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Original Article

Phytochemical screening and antibacterial activity of ethnomedicinal plants from Gayo Lues Highland, Indonesia

[Cribado fitoquímico y actividad antibacteriana de plantas etnomedicinales del altiplano de Gayo Lues, Indonesia]

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Abstract

Context: Investigations of phytochemical screening and antibacterial activity were carried out on traditional medicinal plants collected in the highlands of Gayo Lues, Aceh Province, at an elevation of 1,000 meters above sea level (m.a.s.l.).

Aims: To evaluate the antibacterial activity of plants chosen based on the interview results with the traditional healers (n = 5) in Gayo Lues.

Methods: Ethanolic maceration was performed on the 12 identified ethnomedicinal plants and qualitatively screened for the phytochemical contents. Antibacterial activities against *Escherichia coli* ATCC 25922 and *Staphylococcus aureus* were tested for each extract based on the disc diffusion method, and MIC was determined using cephazolin as a reference drug.

Results: The phytochemical screening of twelve plant species showed secondary metabolites class steroids, terpenoids, flavonoids, phenols, alkaloids, and saponins. Evaluation of the antibacterial activity of the extract (10 mg/mL) yielded inhibition zone ranges of 9.8 ± 0.26 to 21.87 ± 0.47 mm for *E. coli* and 8.93 ± 0.9 to 23.97 ± 0.68 for *S. aureus*. The ethanolic extract of *Garcinia macrophylla* Mart stem barks showed the highest antibacterial activity, where at the lowest concentration (1.25 mg/mL), the inhibition zones were found to be 19.2 ± 0.61 and 20.72 ± 0.44 mm for *E. coli* and *S. aureus*, respectively. The MIC was found to be 1.25 mg/mL.

Conclusions: This study concludes that the twelve plant species are worthy of further investigation for novel antibacterial agent exploration.

Keywords: antibacterial; *Escherichia coli*; ethnomedicinal plant; *Garcinia macrophylla*; phytochemical; *Staphylococcus aureus*.

Resumen

Contexto: Se llevaron a cabo investigaciones de cribado fitoquímico y actividad antibacteriana en plantas medicinales tradicionales recolectadas en las tierras altas de Gayo Lues, provincia de Aceh, a una altitud de 1.000 metros sobre el nivel del mar (m.s.n.m.).

Objetivos: Evaluar la actividad antibacteriana de plantas elegidas basándose en los resultados de las entrevistas con los curanderos tradicionales (n = 5) de Gayo Lues.

Métodos: Se realizó una maceración etanólica de las 12 plantas etnomedicinales identificadas y se analizó cualitativamente su contenido fitoquímico. Se probó la actividad antibacteriana de cada extracto contra *Escherichia coli* ATCC 25922 y *Staphylococcus aureus* mediante el método de difusión en disco y se determinó la CMI utilizando la cefazolina como fármaco de referencia.

Resultados: El cribado fitoquímico de doce especies de plantas mostró una clase de metabolitos secundarios de esteroides, terpenoides, flavonoides, fenoles, alcaloides y saponinas. La evaluación de la actividad antibacteriana del extracto (10 mg/mL), arrojó rangos de zona de inhibición de 9,8 ± 0,26 a 21,87 ± 0,47 mm para *E. coli* y de 8,93 ± 0,9 a 23,97 ± 0,68 para *S. aureus*. El extracto etanólico de la corteza del tallo de *Garcinia macrophylla* Mart mostró la mayor actividad antibacteriana, ya que a la concentración más baja (1,25 mg/mL) las zonas de inhibición fueron de 19,2 ± 0,61 y 20,72 ± 0,44 mm para *E. coli* y *S. aureus*, respectivamente. La CMI fue de 1,25 mg/mL.

Conclusiones: Este estudio concluye que las doce especies de plantas son dignas de una mayor investigación para la exploración de nuevos agentes antibacterianos.

Palabras Clave: antibacteriano; *Escherichia coli*; fitoquímico; *Garcinia macrophylla*; planta etnomedicinal; *Staphylococcus aureus*.

