Trop J Nat Prod Res, November 2023; 7(11):5195-5202 **ISSN 2616-0684 (Print)**
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

Antiacne and Antibacterial Bioactivity Properties of Teak (*Tectona grandis*) Flower Essential Oil

Diky S.Diningrat[1], Erly Marwani[2], Kusdianti[3]

[1]*Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, 20221, Indonesia*
[2]*The School of Life Sciences and Technology, Institut Teknologi Bandung, Bandung, 40132, Indonesia, Indonesia*
[3]*Department of Biology, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia, 40154, Indonesia.*

ARTICLE INFO

Article history:
Received 31 August 2023
Revised 21 October 2023
Accepted 19 November 2023
Published online 01 December 2023

ABSTRACT

Acne is generally associated with *Propionibacterium acnes*, which is treated by administering anti-acne medication. The anti-acne drugs currently available are synthetic ingredients that cause side effects. The side effects of this synthetic anti-acne drug can be eliminated by chemicals derived from natural plants, such as those found in teak flower (*Tectona grandis*) essential oil. Therefore, this study aims to determine bioactive compounds' content and test teak essential oil's anti-acne activity. The steps taken in this research: The extraction of teak flower essential oil is made by steam distillation. The teak flower essential oil was then analyzed using a Gas Chromatography Mass Spectrophotometer (GC-MS). The results were evaluated using the MASLAB program and then analyzed using the PubChem NCBI database and PASS Online. The results of the GC-MS analysis showed that there were 47 bioactive compounds. The PubChem analysis results showed that 13 compounds had antibacterial activity. The antibacterial activity as an anti-acne agent of teak flower essential oil was assessed using the disc diffusion method according to the Bauer method. The results of the PASS Online analysis showed that the antibacterial mechanism, Protein synthesis inhibitor, membrane permeability inhibitor and cell wall synthesis inhibitor, with the highest Pa value of 0.804 in the compound Benzyl benzoate Benzoic acid, phenylmethyl ester (CAS) and the lowest Pa value was 1H-Benzimidazole, 2-(methylthio)-(CAS) 2-thiomethylbenzimidazole. Based on the results of the antibacterial activity test, it has strong activity against *Propionibacterium acnes* with an inhibition zone value of 23.1; 15; 15.4; 11.3 which has the potential as an anti-acne.

Keywords: *Tectona grandis*, GC-MS, Antibacterial, Antiacne, Essential oil,

Introduction

Acne is a multifactorial chronic skin disease characterized by infection of the pilosebaceous parts of the skin, such as comedones, papules, pustules, nodules, and cysts, with a predilection for the face, neck, shoulders, chest, back, and upper arms.[1,2,3] This acne is a common skin disease and attacks almost 80%–100% of the population, the bacteria that causes it is known as *Propionibacterium acnes.*[3,4,5,6] So far, treatment of acne infections usually uses antibiotics or synthetics, both oral and topical. However, the drug can cause bacterial resistance within a few weeks of use.[8] This acne medication also causes side effects from using the drug.[9] Natural plant ingredients are reported to be able to eliminate the shortcomings of synthetic drugs.[8,9]

Teak plants are reported to have bioactive compounds including sitosterol, sambelulinate, eugenin, quercetin, camphor, flavonoids, and tannins which are found in the stems and are extracted with ethanol.[10,11,12] Meanwhile, flowers contain kaempferol, quercetin, myricetin, quercetin-3-glucosides, eugenol, and triterpenoids.[13,14,15] These compounds are reported to have pharmacological activity as antibacterials.[10,11,15] Isolation of bioactive compounds by distillation of essential oils is reported to be able to isolate more volatile bioactive compounds compared to other extraction methods.[16,17,18] Therefore, this research aim is the important of study the bioactive compound profile of teak flower essential oil and test its potential as an antibacterial on *Propionibacterium acnes* to treat acne. The approach to providing the outcomes of this research objective was carried out by isolating essential oils from teak flowers using steam distillation. The essential oil produced was analyzed using GC-MS (gas chromatography-mass spectrometry).[17] The GCMS results were further analyzed using the Pubchem database (https://pubchem.ncbi.nlm.nih.gov/)[18] and PASS online[19]. These results will provide data about the activity of bioactive compounds in working as antibacterials that eliminate *Propionibacterium acnes* which causes acne. The antibacterial activity test of teak flower essential oil was carried out using the disc method.

*Corresponding author. E mail: dikysd@unimed.ac.id
Tel: +6281361362400

Citation: Diningrat DA, Marwani E, Kusdianti. Antiacne and Antibacterial Bioactivity Properties of Teak (*Tectona grandis*) Flower Essential Oil. Trop J Nat Prod Res. 2023; 7(11):5195-5202. http://www.doi.org/10.26538/tjnpr/v7i11.24

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria

Materials and Methods

Plant collection

The flower of Tectona grandis was collected from April to May 2023 at (coll. no: Diningrat-2001; ITB campus Jl. Ganesha, Bandung District, West Java Province; the coordinates of the location at -6.887664346483448, 107.60932232621624). The plant sample was authenticated at Herbarium Bandungense, Institute Technology Bandung of Indonesia, Bandung for its identification by Arifin Surya Dwipa, PhD., and the voucher specimen 4087/V.CO2.2/PL/2023 was deposited in the same institute.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Preparation of Teak Flower Essential Oil

Steam distillation is selected as a method to isolate teak flower essential oil. Two hundred and fifty grams (250 g) of teak flower buds were put in a steam flask and 600 mL distilled water were added into a 1000 mL round bottom flask, and the essential oil collection device was assembled after mixing evenly. The extraction was carried out by heating with water vapor for 6 hours and stopped when the yield of the product no longer increased. The essential oil was cooled and collected and dried with an appropriate amount of anhydrous sodium sulfate, then the oil phase was separated out and weighed (m^2). The experiment was repeated three times and the average value was taken. Finally, the E-oil was analyzed with GC or GC-MS (sealed and stored in cold storage away from light, if necessary).[16,17,18].

