tannins act by disturbing the cell protein, either bind and precipitate or shrink proteins⁴⁵. These conjectures were in line with the literature, which stated that the antibacterial activity could be grouped into four main mechanisms: disturbing bacterial cell wall, disrupting cell membrane, interfering protein biosynthesis, and inhibiting nucleic acid biosynthesis^{43,45}.

Bacteria based on their cell wall structure were differentiated into Gram-positive and Gram-negative bacteria. Gram-positive bacteria have a simple cell wall structure composed of peptidoglycan, while in Gram-negative bacteria, they have an additional structure called an outer membrane. The outer membrane contains lipopolysaccharide and could secrete endotoxin. The outer membrane acts as a protection, including keeping

the bacterial cells from penetrating antibiotics or other unwanted compounds. This layer causes Gram-negative bacteria to generally more resistant than Gram-positive bacteria^{46,47}. The description could explain why in this study, the extract was only affecting *S. aureus*, which was Gram-positive bacteria, while it did not affect *E. coli*. *Escherichia coli* was classified as Gram-negative bacteria and known to have developed multi-drug resistance^{47,48}. This study showed that *E. coli* were resistant to *D. suffruticosa* leaves extract.

Another microorganism tested against the *D. suffruticosa* leaves extract in this study was *C. albicans*. The result showed that the ethanol extract of *D. suffruticosa* leaves neither could inhibit the *C. albicans* growth. As a fungus, the cell wall of *C. albicans* was composed of chitin, glucan, and mannoprotein. The cell wall forms a two-layer structure with mannoproteins in the outer, while chitin in the inner layer. Glucans lie in the inner layer and connecting the inner and outer layers. The mannoproteins in the outer layer have low permeability and porosity, so they could not easily pass by some compounds, including antifungal agents. This structure made the *C. albicans* resistant to antifungal drugs or host defense mechanisms^{49,50}. This finding was corresponding with Lima *et al*⁵¹, which report that a more mannan structure in fungi could develop the resistance in *Candida* against antimicrobial agents. This was probably could explain why the *D. suffruticosa* leaves extract could not inhibit the *C. albicans* growth.

Table IV. Antimicrobial activity of *D. suffruticosa* leaves extract

Extract concentration	Inhibition zone (mm)		
	<i>S. aureus</i>	<i>E. coli</i>	<i>C. albicans</i>
5%	-	-	-
10%	8.35±0.05	-	-
20%	9.34±0.32	-	-
40%	10.52±0.22	-	-
Positive control	42.72±0.14	28.04±0.82	9.44±0.11
Negative control	-	-	-

(-): no activity; positive control: amoxicillin (*S. aureus* and *E. coli*), nystatin (*C. albicans*); negative control: 10% DMSO

CONCLUSION

The ethanolic extract of *D. suffruticosa* leaves could inhibit the growth of *S. aureus*, while *E. coli* and *C. albicans* showed no activity. Further research about the ethanolic extract of *D. suffruticosa* leaves against other pathogens still being suggested, especially the gastrointestinal pathogen.

ACKNOWLEDGMENT

We thank the Ministry of Research and Technology/National Research and Innovation Agency, The Republic of Indonesia for financing research funds through PDP Grant year 2020. This research has been presented in International Conference of Pharmacy and Health Sciences (ICPHS) 2020, 3rd Joint Conference UNAIR-USM in Surabaya, Indonesia, October 28th, 2020.

AUTHORS' CONTRIBUTION

Vilya Syafriana: conceptualization, supervision, methodology, data curation, data analysis, validation, writing-original draft & editing. **Amelia Febriani:** conceptualization, supervision, data analysis, writing-review & editing. **Suyatno:** conceptualization, survey and transportation, methodology, data curation, data analysis, writing-review & editing. **Nurfitri:** project administration, survey and transportation, data curation, data analysis, writing-review & editing. **Fathin Hamida:** conceptualization, methodology and validation, writing-review & editing.

DATA AVAILABILITY

All data are available from the authors.

CONFLICT OF INTEREST

The authors declare there are no conflict of interest.