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INTRODUCTION

Indonesia is a country that belongs to the mega biodiversity pool with tropical rainforest vegetation (Wasis, 2012). Aceh is one of its provinces with a climate of high rainfall (McCarthy, 2002), while Gayo Lues District is a highland area (± 1,000 meters above sea level—masl) enriched with the biodiversity of fauna and flora. The paramount of the Gayo Lues District is the Leuser Ecosystem, which has been popularly known as the lung of the world (Djufri, 2015). This district was covered by hilly and mountainous areas, hence the name Gayo Lues Highland. This area is far from the urban area and can be reached by land where access is difficult to travel by transportation (BPS, 2015). In addition, Gayo Lues has a limited number of hospitals, and their facilities are minimal. Hence, the locals utilize plants from the surrounding environment for disease management (Fitrianti et al., 2012; Lastari and Agustina, 2018; Rosita and Wani, 2018). About 80% of the global population has used plants as traditional medicines (Hosseinzadeh et al., 2015). The potential of plants as a source of medicine is due to the active role of secondary metabolites contained in plants (Barnes, 2010; Lipkovskaya et al., 2014; Takos and Rook, 2013). Many consider that plant-based medicines are less toxic, minimal side effects and cost-effective. Antibacterial activity is the most common bioactivity observed in medicinal plants.

Multiple investigations have been carried out to explore the antibacterial potentials of plant extracts. This is because bacterial infection diseases have been perceived as a significant threat to human health, with a high number of annual deaths recorded (Jones et al., 2008). Moreover, the demand for new antibacterial agents is currently high since the development of multidrug-resistant bacteria caused by the improper use of antibiotics (Pulingam et al., 2022). Of many cases of bacterial infection or intoxication, *Escherichia coli* and *Staphylococcus aureus* have been reported to be predominant (Frickmann et al., 2019). These two pathogenic bacteria are responsible for hygiene quality-related diseases such as diarrhea (Barreto de Deus et al., 2017). In a review article, antibacterial plant extracts have been recognized as being almost as effective as synthetic drugs (Kadhim et al., 2016).

Herein, we have reported the results from antibacterial activity screening against *E. coli* and *S. aureus* of ethnomedicinal plants from Gayo Lues Highlands (geographically located at 3°40'24"- 4°40'26" N and 96°43'24" - 97°55'24" E Longitude) (BPS, 2020). The sampling location generally has an elevation above sea level of >700 masl (Istiawan and Kastono, 2019). We first retrieved information about the ethnomedicinal plant by interviewing the traditional healer in Gayo Lues. Only plants rarely used or underreported were included to add novelty to our study.

MATERIAL AND METHODS

Materials

The supporting instruments for research were a rotary evaporator (Hidolph Laborota 4003 Control), autoclave (Llenado-Filling), shaker (Edmund Buhler D-7454 Bodelshausen), spectrophotometer (Spectro 20 D Plus Spectrophotometer), and an incubator (Lab-Line Instruments Ultra-Clean "100").

The bacteria (*Escherichia coli* ATCC 25922 and *Staphylococcus aureus* ATCC 25923) were obtained from the Microbiology Laboratory, Faculty of Pharmacy at the University of Sumatera Utara (USU), Medan, Indonesia. This research was run with the following materials: Lactose Broth (LB), distilled water, Muller Hinton Agar (MHA), dimethyl sulfoxide (DMSO) 99.9%, NaCl, paper disc (6 mm), cephazolin 30 µg (disc 6 mm), ethanol 96%, Whatman filter paper grade 41 (Merck, Darmstadt, Germany), Liebermann-Burchard's reagent, NaOH, Shinoda's reagent, $FeCl_3$, Dragendorff's reagent, Wagner's reagent, and Mayer's reagent. Otherwise stated, all chemicals used in this research were analytical grade and purchased from Merck (Selangor, Malaysia).