The GC-MS analysis

The GC-MS technique is used to identify the phytochemical compounds contained in a plant. It is a process of gas chromatography, detecting volatile substances and compounds, while mass spectrometry is the process of identifying molecular compounds through molecular weights and determining their molecular formulas. The GC-MS method is very suitable for volatile essential oils.[18,19] Before the real operation, the instrument was checked for gas flow starting at a low flow rate by opening the main and secondary valves on the carrier gas tank until it showed the 15-psi needle; this allows 2–5 mL/min carrier gas flow for the packed column or 0–5 mL/min for the capillary column. The column was heated to the desired initial temperature. Then, the detector temperature was set at 10–25 ℃ higher than the column temperature, and so was the injection port temperature.

The speed (rate) of the gas flow was then increased to 25–30 ml/minute in the packing column, or until the optimum gas flow rate was achieved. When using a flame ionization detector, it is necessary to pay attention to the presence of hydrogen gas and air flowing into the detector. The sample was dissolved in a volatile solvent, and the volume of the sample injected depended on the type of detector used. For this purpose, in the GCMS tool, the settings are as follows TCD = 10 l, FID = 1–10 l, BCD = 0.1–5 l with a micro syringe, during elution was during the PASSage of the sample from the injection port to the signal detector. From this detector, it would be recorded as a chromatogram on a simple recorder or processed by a microprocessor and displayed on the monitor screen. The chromatogram is displayed by the microprocessor to determine each component simultaneously.

Data analysis technique

The data obtained from the results of this study were qualitative data, which were analyzed descriptively in the form of tables and pictures. Qualitative data included the identification of the bioactive compounds of teak flower essential oil obtained from the GC-MS chromatograms. The information was analyzed using the PubChem software program to identify the activity of these compounds and the canonical smiles were used as advanced analysis codes with the PASS online software to determine compounds that have potential as antibacterials.

The disc diffusion method for antimicrobial susceptibility testing was carried out according to the Bauer method to assess the presence of antibacterial activities of teak flower essential oil against *Propionibacterium acnes*.[20,21,22] A bacteria culture (which has been adjusted to 0.5 McFarland standard), was used to lawn Muller Hinton agar plates evenly using a sterile swab. The plates were dried for 15 minutes and then used for the sensitivity test. The discs which had been impregnated with a series of teak flower essential oils were placed on the MuellerHinton agar surface. Each test plate comprises six discs. One positive control, which is a standard commercial antibiotic disc, one negative control, and four treated discs. The standard antibiotic discs were clindamycin, and the negative control was distilled water. The plate was then incubated at 37°C for 24 hours in the test. After the incubation, the plates were examined for inhibition zone. The inhibition zones were then measured using calipers and recorded. The tests were repeated three times to ensure reliability.

Result and Discussion

The result of the distillation of teak flower essential oil takes approximately 8 hours, with the plant part dried beforehand until the water content has completely run out. This is intended so that the results obtained from essential oils are more optimal. The oil result obtained was 14.9 ml/75 grams. The GC-MS analysis showed a prediction of compounds containing a total of 47 compounds in the essential oil extract. Among the 47 compounds, the highest retention peak was 28.68 m/z, and the lowest was 5.40 m/z. Table 1 shows the results of the GC-MS analysis of Teak Flower Essential Oil. Table 1 and Figure 1 show that the number of phytochemical compounds contained in teak flower essential oil is 46 peaks, starting from 6-Methyl-5-hepten-2-one, 5-Hepten-2-one, 6-methyl-(CAS) Methylheptenone with the lowest retention time of 5.40 to the last vineomycinone B2 Methyl ether with the highest retention time of 28.68.

The bioinformatics for the molecular characterization stage and the GC-MS results were analyzed using Pubchem (http://pubchem.ncbi.nlm.nih.gov/) and PASS Online software. Then, the analysis was carried out using data obtained from the NCBI library of chemical compounds. Identification of the compound resulting from GC-MS, which includes the properties of the compound's molecular structure and obtaining a canonical smile that serves as a code for further analysis, and others use PubChem online software.

PASS Online (Prediction of Activity Spectra for Substances) is a PC-based software used to predict the biological activity of a compound. Many analyses with PASS have been carried out, namely 205,000 compounds and the results have more than 3,750 biological activities.[20]

Table 2 shows the results of the analysis of antibacterial mechanisms that have the potential to be anti-acne. Among the 29 compounds with antibacterial bioactivity, 11 were obtained through antibacterial mechanisms. Antibacterial mechanisms were identified from the results of the PASS Online software analysis, named cell wall synthesis inhibitors, protein synthesis inhibitors, and membrane permeability inhibitors.

Table 2 shows, a comparison of the Pa values of antibacterial compounds as cell wall synthesis inhibitors, protein synthesis inhibitors, and membrane permeability inhibitors the highest Pa value was 0.804 in the compound Benzyl benzoate Benzoic acid, and phenylmethyl ester (CAS), while the lowest Pa value was 0.115 in the compound 1H-Benzimidazole, 2-(methylthio)-(CAS) 2-thiomethylbenzimidazole. Table 2 shows the comparison of the Pa values of antibacterial compounds as cell wall synthesis inhibitors, protein synthesis inhibitors, and membrane permeability inhibitors can be seen. The highest Pa value was 0.804 in the compound Benzyl benzoate $$ Benzoic acid, and phenylmethyl ester (CAS), while the lowest Pa value was 0.115 in the compound 1H-Benzimidazole, 2-(methylthio)- (CAS) 2-thiomethylbenzimidazole.

The antibacterial activity of *Propionibacterium acnes* growth was conducted in triplicate at four series of teak flower oil concentrations (%gr/mL): 0.1, 0.25, 1, and 4, using the disk diffusion method. Clindamycin was used as a positive control and distilled water as a negative control. Inhibitory activity was indicated by the presence of a clear zone that formed around the paper disc (Figure 2). The average value of the inhibition zone for each treatment can be seen in Table 3. Based on Table 3, the inhibition zone on the growth of *Propionibacterium acnes* increased by the decreasing of the concentration series of teak flower essential oil. A small concentration of teak flower essential oil (0.1%) obtained the highest mean value of the inhibition zone (23.1 mm ± 4.42). In the clindamycin as a comparison, the average value of the inhibition zone was (33.9 ± 0.25).