REFERENCES

1. von Rintelen K, Arida E, Häuser C. A review of biodiversity-related issues and challenges in megadiverse Indonesia and other Southeast Asian countries. *Res Ideas Outcomes*. 2017;3:e20860. doi:10.3897/rio.3.e20860
2. Condro AA, Prasetyo LB, Rushayati SB, Santikayasa IP, Iskandar E. Predicting Hotspots and Prioritizing Protected Areas for Endangered Primate Species in Indonesia under Changing Climate. *Biology*. 2021;10(2):154. doi:10.3390/biology10020154
3. Jadid N, Kurniawan E, Himayani CES, Prasetyowati I, Purwani KI, Muslihatin W, et al. An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia. *PLoS One*. 2020;15(7):e0235886. doi:10.1371/journal.pone.0235886
4. Yazan LS, Armania N. *Dillenia* species: A review of the traditional uses, active constituents and pharmacological properties from pre-clinical studies. *Pharm Biol*. 2014;52(7):890-7. doi:10.3109/13880209.2013.872672
5. DeFilipps RA, Krupnick GA. The medicinal plants of Myanmar. *PhytoKeys*. 2018;102:1-341. doi:10.3897/phytokeys.102.24380
6. Sabandar CW, Jalil J, Ahmat N, Aladdin NA. Medicinal uses, chemistry and pharmacology of *Dillenia* species (*Dilleniaceae*). *Phytochemistry*. 2017;134:6-25. doi:10.1016/j.phytochem.2016.11.010
7. Lima CC, Lemos RPL, Conserva LM. *Dilleniaceae* family: an overview of its ethnomedicinal uses, biological and phytochemical profile. *J Pharmacogn Phytochem*. 2014;3(2):181-204.
8. Muliawan SY. Effect of *Dillenia suffruticosa* extract on dengue virus type 2 replication. *Univ Med*. 2008;27(1):1-5. doi:10.18051/UnivMed.2008.v27.1-5
9. Goh MPY, Basri AM, Yasin H, Taha H, Ahmad N. Ethnobotanical review and pharmacological properties of selected medicinal plants in Brunei Darussalam: *Litsea elliptica*, *Dillenia suffruticosa*, *Dillenia excelsa*, *Aidia racemosa*, *Vitex pinnata* and *Senna alata*. *Asian Pac J Trop Biomed*. 2017;7(2):173-80. doi:10.1016/j.apjtb.2016.11.026
10. Yuningtyas S, Roswiem AP, Erfina. Aktivitas Inhibisi α -Glukosidase dari Ekstrak Air dan Etanol Daun Sempur Air (*Dillenia suffruticosa* (Griff.) Martelli).