Interview and sample collection

Plant specimens were collected based on the interview results from traditional healers (n = 5) located across different sub-districts in Gayo Lues Highland. The interview was conducted by asking close-ended questions and note-taking to record the data. The questions included the name of the medicinal plants, their medicinal benefits, and how to prepare and administer them. The medicinal plants should be uncommonly used by the local community (for example, *Murraya koenigii*, a medicinal plant but commonly used as one of the local spices, hence was not enlisted). In addition, medicinal plants should be used individually without concoction. After that, the sample collection began in September 2016. Sampling locations were sub-districts in Gayo Lues, namely Blangkejeren, Dabun Gelang, Blang Pegayon, and Putri Betung. The map visually indicating the sampling locations is presented in Fig. 1, while the coordinates have been presented in Table 1. the specimens were identified by a botanist at Research Center for

Biology at the Indonesian Institute of Sciences (LIPI), Bogor, Indonesia.

Extraction

Different parts of one plant sample another were used according to information obtained from the healers; for instance, the extraction of *Artocarpus elasticus* Reinw ex Blume was only carried out on its stem barks while *Lonicera pulcherrima* Ridl – on its leaves (Table 2). The already chopped leaves or stem barks from the respective plant were air-dried at room temperature (25 ± 1°C) for 7 days. Each dried sample weighed 170 g was macerated with hot ethanol 96% (1.7 L) (initial temperature of 60°C) and left in a sealed container for three days at room temperature. After the separation, all filtrates were subsequently concentrated using a rotary evaporator.

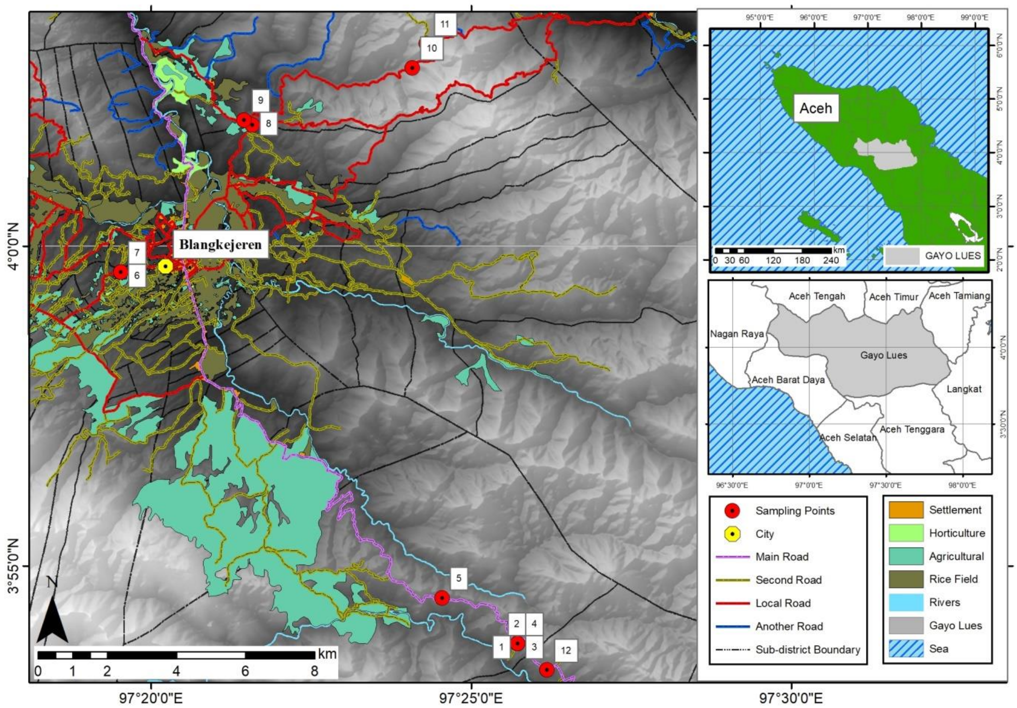

Figure 1. Description of the sampling coordinates in Gayo Lues Highland. Label with code number is assigned for each plant species.

Table 1. Location of the coordinates of sampling points in Gayo Lues Regency.