After knowing the area of the inhibition zone for each treatment group, each treatment group was then classified based on the average diameter of the inhibition zone (mm) by observed from the response table for bacterial growth inhibition. Based on Table 4, shows that the lower the concentration of teak flower essential oil is given, the stronger the response is toward the inhibition of the growth of *Propionibacterium acnes*. Likewise, clindamycin as a positive control showed a strong inhibitory response. In contrast to the negative

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

control, which only used distilled water, it did not show any inhibition response.

The volume of essential oils for the teak flowers was 14.9 ml per 3 kg fresh flower. The yield obtained was 4.46%. Considerable amounts of essential oils were extracted from the teak flowers. The differences in the yields were due to differences in flower maturity and odor. Moreover, the amount of the yield is influenced by geographical origin, period of harvest, and condition of the teak varieties. The yield percentage of essential oils depends upon the amount of time spent during extraction, as prolonged extraction time would have a high chance of interaction between the solvent and the sample materials.[21] A unfavorable, such as being too long during the drying process or too long in storage.[21] This can cause the flowers to be less well processed and the oil to be taken, so it is feared that there will be a lot of loss of teak oil in these teak flowers. The differences in isolation methods, clove flower origins, and clove flower preparation before distillation can affect the result of clove oil produced.[21,22,23]

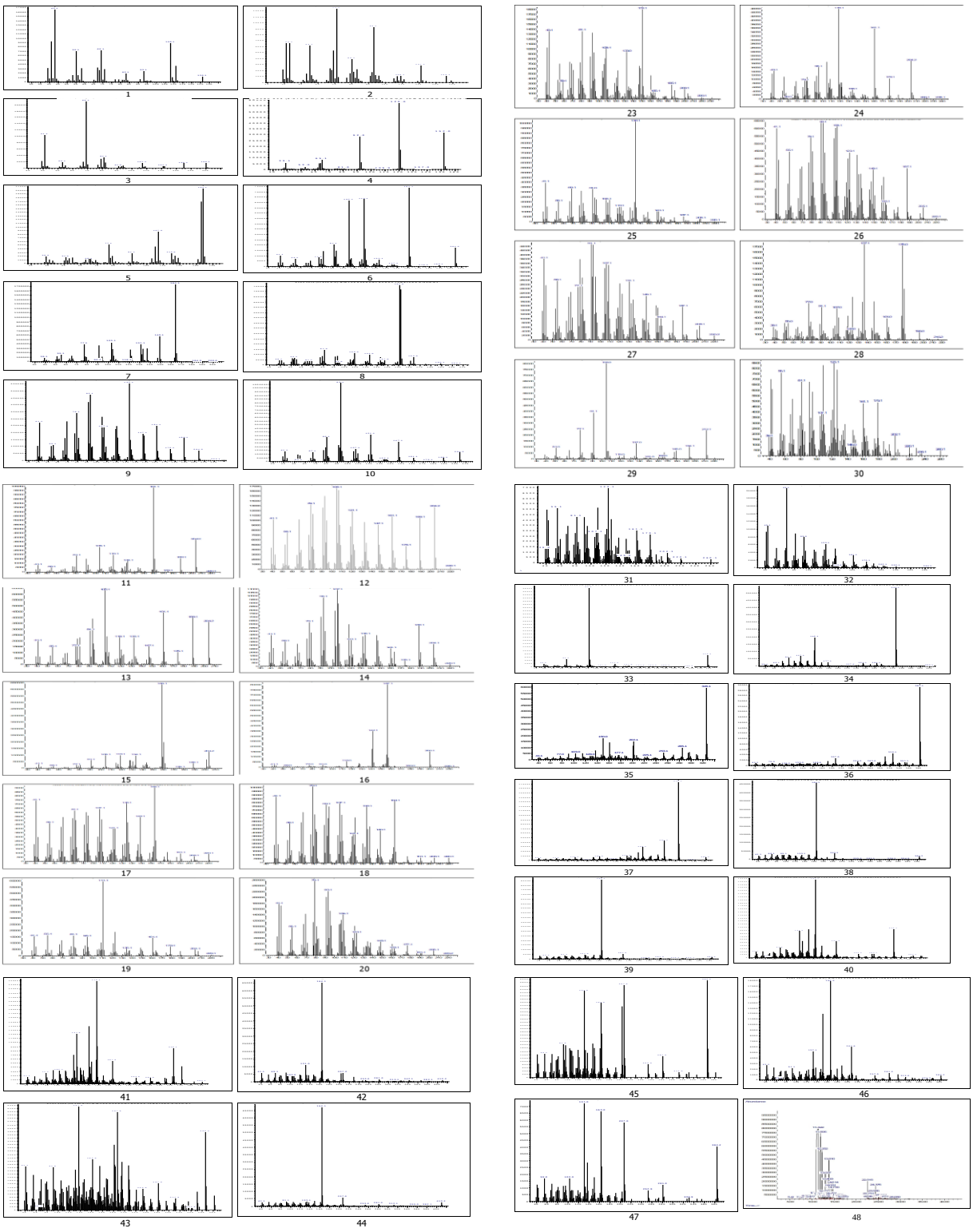


Figure 1: GC MS chromatogram of teak flower essential oil

Caption:

1. 6-Methyl-5-hepten-2-one 5-Hepten-2-one, 6-methyl- (CAS) Methylheptenone
2. 1,6-Octadien-3-ol, 3,7-dimethyl-beta-Linalool Linalol Li nalool
3. (E)-4,8-Dimethyl-1,3,7-nonatriene
4. Methyl salicylate Benzoic acid2-hydroxy-, methyl ester Analgit
5. Chavicol-4-allylphenol para- allyl phenol Phenol,4-(2-propenyl)-
6. alpha-Cubebene (-)-alpha-Cubebene
7. Phenol, 2-methoxy-4-(2-propenyl)-(CAS) Eugenol Engenol p-Eugenol
8. Vanillin Benzaldehyde, 4-hydroxy-3-methoxy-Lioxin Vanillaldehyde
9. Caryophyllene beta-Caryophyll en beta-Caryophyllene
10. alpha-Humulene (CAS) Humulene alpha-Caryophyllene alpha–humulene
11. Naphthalene,1,2,3,5,6,8a-hexahydr o-4,7 dimethyl-1-(1-methylethyl)-, (1S-cis)-
12. beta-Selinene (CAS) Eudesma-4(14),11-diene (CAS) beta-Eudesmene
13. alpha-Gurjunene
14. Guaia-1(10),11-diene alpha-Bulnesene
15. Naphthalene, 1,2,3,4-tetrahydro-1, 6-dimethyl-4-(1-methylethyl)-, (1S-cis)-
16. Benzene,1-methyl-3-[(1-methylethylidene) cyclopropyl]-
17. 1-alpha,9-alpha-Dimethyl-cis bicyclo[4.3.0]non-7-en-2-one
18. triplal 1 (iff) 2,4-dimethyl-3- cyclohexene-1-carbaldehyde
19. Caryophyllenyl alcohol
20. (-)-Caryophyllene oxide (-)-.beta.-Caryophyllene epoxide
21. Camphene (CAS) Bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene- (CAS)
22. Naphthalene, decahydrate- (CAS) Dec Decalin Dekalin Naphthan
23. (1S-(1Alpha,2alpha,4beta))-1-isopropenyl-4-methyl-1,2-cyclohexanedio
24. cadina-1,4-diene
25. caryophylla-4(12),8(13)-dien-5.beta.-ol
26. caryophylla-3,8(13)-dien-5.beta.-o
27. Caryophyllenol-II Caryophyllenol II
28. 2-Propenal, 3-(4-hydroxy-3-methoxyphenyl)-
29. Benzyl benzoate Benzoic acid, phenylmethyl ester (CAS) Ascabin
30. 6-Hydroxycariophyllene
31. trimethyl - perhydro – naphthalene trimethyl – decalin
32. Farnesol, acetate
33. Benzoic acid, 2-hydroxy-, phenylmethyl ester Salicylic acid, benzyl ester
34. Dihydrophenanthropyrane
35. 4-Methylene-1-[4',6'- dimethylpyrimidin-2'-yl]-3,5,6-trimethyl-1H,3H, 6H-pyrim
36. Methyl 3-chloro-5-[(E)-3,7-dimethy l-2,6-octadienyl]-4,6-dimethoxy-2- methylbe.
37. 2-(5-Formyl-4-propyl-2-pyrrolyl)-5-(4-propyl-2-pyrrolyl)thiophene
38. 4,6-Dimethyl-2-mercapto pyridine-3- carbonitrile
39. 1H-Benzimidazole, 2-(methylthio)- (CAS) 2-thiomethylbenzimidazole
40. Benzotriazole, 1-(4-methyl-3-nitro benzoyl)-
41. 2-Methyl-6-methoxy-1-indenol
42. Cis-isoeugenol cis-1-hydroxy-2- methoxy-4-propenyl-benzene (e)- isoeugenol
43. (Z)-5-tert-Butyl-8-(2-phenylethenyl) [2.2]metacyclophane
44. 3-Cyclopentylpropionamide, N-(3,4- dimethoxyphenethyl)-
45. 11-(1-Pyrenyl)undeca-10-ynal
46. 2'-Hydroxy-5'-methoxy acetophenone, acetate
47. vineomycinone B2 Methyl Ether
48. overall chromatogram

The results of the GC-MS analysis of teak flower essential oil showed the presence of 46 bioactive compounds contained in teak flower essential oil. The bioactive compounds start with 6-Methyl-5-hepten-2-one 5-Hepten-2-one,6-methyl-(CAS) Methylheptenone with the lowest retention time was 5.40, followed by vineomycinone B2 Methyl Ether with a retention time of 28.68. The chemical components of essential oils vary depending on geographical area, plant elements, local climate, season, and experimental conditions[24,25]. In addition, harvest and post-harvest treatments can affect the composition and essential oils[26]. 13 compounds have antibacterial bioactivity as follows: 1,6-octadien-3-ol, 3,7-dimethyl-beta-linalool linalol li nalool ; alpha-cubebene (-)-alpha-cubebene; phenol, 2-methoxy-4-(2-propenyl)-(CAS) eugenol eugenol p-eugenol; alpha-humulene (CAS) humulene alpha-caryophyllene alpha –humulene; naphthalene,1,2,3,5,6,8a-hexahydr o-4,7 dimethyl-1-(1-methylethyl)-,(1s-cis); beta-selinene (CAS) eudesma-4(14),11-diene (CAS) beta-eudesmene; alpha-gurjunene; (-)-caryophyllene oxide $$ (-)-beta-caryophyllene epoxide; cadina-1,4-diene; caryophyllenol-ii caryophyllenol ii; benzyl benzoate benzoic acid, phenylmethyl ester (CAS); 4,6-dimethyl-2-mercaptopyridine-3- carbonitrile; and 1h-benzimidazole,2-(methylthio)- (CAS) 2-thiomethylbenzimidazole.

This has obtained 13 phytochemical compounds that have activity as antibacterials from teak flower essential oil. These results are the output of analysis with PubChem, which is a database that stores a collection of molecular data information consisting of three interrelated databases: substance, component, and bioassay.[27]

The results of the analysis with PASS online show that the highest Pa (Probable activity) value is for the compound 0.804 and the Pi value is 0.115 as a Membrane permeability inhibitor. The results show that the mechanism for inhibiting membrane permeability in the compounds Benzyl benzoate, benzoic acid, and phenylmethyl ester (CAS) which have a Pa value > 0.7 leads us to the high potential of these compounds for further exploration. The Pa value also indicates the potential of a compound for various biological activities based on the structure of the structural activity relationship between natural compounds and synthetic drugs.