- Jurnal Farmamedika (Pharmamedica Journal). 2018;3(1):21-6. doi:10.47219/ath.v3i1.23
11. Yakop F, Hamid MHS, Ahmad N, Majid MA, Pillai MK, Taha H. Phytochemical Screening, Antioxidant and Antibacterial Activities of Extracts And Fractions of *Dillenia suffruticosa* Leaves. *Malays Appl Biol*. 2020;49(1):121-30.
 12. Wiart C, Mogana S, Khalifah S, Mahan M, Ismail S, Buckle M, et al. Antimicrobial screening of plants used for traditional medicine in the state of Perak, Peninsular Malaysia. *Fitoterapia*. 2004;75(1):68-73. doi:10.1016/j.fitote.2003.07.013
 13. Johnny L, Yusuf UK, Nulit R. The effect of herbal plant extracts on the growth and sporulation of *Colletotrichum gloeosporioides*. *J Appl Biosci*. 2010;34:2218-24.
 14. Joshi DR, Adhikari N. An Overview on Common Organic Solvents and Their Toxicity. *J Pharm Res Int*. 2019;28(3):1-18. doi:10.9734/jpri/2019/v28i330203
 15. Putra AYT, Supriyadi, Santoso U. Skrining Fitokimia Ekstrak Etil Asetat Daun Simpor (*Dillenia Suffruticosa*). *JITIPARI (Jurnal Ilmiah Teknologi dan Industri Pangan UNISRI)*. 2019;4(1):36-40. doi:10.33061/jitipari.v4i1.3017
 16. Mankanjuola SA. Influence of particle size and extraction solvent on antioxidant properties of extracts of tea, ginger, and tea-ginger blend. *Food Sci Nutr*. 2017;5(6):1179-85. doi:10.1002/fsn3.509
 17. Mahato N, Sinha M, Sharma K, Koteswararao R, Cho MH. Modern Extraction and Purification Techniques for Obtaining High Purity Food-Grade Bioactive Compounds and Value-Added Co-Products from Citrus Wastes. *Foods*. 2019;8(11):523. doi:10.3390/foods8110523
 18. Altemimi A, Lakhssassi N, Baharlouei A, Watson DG, Lighfoot DA. Phytochemicals: Extraction, Isolation, and Identification of Bioactive Compounds from Plant Extracts. *Plants*. 2017;6(4):42. doi:10.3390/plants6040042
 19. Doss A. Preliminary phytochemical screening of some Indian Medicinal Plants. *Anc Sci Life*. 2009;29(2):12-6.
 20. Nassar MSM, Hazzah WA, Bakr WMK. Evaluation of antibiotic susceptibility test results: how guilty a laboratory could be? *J Egypt Public Health Assoc*. 2019;94:4. doi:10.1186/s42506-018-0006-1
 21. Rachmatiah T, Syafriana V, Elfira L. Aktivitas Daya Hambat Minyak Atsiri dan Ekstrak Etanol Daun Sirih Merah (*Piper crocatum* Ruiz & Pav.) Terhadap *Candida albicans*. *Sainstech Farma Jurnal Ilmu Kefarmasian*. 2018;11(2):1-4. doi:10.37277/sfj.v11i2.387
 22. Syafriana V, Rachmatiah T, Utama NW. Antibacterial Activity of Methanol Extract of Meranti Sarang Punai Cortex (*Shorea parvifolia* Dyer) against *Staphylococcus aureus* and *Propionibacterium acnes*. *Jurnal Farmasi Udayana*. 2020;9(Special Issue):160-70. doi:10.24843/JFU.2020.v09.i03.p04
 23. Syafriana V, Hamida F, Sukanto AR, Aliya LS. Resistensi *Escherichia coli* dari Air Danau ISTN Jakarta Terhadap Antibiotik Amoksisilin, Tetrasiklin, Kloramfenikol, dan Siprofloksasin. *Sainstech Farma Jurnal Ilmu Kefarmasian*. 2020;13(2):92-8. doi:10.37277/sfj.v13i2.761
 24. Colvin DM. A Review on Comparison of the Extraction Methods Used in Licorice Root: Their Principle, Strength and Limitation. *Med Aromat Plants*. 2018;7(6):1000323. doi:10.4172/2167-0412.1000323
 25. Abubakar S, Al-Mansoub MA, Murugaiyah V, Chan KL. The phytochemical and anti-inflammatory studies of *Dillenia suffruticosa* leaves. *Phytother Res*. 2019;33(3):660-75. doi:10.1002/ptr.6255
 26. Shah MD, Seelan JSS, Iqbal M. Phytochemical investigation and antioxidant activities of methanol extract, methanol fractions and essential oil of *Dillenia suffruticosa* leaves. *Arab J Chem*. 2020;13(9):7170-82. doi:10.1016/j.arabjc.2020.07.022
 27. Priamsari MR, Susanti MM, Atmaja AH. Pengaruh Metode Pengeringan Terhadap Kualitas Ekstrak dan Kadar Flavonoid Total Ekstrak Etanolik Daun Sambung Nyawa (*Gynura Procumbens* (Lour.) Merr.). *Jurnal Farmasi (J Pharm)*. 2016;5(1):29-33. doi:10.37013/jf.v5i1.32
 28. Rivai H, Nurdin H, Suyani H, Bakhtiar A. Effects of Drying Methods in Gaining of Extractive, Phenolic Content and Antioxidant Activity in *Gynura pseudochina* (Lour.). *Majalah Obat Tradisional*. 2010;15(1):26-33. doi:10.22146/tradmedj.8065
 29. Luliana S, Purwanti NU, Manihurul KN. Pengaruh Cara Pengeringan Simplisia Daun Senggani (*Melastoma malabathricum* L.) Terhadap Aktivitas Antioksidan Menggunakan Metode DPPH (2,2-