Plant code	Coordinates		Elevation (m.a.s.l.)	Subdistrict
	Latitude	Longitude		
1	3° 53' 47.544'' N	97° 25' 43.536'' E	1268	Blangkejeren
2	3° 53' 47.544'' N	97° 25' 43.536'' E	1268	Blangkejeren
3	3° 53' 47.544'' N	97° 25' 43.536'' E	1268	Blangkejeren
4	3° 53' 47.544'' N	97° 25' 43.536'' E	1268	Blangkejeren
5	3° 54' 30.276'' N	97° 24' 32.868'' E	1285	Blangkejeren
6	3° 59' 35.988'' N	97° 19' 31.296'' E	997.9	Blang Pegayon
7	3° 59' 35.988'' N	97° 19' 31.296'' E	997.9	Blang Pegayon
8	4° 1' 54.012'' N	97° 21' 34.632'' E	1033.2	Dabun Gelang
9	4° 1' 58.692'' N	97° 21' 27.036'' E	1038.4	Dabun Gelang
10	4° 2' 47.724'' N	97° 24' 4.896'' E	1456	Dabun Gelang
11	4° 3' 10.548'' N	97° 24' 18.144'' E	1624.4	Dabun Gelang
12	3° 53' 22.74'' N	97° 26' 10.86'' E	1239.4	Putri Betung

Table 2. Weight and percent yield extracted from traditional medicinal plants used in Gayo Lues.

Plant code	Name	Part	Weight (g)	Yield (%)
1	*Artocarpus elasticus* Reinw ex Blume	Stem bark	5.80	3.41
2	*Cinnamomum iners* Reinw. ex Blume	Stem bark	3.70	2.18
3	*Lonicera pulcherrima* Ridl.	Leaf	7.10	4.18
4	*Orophea corymbosa* (Blume) Miq.	Leaf	7.80	4.59
5	*Macaranga diepenhorstii* (Miq.) Mull. Arg.	Stem bark	6.90	4.06
6	*Bischofia javanica* Blume	Stem bark	3.30	1.94
7	*Stemonurus malaccensis* (Mast.) Sleumer	Stem bark	4.10	2.41
8	*Glochidion philippicum* (Cav.) C. B. Rob.	Stem bark	4.70	2.76
9	*Homalanthus populneus* (Geiseler) Pax	Stem bark	6.50	3.82
10	*Piper aduncum* L.	Leaf	6.10	3.59
11	*Garcinia macrophylla* Mart.	Stem bark	5.20	3.06
12	*Cinnamomum porrectum* (Roxb.) Kosterm	Stem bark	4.80	2.82

Phytochemical test

Secondary metabolites for steroids, terpenoids, flavonoids, phenols, alkaloids, and saponins of the extracts were identified using phytochemical screening methods. The steroids and terpenoids test were analyzed with Liebermann-Burchard's reagent, the flavonoids were observed by adding NaOH and Shinoda's reagent, the phenols were confirmed to the $FeCl_3$, the alkaloids were indicated by adding the Dragendorff's, the Wagner's and Mayer's reagents and the saponins were offered to a firm of formation foam (Tiwari et al., 2011).

Antibacterial assay

Bacteria *E. coli* ATCC 25922 and *S. aureus* ATCC 25923 were used for antibacterial testing as representatives of Gram-negative and Gram-positive bacterial strains, respectively. The subcultures method was done to inoculate each strain of bacteria, as suggested previously (Khan et al., 2013). A volume of 20 mL of LB medium was prepared for each bacterium. The bacterium was taken from agar media stock and added to each LB medium. The bacterium in LB media was regenerated overnight at 37°C. The fresh bacterium was suspended in 10 mL NaCl 0.85% until an absorbance came to be 0.5-0.8 (to afford 1 × 10^8 CFU/mL) on OD_{600} by a spectrophotometer (Ngule and Ndiku, 2014).

The antibacterial activities were carried out by the disc diffusion method (Mostafa et al., 2018). A 25 mL of MHA solution was poured into a petri dish glass (size 150 × 15 mm) for screening assay of the ethanolic extract of the plants. Furthermore, new *E. coli* and *S. aureus* were smeared over the petri dish agar media. The paper discs containing extracts (dose of 10 mg/mL), positive control of cephazolin (30 µg/mL), and negative control of DMSO (99.9%) were placed on the top of the growth media. Incubation was carried out at 37ºC for 24 h. The inhibition zones were measured by a caliper in millimeters (mm) to indicate antibacterial activity.