The disruption of membrane permeability in bacterial cells causes leakage of proteins and nucleic acids. Protein or nucleic acid leakage indicates permanent damage and changes in the permeability of the bacterial cell wall. Most antibacterials work by damaging the cytoplasmic membrane, which can secrete nucleic acids and proteins.[29,30,31]

The teak flower essential oils showed different degrees of growth inhibition of the assayed essential oils against the *Propionibacterium acnes*. The growth of the tested *P. acnes* was affected by the concentration of essential oils which ranged from 0.1 to 1 % v/v. In this present, the diameter of the inhibition zone (mm) found in positive control clindamycin (33.9 mm) is followed by an extract concentration of 0.1% (23.1 mm), up to the concentration of 0.25% (15 mm), and 1%, 4%, and negative control distilled water (0 mm), which take the lowest position. Antibacterials have high activity against bacteria if the minimum concentration value is low, but the inhibition is high.[31,32,33]

These findings suggest significant antibacterial activity against *Propionibacterium acnes*. The effectiveness of antibacterial activity varied depending on the concentration. The essential oils from teak flowers showed potent antimicrobial properties with lower antibacterial activity against *P. acnes* than the commercial antibiotic clindamycin (Table 4).

Components of essential oils that are suspected of having an active role as an antibacterial are Benzyl benzoate Benzoic acid, phenylmethyl ester (CAS; Phenol, 2-methoxy-4-(2-propenyl)- (CAS) Eugenol Eugenol p-Eugenol which is a phenol group compound. Phenol compounds can denature bacterial cell proteins and damage cell membranes. Meanwhile, essential oil components that play an active role are 1,6-Octadien-3-ol, 3,7-dimethyl-beta-Linalool Linalol Li nalool; Caryophyllenol-II Caryophyllenol II which is a monoterpene and other compounds alpha-Cubebene (-)-alpha-Cubebene; alpha-Humulene (CAS) Humulene alpha -Caryophyllene alpha–humulene; Naphthalene,1,2,3,5,6,8a-hexahydr o-4,7 dimethyl-1-(1-methylethyl)-, (1S-cis)-; beta- Selinene (CAS) Eudesma-4(14),11-diene (CAS) beta-Eudesmene; Terpenoid compounds can also inhibit bacterial growth, namely by interfering with the process of forming membranes or cell walls. Cell wall membranes are not formed or are not completely formed.[32,33,34]

Due to the presence of 13 compound components in teak flower essential oils mentioned previously have been proven to have antibacterial potential because they contain phenols and terpenoids which can provide antibacterial effects against *Propionibacterium acnes*.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 1: Results of teak flower essential oil analysis from GC-MS library

NO	Library/ID	RT	Area (%)	Quality (%)
1.	6-Methyl-5-hepten-2-one 5-Hepten-2-one, 6-methyl- (CAS) Methylheptenone	5.40	0.06	93
2.	1,6-Octadien-3-ol, 3,7-dimethyl-beta-Linalool Linalol Li nalool	7.09	0.05	91
3.	(E)-4,8-Dimethyl-1,3,7-nonatriene	7.31	0.03	91
4.	Methyl salicylate Benzoic acid2-hydroxy-, methyl ester Analgit	8.57	0.20	96
5.	Chavicol-4-allylphenol para- allyl phenol Phenol,4-(2-propenyl)-	9.48	0.31	97
6.	alpha-Cubebene (-)-alpha-Cubebene	10.71	0.26	95
7.	Phenol, 2-methoxy-4-(2-propenyl)-(CAS) Eugenol Engenol p-Eugenol	11.32	57.70	98
8.	Vanillin Benzaldehyde, 4-hydroxy-3-methoxy-Lioxin Vanillaldehyde	11.61	0.59	95
9.	Caryophyllene beta-Caryophyll en beta-Caryophyllene	11.90	15.79	99
10.	alpha-Humulene (CAS) Humulene alpha-Caryophyllene alpha–humulene	12.25	4.24	98
11.	Naphthalene,1,2,3,5,6,8a-hexahydr o-4,7 dimethyl-1-(1-methylethyl)-, (1S-cis)-	12.41	0.52	91
12.	beta-Selinene (CAS) Eudesma-4(14),11-diene (CAS) beta-Eudesmene	12.61	0.17	99
13.	alpha-Gurjunene	12.71	0.40	96
14.	Guaia-1(10),11-diene alpha-Bulnesene	12.80	0.15	99
15.	Naphthalene, 1,2,3,4-tetrahydro-1, 6-dimethyl-4-(1-methylethyl)-, (1S-cis)-	13.01	2.47	96
16.	Benzene,1-methyl-3-[(1-methylethylidene) cyclopropyl]-	13.26	0.11	72
17.	1-alpha,9-alpha-Dimethyl-cis bicyclo[4.3.0]non-7-en-2-one	13.32	0.08	53
18.	triplal 1 (iff) 2,4-dimethyl-3- cyclohexene-1-carbaldehyde	13.40	1.09	50
19.	Caryophyllenyl alcohol	13.64	0.34	72
20.	(-)-Caryophyllene oxide (-)-.beta.-Caryophyllene epoxide	13.81	4.30	91
21.	Camphene (CAS) Bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene- (CAS)	13.96	0.40	78
22.	Naphthalene, decahydrate- (CAS) Dec Decalin Dekalin Naphthan	14.09	0.63	78
23.	(1S-(1Alpha,2alpha,4beta))-1-isopropenyl-4-methyl-1,2-cyclohexanedio	14.18	0.19	64
24.	cadina-1,4-diene	14.26	0.29	70
25.	caryophylla-4(12),8(13)-dien-5.beta.-ol	14.39	1.29	95
26.	caryophylla-3,8(13)-dien-5.beta.-o	14.61	1.02	91
27.	Caryophyllenol-II Caryophyllenol II	14.76	1.24	86
28.	2-Propenal, 3-(4-hydroxy-3-methoxyphenyl)-	15.54	0.58	95
29.	Benzyl benzoate Benzoic acid, phenylmethyl ester (CAS) Ascabin	15.76	0.33	98
30.	6-Hydroxycariophyllene	16.30	0.17	64
31.	trimethyl - perhydro – naphthalene trimethyl – decalin	16.38	0.09	45
32.	Farnesol, acetate	16.43	0.17	90
33.	Benzoic acid, 2-hydroxy-, phenylmethyl ester Salicylic acid, benzyl ester	16.88	0.04	93
34.	Dihydrophenanthropyrane	22.51	1.12	86
35.	4-Methylene-1-[4',6'- dimethylpyrimidin-2'-yl]-3,5,6-trimethyl-1H,3H, 6H-pyrim	22.75	0.23	76
36.	Methyl 3-chloro-5-[(E)-3,7-dimethy l-2,6-octadienyl]-4,6-dimethoxy-2- methylbe.	22.86	0.04	83
37.	2-(5-Formyl-4-propyl-2-pyrrolyl)-5-(4-propyl-2-pyrrolyl)thiophene	23.93	0.50	83
38.	4,6-Dimethyl-2-mercapto pyridine-3- carbonitrile	24.37	1.10	64
39.	1H-Benzimidazole, 2-(methylthio)- (CAS) 2-thiomethylbenzimidazole	25.02	0.25	64
40.	Benzotriazole, 1-(4-methyl-3-nitro benzoyl)-	25.11	0.20	42
41.	2-Methyl-6-methoxy-1-indenol	25.37	0.41	43
42.	Cis-isoeugenol cis-1-hydroxy-2- methoxy-4-propenyl-benzene (e)- isoeugenol	25.61	0.35	72
43.	(Z)-5-tert-Butyl-8-(2-phenylethenyl) [2.2]metacyclophane	26.44	0.14	90
44.	3-Cyclopentylpropionamide, N-(3,4- dimethoxyphenethyl)-	26.61	0.11	64
45.	11-(1-Pyrenyl)undeca-10-ynal	26.78	0.08	72

