Borneo Journal of Pharmacy
Vol 4 Issue 2 May 2021
Page 135 – 144
http://journal.umpalangkaraya.ac.id/index.php/bjop/article/view/1870
DOI: https://doi.org/10.33084/bjop.v4i2.1870
e-ISSN: 2621-4814

Research Article

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

Vilya Syafriana*

Amelia Febriani

Suyatno

Nurfitri

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, 2020
Accepted: February 19th, 2021
Published: May 30th, 2021

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 used[3].

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 healing[6]. 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, simpor, simpoh, simpur air,* and *simpur bini*[4,8-11]. The name *sempur* is derived from the hissing sound when the trunk tree is cut[4]. 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 mellitus[10]. 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 methanol[14]. 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), $FeCl_3$ (Merck), Wagner's reagent, Mayer's reagent, Dragendorff's reagent, ammonia (Merck), acetic acid anhydride (Merck), $NaNO_2$ (Merck), $AlCl_3$ (Merck), HCl (Merck), chloroform (Merck), H_2SO_4 (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 process[16].

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 extract[17].

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 it[18].

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 triterpenoids[19]. 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, Serpong[20]. 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 plant[4]. 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 polyphenols[24]. 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 brown[29]. The *D. suffruticosa* leaves powder in this research was showed a greenish color (**Figure 2**). However, this method had limitations, such as time-consuming[27-29]. 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 dried[24].

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 plants[30]. 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 increase[34].

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

***Dillenia suffruticosa* 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.

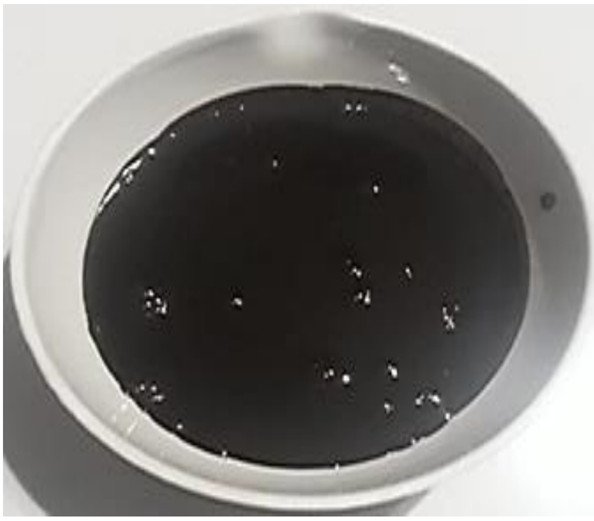

Figure 3. Thick extract of *D. suffruticosa* leaves

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 reagents[35]. 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 polyphenols[36]. Ethanol was known as a solvent that was best for extracting polyphenols from plants[37]. Besides the flavonoids and tannins, the extract also contains saponins. Saponins were triterpene glycosides that had polar tendencies in their glycosidic bonds[38]. 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 versa[32]. 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 greater[42].

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 synthesis[43]. Flavonoids and saponins were work by disrupting the bacterial cell membrane of microorganisms[44]. Meanwhile, tannins act by disturbing the cell protein, either bind and precipitate or shrink proteins[45]. 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)		
	S. aureus	*E. coli*	*C. albicans*
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. PhtoKeys. 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 Simpur Air (Dillenia suffruticosa (Griff.) Martelli).

Jurnal Farmamedika (Pharmamedica Journal). 2018;3(1):21-6. doi:10.47219/ath.v3i1.23

11. Yakop F, Hamid MHSA, 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. Makanjuola 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, Sukamto 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/leksir1737045J

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.jarmap.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