The most effective extract was determined the MIC value by the disc diffusion method. A volume of 15 mL of MHA was placed into a Petri dish glass (size of 100 × 15 mm) and spread with fresh bacteria. The paper discs contained different concentrations (15, 12.5, 10, 5, 2.5, and 1.25 mg/mL), DMSO as a negative control and cephazolin (30 µg/mL) as a positive control were sited on top of the media. The incubation time and temperature were set at 24 h and 37ºC, respectively. A measurement of the inhibition zone (mm) was done by using the calipers. The MIC was calculated as suggested by a previous study (Mostafa et al., 2018), where the value represents the lowest concentration of the extract to inhibit the bacterial growth following 24 h incubation.

Data analysis

The obtained data were managed using Microsoft Excel 2010 software (Microsoft Corp., Redmond, WA). All data were presented as means ± standard deviation (SD) in the antibacterial assay. The statistical significance of differences was analyzed on GraphPad Prism 9 based on ANOVA and post hoc Tukey. Statistical significance was considered reached if $p<0.05$.

RESULTS AND DISCUSSION

Medicinal plants suggested by the local healers

The interview results with the local healers in Gayo Lues Highland across four sub-districts (Blangkejeren, Dabun Gelang, Blangpegayon, and Putri Betung) have been presented (Table 3). All healers were above 50 years old, 54 years old being the youngest, and 74 years old being the oldest. The healers identified 12 medicinal plants: terap, rangut galang, jerig, mata kule, tampu, aging, selupik, bebelo, medang kanis, tingkem, toyol uten, gerupel, which were characterized as *Artocarpus elasticus* Reinw ex Blume, *Cinnamomum iners* Reinw. ex Blume, *Orophea corymbosa* (Blume) Miq., *Lonicera pulcherrima* Ridl., *Macaranga diepenhorstii* (Miq.) Mull. Arg., *Glochidion philippicum* (Cav.) C. B. Rob., *Homalanthus populneus* (Geiseler) Pax, *Piper aduncum* L., *Garcinia macrophylla* Mart., *Bischofia javanica* Blume, *Stemonurus malaccensis* (Mast.) Sleumer, and *Cinnamomum porrectum* (Roxb.) Kosterm, respectively. These plants are from families *Annonaceae* (n = 1), *Caprifoliaceae* (n = 1), *Clusiaceae* (n = 1), *Euphorbiaceae* (n = 2), *Lauraceae* (n = 2), *Moraceae* (n = 1), *Phyllanthaceae* (n = 2), *Piperaceae* (n = 1), and *Stemonuraceae* (n = 1). The commonly utilized part is their stem barks or leaves in treating various diseases, including diarrhea, skin diseases, fever, and diabetes. Many preparation methods included boiling the plant and administering it by drinking (oral) or making the plant paste by crushing and applied on the skin.

A dozen plants in this study have been used by many people in Gayo Lues highland from generation to generation to treat diseases caused by bacteria. They are *Artocarpus elasticus* Reinw ex Blume, *Bischofia javanica* Blume, *Glochidion philippicum* (Cav.) C. B. Rob, *Cinnamomum iners* Reinw. ex Blume, *Cinnamomum porrectum* (Roxb.) Kosterm, *Garcinia macrophylla* Mart., *Stemonurus malaccensis* (Mast.) Sleumer, *Homalanthus populneus* (Geiseler), *Macaranga diepenhorstii* (Miq.) Mull. Arg., *Lonicera pulcherrima* Ridl., *Orophea corymbosa* (Blume) Miq., and *Piper aduncum* L. Our search of scientific document database suggested that the previous ethnomedicinal plants were underreported. Therefore, to compare with published reports, we searched for their families, where the results have been presented in Table 4. The bioactivity of plants under the same family could be similar to their mutually shared secondary metabolites among the family members (Wink, 2003). Most of the studies, however, did not discuss the chemical content and the value of the antibacterial activity. Therefore, the results of our work could be novel findings for reporting the antibacterial activities of the ethnomedicinal plants from Gayo Lues Highland.

Table 3. Interview results with healers in Gayo Lues Highland.