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

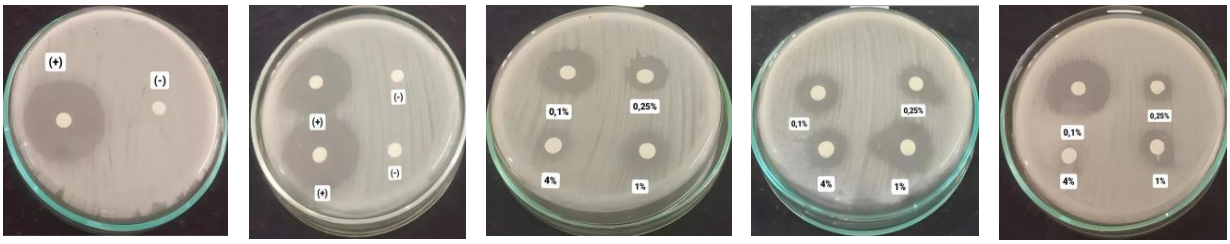
46.	2'-Hydroxy-5'-methoxy acetophenone, acetate	27.03	0.11	58
47.	vineomycinone B2 Methyl Ether	28.69	0.08	25

Table 2: Results of analysis of antibacterial mechanisms using PASS ONLINE

No	Compound names	Value		Antiacne Mechanism
		Pa	Pi	
1.	1,6-Octadien-3-ol, 3,7-dimethyl-. beta.-Linalool Linalol Li nalool	0.743	0.023	Membrane permeability inhibitor
2.	alpha-Cubebene (-)-.alpha.-Cubebene	-	-	-
3.	Phenol, 2-methoxy-4-(2-propenyl)- (CAS) Eugenol Engenol p-Eugenol	0.781	0.013	Membrane permeability inhibitor
4.	alpha-Humulene (CAS) Humulene alpha-Caryophyllene alpha –humulene	0.388	0.209	Membrane permeability inhibitor
5.	Naphthalene,1,2,3,5,6,8a-hexahydr o-4,7 dimethyl-1-(1-methylethyl)-, (1S-cis)-	-	-	-
6.	beta-Selinene (CAS) Eudesma-4(14),11-diene (CAS)	0.439	0.152	Membrane permeability inhibitor
	beta-Eudesmene	0.304	0.052	DNA synthesis inhibitor
7.	alpha-Gurjunene	0.578	0.100	Membrane permeability inhibitor
8.	(-)-Caryophyllene oxide (-)-.beta.-Caryophyllene epoxide	0.416	0.013	Protein synthesis inhibitor
9.	cadina-1,4-diene	0.570	0.105	Membrane permeability inhibitor
10.	Caryophyllenol-II Caryophyllenol II	0.381	0.018	Protein synthesis inhibitor
11.	Benzyl benzoate Benzoic acid, phenylmethyl ester (CAS)	0.804	0.009	Membrane permeability inhibitor
12.	4,6-Dimethyl-2-mercapto pyridine-3-carbonitrile	0.426	0.191	Membrane permeability inhibitor
13.	1H-Benzimidazole, 2-(methylthio)- (CAS) 2-thiomethylbenzimidazole	0.115	0.037	Cell wall synthesis inhibitor

Table 3: Inhibition area zone of antibacterial activity of teak flower essential oil on *Propionibacterium acnes*

Repetition	Negative Control (mm)	Positive Control (mm)	Diameter of Inhibition Zone for each Essential Oil Concentration (mm)			
			0.1	0.25	1	4
I	0	34.2	22.7	15.5	14.8	12.6
II	0	34.0	19.0	15.4	16.5	13.4
II	0	33.7	27.9	14.3	15.1	8.0
Average ± SD	0	33.9± 0.25	23.1± 4.42	15.0± 0.67	15.4± 0.91	11.3± 0.56



(a) (b) (c) (d) (e)

Figure 2: Results of the inhibition zone of teak flower essential oil against *Propionibacterium acnes* (a,b) duplicate of positive control (Clindamycin) and negative (c,d,e) triplicate of different concentration (%gr/mL) 0.1, 0.25, 1, and 4.

Table 4: Classification of the Inhibitory Response of Each Concentration of Teak Flower Essential Oil against *Propionibacterium acnes*.