- difenil-1-pikrilhidrazil). *Pharm Sci Res.* 2016;3(3):120-9. doi:10.7454/psr.v3i3.3291
30. Truong DH, Nguyen DH, Ta NTA, Bui AV, Do TH, Nguyen HC. Evaluation of the Use of Different Solvents for Phytochemical Constituents, Antioxidants, and In Vitro Anti-Inflammatory Activities of *Severinia buxifolia*. *J Food Qual.* 2019;2019:8178294. doi:10.1155/2019/8178294
 31. Jovanović A, Petrović P, Đorđević V, Zdunić G, Šavikin K, Bugarski B. Polyphenols Extraction from Plant Sources. *Lekovite Sirovine.* 2017;37:45-9. doi:10.5937/lekir1737045J
 32. Zhang QW, Lin LG, Ye WC. Techniques for extraction and isolation of natural products: a comprehensive review. *Chin Med.* 2018;13:20. doi:10.1186/s13020-018-0177-x
 33. Hasnaeni H, Wisdawati W, Usman S. Pengaruh Metode Ekstraksi Terhadap Rendemen Dan Kadar Fenolik Ekstrak Tanaman Kayu Beta-Beta (*Lunasia amara Blanco*). *Jurnal Farmasi Galenika (Galenika J Pharm).* 2019;5(2):175-82. doi:10.22487/j24428744.2019.v5.i2.13599
 34. Noviyanty A, Syamsiar S, Salingkat CA. Pengaruh Jenis Pelarut Terhadap Ekstraksi Dari Kulit Buah Naga Merah (*Hylocereus polyrhizus*). *KOVALEN Jurnal Riset Kimia.* 2019;5(3):271-9. doi:10.22487/kovalen.2019.v5.i3.14037
 35. Atanasov AG, Waltenberger B, Pferschy-Wenzig EM, Linder T, Wawrosch C, Uhrin P, et al. Discovery and resupply of pharmacologically active plant-derived natural products: A review. *Biotechnol Adv.* 2015;33(8):1582-614. doi:10.1016/j.biotechadv.2015.08.001
 36. Sadeek AMM, Abdallah M. Phytochemical Compounds as Antibacterial Agents A Mini Review. *Glob J Pharm Pharm Sci.* 2019;7(4):131-6. doi:10.19080/GJPPS.2019.07.555720
 37. Thouri A, Chahdoura H, Arem AE, Hichri AO, Hassin RB, Achour L. Effect of solvents extraction on phytochemical components and biological activities of Tunisian date seeds (var. Korkobbi and Arechti). *BMC Complement Altern Med.* 2017;17:248. doi:10.1186/s12906-017-1751-y
 38. Bahrami Y, Franco CMM. Acetylated Triterpene Glycosides and Their Biological Activity from Holothuroidea Reported in the Past Six Decades. *Mar Drugs.* 2016;14(8):147. doi:10.3390/md14080147
 39. Surbakti PAA, De Queloe E, Boddhi W. Skrining Fitokimia Dan Uji Toksisitas Ekstrak Etanol Daun Binahong (*Andredera cordifolia* (Ten.) Steenis) dengan Metode Brine Shrimp Lethality Test (BSLT). *Pharmacon.* 2018;7(3):22-31. doi:10.35799/pha.7.2018.20112
 40. Verma N, Shukla S. Impact of various factors responsible for fluctuation in plant secondary metabolites. *J Appl Res Med Aromat Plants.* 2015;2(4):105-13. doi:10.1016/j.jarmp.2015.09.002
 41. Dafale NA, Semwal UP, Rajput RK, Singh GN. Selection of appropriate analytical tools to determine the potency and bioactivity of antibiotics and antibiotic resistance. *J Pharm Anal.* 2016;6(4):207-13. doi:10.1016/j.jpha.2016.05.006
 42. Syafriana V, Hamida F, Damayanti R, Nanda EV. Aktivitas Antibakteri Ekstrak Biji Anggur (*Vitis vinifera L.*) terhadap *Streptococcus pyogenes*. *Sainstech Farma Jurnal Ilmu Kefarmasian.* 2020;13(1):40-4. doi:10.37277/sfj.v13i1.523
 43. Khameneh B, Iranshahy M, Soheili V, Bazzaz BSF. Review on plant antimicrobials: a mechanistic viewpoint. *Antimicrob Resist Infect Control.* 2019;8:118. doi:10.1186/s13756-019-0559-6
 44. Górniak I, Bartoszewski R, Króliczewski J. Comprehensive review of antimicrobial activities of plant flavonoids. *Phytochem Rev.* 2019;18:241-72. doi:10.1007/s11101-018-9591-z
 45. Othman L, Sleiman A, Abdel-Massih RM. Antimicrobial Activity of Polyphenols and Alkaloids in Middle Eastern Plants. *Front Microbiol.* 2019;10:911. doi:10.3389/fmicb.2019.00911
 46. Breijyeh Z, Jubeh B, Karaman R. Resistance of Gram-Negative Bacteria to Current Antibacterial Agents and Approaches to Resolve It. *Molecules.* 2020;25(6):1340. doi:10.3390/molecules25061340
 47. Exner M, Bhattacharya S, Christiansen B, Gebel J, Goroncy-Bermes P, Hartemann P, et al. Antibiotic resistance: What is so special about multidrug-resistant Gram-negative bacteria? *GMS Hyg Infect Control.* 2017;12:Doc05. doi:10.3205/dgkh000290
 48. Vila J, Sáez-López E, Johnson JR, Römling U, Dobrindt U, Cantón R, et al. *Escherichia coli*: an old friend with new tidings. *FEMS Microbiol Rev.* 2016;40(4):437-63. doi:10.1093/femsre/fuw005

49. Garcia-Rubio R, de Oliveira HC, Rivera J, Trevijano-Contador N. The Fungal Cell Wall: Candida, Cryptococcus, and Aspergillus Species. *Front Microbiol.* 2019;10:2993. doi:10.3389/fmicb.2019.02993
50. Malanovic N, Lohner K. Gram-positive bacterial cell envelopes: The impact on the activity of antimicrobial peptides. *Biochim Biophys Acta.* 2016;1858(5):936-46. doi:10.1016/j.bbamem.2015.11.004
51. Lima SL, Colombo AL, Junior JNdA. Fungal Cell Wall: Emerging Antifungals and Drug Resistance. *Front Microbiol.* 2019;10:2573. doi:10.3389/fmicb.2019.02573