Healer (age, years old)	Sub-district address	Medicinal plant		Traditional medicine			
		Local name	Latin name (Family)	Part	Disease	Stock or preparation	Administration
A (54)	Blangkejeren	Terap	*Artocarpus elasticus* Reinw. ex Blume (*Moraceae*)	Stem bark	Diarrhea	Brew	Oral
					Facial spots	Paste	Topical
					Diabetes	Brew	Oral
		Rangut galang	*Cinnamomum iners* Reinw. ex Blume (*Lauraceae*)	Stem bark	Diarrhea	Brew	Oral
					Damaged skin	Brew, paste	Oral, topical
					Inflammation	Brew	Oral
		Jerig	*Orophea corymbosa* (Blume) Miq. (*Annonaceae*)	Leaf	Fever	Crushed-squeezed	Oral
					Nausea	Crushed-squeezed, paste	Oral, respiratory
					Stomachache	Brew	Oral
					Wound	Paste	Topical
					Skin diseases	Brew, paste	Oral, topical
					Diabetes	Brew	Oral

Table 3. Interview results with healers in Gayo Lues Highland (continued…)

Healer (age, years old)	Sub-district address	Medicinal plant		Traditional medicine			
		Local name	Latin name (Family)	Part	Disease	Stock or preparation	Administration
B (56)	Blangkejeren	Mata kule	*Lonicera pulcherrima* Ridl. (*Caprifoliaceae*)	Leaf	Wound	Paste	Topical
					Inflammation	Brew	Oral
					Stomachache	Brew	Oral
					Flu	Crushed-squeezed	Oral
					Diabetes	Brew	Oral
					Oral hygiene	Brew	Gargle
		Tampu	*Macaranga diepenhorstii* (Miq.) Mull. Arg. (*Euphorbiaceae*)	Stem bark	Diarrhea	Brew	Oral
					Wound	Paste	Topical
					Furuncle	Paste	Topical
					Bruise	Paste	Topical
					Swelling	Paste	Topical
					Damaged skin	Brew, paste	Oral, topical
C (58)	Dabun Gelang	Aging	*Glochidion philippicum* (Cav.) C. B. Rob. (*Phyllanthaceae*)	Stem bark	Common cold	Fresh	Chew
					Diarrhea	Brew	Oral
					Diabetes	Brew	Oral
					Hypercholesterolemia	Brew	Oral
					Wound	Paste	topical
		Selupik	*Homalanthus populneus* (Geiseler) Pax (*Euphorbiaceae*)	Stem bark	Diarrhea	Brew	Oral
					Wound	Paste	Topical
					Furuncle	Paste	Topical
					Bruise	Paste	Topical
					Swelling	Paste	Topical
					Damaged skin	Brew, paste	Oral, topical
		Bebelo	*Piper aduncum* L. (*Piperaceae*)	Leaf	Cold and fever	Crushed-squeezed	Oral
					Diarrhea	Brew	Oral
					Wound	Paste	Topical
					Diabetes	Brew	Oral
					Skin diseases	Brew, paste	Oral, topical
					Sprue	Brew	Gargle
		Medang kanis	*Garcinia macrophylla* Mart. (*Clusiaceae*)	Stem bark	Diarrhea	Brew	Oral
					Diabetes	Brew	Oral
					Wound	Paste	Topical
					Obesity	Dried-powder	Oral
					Anti-carcinogenic	Brew	Oral
					Skin diseases	Brew, paste	Oral, topical
					Hypertension	Brew	Oral

Table 3. Interview results with healers in Gayo Lues Highland (continued…)

Healer (age, years old)	Sub-district address	Medicinal plant		Traditional medicine			
		Local name	Latin name (Family)	Part	Disease	Stock or preparation	Administration
D (73)	Blangpegayon	Tingkem	*Bischofia javanica* Blume (*Phyllanthaceae*)	Stem bark	Diarrhea	Brew	Oral
					Diabetes	Brew	Oral
					Common cold	Brew	Oral or topical
					Wound	Paste	topical
		Toyol uten	*Stemonurus malaccensis* (Mast.) Sleumer (*Stemonuraceae*)	Stem bark	Diarrhea	Brew	Oral
					Asthma	Paste	Respiratory
					Hypertension	Brew	Oral
E (74)	Putri Betung	Gerupel	*Cinnamomum porrectum* (Roxb.) Kosterm (*Lauraceae*)	Stem bark	Diarrhea	Brew	Oral
					Diabetes	Brew	Oral
					Hypercholesterolemia	Brew	Oral
					Wound	Paste	Topical

Table 4. The profiles of the traditional medicinal family plants used in Gayo Lues Highland.