No	Concentration	Average Area of Inhibition Zone (mm) ± SD	Inhibition Response
1.	Control (-)	0	unavailable
2.	Clindamycin (+)	33.9 ± 0.25	Very Strong
3.	0,1%	23.1 ± 4.42	Strong
4.	0,25%	15.0 ± 0.67	Moderate
5.	1%	15.4 ± 0.91	Moderate
6.	4%	11.3 ± 0.56	Weak

Conclusion

The total bioactive compounds in teak flowers, it is known that 13 compounds have antibacterial bioactivity. The mechanisms obtained from the antibacterial compounds in the study were membrane permeability inhibitors, protein synthesis inhibitors, and cell wall synthesis inhibitors, with the highest Pa value of 0.804 in the compound Benzyl benzoate Benzoic acid, phenylmethyl ester (CAS) and the lowest Pa value of 0.115 in the compound 1H-Benzimidazole, 2-(methylthio)- (CAS), 2-thiomethylbenzimidazole. Teak flower essential oil has strong antibacterial activity against *Propionibacterium acnes*.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgements

Acknowledgments: The authors are thankful to the Directorate General of Higher Education, Research and Technology Ministry of Education, Culture, Research, and Technology through basic domestic cooperation research with no contract 019/UN33.8/DRTPM/PL/2023. We appreciate the facilities provided by the Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, The School of Life Sciences and Technology, Institut Teknologi Bandung and Department of Biology, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia for this work.

References

1. Daniele SG, Kim SR, Grada A, Moore AY, Suozzi KC, Bunick CG. Truncal acne and scarring: A comprehensive review of current medical and cosmetic approaches to treatment and patient management. Am. J. Clin. Dermatol. 2023; 24(2):199-223. https://doi.org/10.1007/s40257-022-00746-4
2. Melnik B, Chen W. Acne and Rosacea. Braun-Falco´s Dermatol. 2020;1-33. https://doi.org/10.1007/978-3-662-58713-3_71-1
3. Bhatnagar A, Mitra D, Kishore K, Kumar M, Valarmathi T, Kumar A, Kumar R. Efficacy of carbon peel laser in acne vulgaris in skin of color: A single center prospective study. J. Cutaneous and Aesthetic Surg. 2023; 23:1-5. https://doi.org/10.4103/JCAS.JCAS_141_22
4. Eichenfield DZ, Sprague J, Eichenfield LF. Management of acne vulgaris: a review. Jama. 2021; 326(20):2055-67. https://doi.org/10.1001/jama.2021.17633
5. Mendes-Bastos P, Ladizinski B, Guttman-Yassky E, Jiang P, Liu J, Prajapati VH, Simpson EL, Vigna N, Teixeira HD, Barbarot S. Characterization of acne associated with upadacitinib treatment in patients with moderate-to-severe atopic dermatitis: a post hoc integrated analysis of 3 phase 3 randomized, double-blind, placebo-controlled trials. J. Am. Acad. Dermatol. 2022; 87(4):784-91. https://doi.org/10.1016/j.jaad.2022.06.012
6. Tamara A, Anggowarsito JL, Tandyono V. Association between magnesium levels and the severity of Acne vulgaris. J. Widya Medika Junior. 2021; 3(4):237-41. https://doi.org/10.33508/jwmj.v3i4.3504
7. Bhate K, Lin LY, Barbieri JS, Leyrat C, Hopkins S, Stabler R, Shallcross L, Smeeth L, Francis N, Mathur R, Langan SM. Is there an association between long-term antibiotics for acne and subsequent infection sequelae and antimicrobial resistance? A systematic review. BJGP open. 2021; 5(3):1-5. https://doi.org/10.3399/BJGPO.2020.0181
8. Martins AM, Marto JM, Johnson JL, Graber EM. A review of systemic minocycline side effects and topical minocycline as a safer alternative for treating acne and rosacea. Antibiotics. 2021; 10(7):757-61. https://doi.org/10.3390/antibiotics10070757
9. Otlewska A, Baran W, Batycka-Baran A. Adverse events related to topical drug treatments for acne vulgaris. Expert Opin. Drug Saf. 2020; 19(4):513-21. https://doi.org/10.1080/14740338.2020.1757646
10. Diningrat DS, Widiyanto SM, Pancoro A, Shim D, Panchangam B, Zembower N, Carlson JE. Transcriptome of teak (*Tectona grandis*, Lf) in vegetative to generative stages development. J. Plant Sci. 2015; 10(1):1-5. https://doi.org/10.3923/jps.2015.1.14
11. Diningrat DS, Widiyanto SM, Pancoro A, Shim D, Panchangam B, Zembower N, Carlson JE. Identification of Terminal Flowering1 (TFL1) Genes Associated with the Teak (*Tectona grandis*) Floral Development Regulation Using RNA-seq. Res. J. Bot. 2015; 10(1):1-5. https://doi.org/10.3923/rjb.2015.1.13
12. Islam AM, Suttiyut T, Anwar MP, Juraimi AS, Kato-Noguchi H. Allelopathic properties of Lamiaceae species: Prospects and challenges to use in agriculture. Plants. 2022; 11(11):1-45. https://doi.org/10.3390/plants11111478
13. Sandhya S, Mehta S, Pandey S, Husen A. Adventitious root formation in cuttings as influenced by genotypes, leaf area, and types of cuttings. In Environmental, Physiological and Chemical Controls of Adventitious Rooting in Cuttings. Acad. Press. 2022; 381-395. https://doi.org/10.1016/B978-0-323-90636-4.00021-0
14. Asdaq SM, Nayeem N, Alam MT, Alaqel SI, Imran M, Hassan EW, Rabbani SI. *Tectona grandis* Lf: A comprehensive review on its patents, chemical constituents, and biological activities. Saudi J. Biol. Sci. 2022; 29(3):1456-64. https://doi.org/10.1016/j.sjbs.2021.11.026
15. Sousa VI, Parente JF, Marques JF, Forte MA, Tavares CJ. Microencapsulation of essential oils: A review. Polym.

2022; 14(9):1730-41. https://doi.org/10.3390/polym14091730
16. Diningrat DS, Sari AN, Harahap NS. Potential of Hanjeli (*Coix lacryma-jobi*) essential oil in preventing SARS-CoV-2 infection via blocking the Angiotensin Converting Enzyme 2 (ACE2) receptor. J. Plant Biotechnol. 2021; 48(4):289-303. https://doi.org/10.5010/JPB.2021.48.4.289
17. Diningrat DS, Sari AN, Harahap NS. In silico study of the toxicity and antiviral activity prediction of jamblang (*Syzygium cumini*) leaves essential oil as ACE2 inhibitor. Pharmacologyonline. 2021; 3:1334-51. https://pharmacologyonline.silae.it/front/archives_2021_3
18. Wasilah S, Sari AN, Nasution RS, Diningrat DS. Anti-meningitis agent potentially of *Syzigium cumini* Essential oil by GC-MS. In IOP Conference Series: Earth and Enviro. Sci. 2021; 753(1):012051-55). IOP Publishing. https://doi.org/10.1088/1755-1315/753/1/012051
19. Bhavaniramya S, Vishnupriya S, Vijayarani K, Vanajothi R. Elucidating the Role of Essential Oils in Pharmaceutical and Industrial Applications. Essential Oils: Extr. Methods Appl. 2023; 14:185-205. https://doi.org/10.1002/9781119829614.ch9
20. Filimonov DA, Lagunin AA, Gloriozova TA, Rudik AV, Druzhilovskii DS, Pogodin PV, Poroikov VV. Prediction of the biological activity spectra of organic compounds using the PASS online web resource. Chem. Heterocycl. Compd. 2014; 50:444-57. https://doi.org/10.3390/ijms21207492
21. Suresh A, Velusamy S, Ayyasamy S, Rathinasamy M. Techniques for essential oil extraction from kaffir lime and its application in health care products—A review. Flavour Fragance J. 2021; 36(1):5-21. https://doi.org/10.1002/ffj.3626
22. Hariyadi MA, Yahya S, Wachjar A. Agro-morphologies and physicochemical properties of flower bud, stem and leaf oils in two clove varieties (*Syzygium aromaticum* L. Merr. and Perry.) originated from Ambon island. Chiang Mai Univ. J. Nat. Sci. 2020; 19(3):516-30. https://www.thaiscience.info/Journals/Article/CMUJ/10991134.pdf
23. Robiatun RR, Pangondian A, Paramitha R, Rani Z, Gultom ED. Formulation and evaluation of hand sanitizer gel from clove flower extract (*Eugenia aromatica* L.). Int. J. Sci. Technol. Manage. 2022; 3(2):484-91. https://doi.org/10.46729/ijstm.v3i2.472
24. Mehalaine S, Chenchouni H. Quantifying how climatic factors influence essential oil yield in wild-growing plants. Arabian J. Geosci. 2021; 14(13):1257. https://doi.org/10.1007/s12517-021-07582-6
25. AL-Hmadi H, El Mokni R, Joshi RK, Ashour ML, Hammami S. The impact of geographical location on the chemical compositions of *Pimpinella lutea* Desf. growing in Tunisia. Appl. Sci. 2021; 11(16):7739-51. https://doi.org/10.3390/app11167739
26. Shehata SA, Abdeldaym EA, Ali MR, Mohamed RM, Bob RI, Abdelgawad KF. Effect of some citrus essential oils on post-harvest shelf life and physicochemical quality of strawberries during cold storage. Agron. 2020; 10(10):1466-75. https://doi.org/10.3390/agronomy10101466
27. Kim S, Chen J, Cheng T, Gindulyte A, He J, He S, Li Q, Shoemaker BA, Thiessen PA, Yu B, Zaslavsky L. PubChem in 2021: new data content and improved web interfaces. Nucleic Acids Res. 2021; 49(D1): D1388-95. https://doi.org/10.1093/nar/gkaa971
28. Yan J, Liu W, Cai J, Wang Y, Li D, Hua H, Cao H. Advances in phenazines over the past decade: Review of their pharmacological activities, mechanisms of action, biosynthetic pathways and synthetic strategies. Mar. Drugs. 2021; 19(11):610. https://doi.org/10.3390/md19110610
29. Lobiuc A, Pavăl NE, Mangalagiu II, Gheorghiță R, Teliban GC, Amăriucăi-Mantu D, Stoleru V. Future antimicrobials: Natural and functionalized phenolics. Mol. 2023; 28(3):1114-21. https://doi.org/10.3390/molecules28031114
30. Guimarães AC, Meireles LM, Lemos MF, Guimarães MC, Endringer DC, Fronza M, Scherer R. Antibacterial activity of terpenes and terpenoids present in essential oils. Mol. 2019; 24(13):2471-82. https://doi.org/10.3390/molecules24132471
31. Ibtisam AA. Inhibitory Activity of Anti-Acne Serum Ethanol Extract from Natural Materials: A Literature Review. Manganite J. Chem. Educ. 2022; 1(1):21-7. https://jurnal.institutsunandoe.ac.id/index.php/manganite/article/view/75
32. Ardhany SD, Fansuri MA, Novaryatiin S. Pharmacognostic Study of Bawang Dayak (*Eleutherine bulbosa* (Mill.) Urb.) and its Clay Mask Against Acne-Causing Bacteria. Trop. J. Nat. Prod. Res. 2022; 6(10):1614-1621. http://www.doi.org/10.26538/tjnpr/v6i10.9
33. Ratnah S, Salasa AM, Ramadhan DS. Formulation, Physical Quality, and Microbial Contamination Tests of Anti-Acne Cream from Longan (*Euphoria longan* [Lour. Steud.]) Seed Extract. Trop. J. Nat. Prod. Res. 2023; 7(7):3297-3305. http://www.doi.org/10.26538/tjnpr/v7i7.5
34. Khamphukdee C, Chulikhit Y, Monthakantirat O, Maneenet J, Boonyarat C, Daodee S. Phytochemical Constituents and Antioxidative Activity of *Schleichera oleosa* Fruit: Trop. J. Nat. Prod. Res. 2021; 5(8):1445-9. http://www.doi.org//10.26538/tjnpr/v5i8. 20.