Plant family	Secondary metabolites	Uses as traditional medicine	Reference
Annonaceae	Alkaloids, flavonoids, terpenoids, steroids, lignans, acetogenins, phenols	Malaria, wounds, respiratory infections, skin diseases, diarrhea, dysentery, fever, chills, cancer, hepatitis	(Attiq et al., 2017; Harahap et al., 2022; Zhao et al., 2019)
Caprifoliaceae	Saponins, flavonoids, coumarins, phenolics, alkaloids, terpenoids	Infectious diseases, wounds, inflammation, hypotension, sedation, fever	(Chen et al., 2012; Guvenalp et al., 2012)
Clusiaceae	Flavonoids, phenols, tannins, saponins, terpenoids, alkaloids	Inflammation, oxidative stress, microbial infection, cancer, obesity	(Che Hassan et al., 2018; Hemshekhar et al., 2011; Utami, 2016)
Euphorbiaceae	Terpenoids, flavonoids, tannins, coumarins, polyphenols, alkaloids, steroids, saponins	Diarrhea, inflammation of the respiratory tract, swelling, wounds, ulcers, bruises, skin diseases, suppuration, tumors, asthma, cough, dysentery	(MagadulaJoseph, 2014; Pascal et al., 2017; Rizk, 1987)
Lauraceae	Alkaloids, phenylpropanoids, polyphenols, terpenoids, steroids, flavonoids	Toothache, oral infections, diarrhea, cardiovascular disease, oxidative stress	(Espineli et al., 2013; Hammid et al., 2016; Nabavi et al., 2015; Oliveira Filho et al., 2015; Saetan et al., 2016)
Moraceae	Alkaloids, flavonoids, phenols, tannins, terpenoids, steroids, saponins	Stomach pain, ulcers, asthma, ringworm, diabetes, gallstones, wounds, liver cirrhosis, hypertension, skin diseases	(Jagtap and Bapat, 2010; Somashekhar et al., 2013)
Phyllanthaceae	Terpenoids, tannins, alkaloids, flavonoids, phenols, steroids	Hair stimulant, wounds, diarrhea, dysentery	(Ajaib and Khan, 2012; Aththorick and Berutu, 2018; Huang et al., 2015; Jambak et al., 2019)
Piperaceae	Alkaloids, flavonoids, steroids, terpenoids, saponins, phenols	Insecticides, asthma, bronchitis, hay fever, inflammation, sores, diarrhea, dysentery, nausea, ulcers, genito-urinary infections	(Batan et al., 2018; Bouzada et al., 2009; Chahal et al., 2011; Kartika et al., 2019; Pacheco et al., 2014; Torres-Pelayo et al., 2016)
Stemonuraceae	Terpenoids, alkaloids, tannins	Hypertension, asthma, stomachache	(Potgieter et al., 2016)

Table 5. The phytochemical screening of the traditional medicinal plant extract.

Plant	Secondary metabolites					
	Steroid	**Terpenoid**	**Flavonoid**	**Alkaloid**	**Phenol**	**Saponin**
A. elasticus	-	+	+	+	+	+
C. iners	-	+	+	+	+	+
L. pulcherrima	+	+	+	+	+	+
O. corymbosa	+	+	+	+	+	+
M. diepenhorstii	-	+	+	+	+	+
B. javanica	+	+	+	+	+	-
S. malaccensis	+	+	+	+	+	+
G. philippicum	+	+	+	+	+	+
H. populneus	+	+	+	+	+	+
P. aduncum	+	+	+	+	+	+
G. macrophylla	+	+	+	+	+	+
C. porrectum	-	+	+	+	+	-

(+): present; (-): absent.

Phytochemical profiles of the ethnomedicinal plants

The obtained weight and yield of the extract of each plant specimen have been presented in Table 2. Yield percentages ranged from 1.94 to 4.59%, with *B. javanica* having the lowest percentage and *O. corymbosa* having the highest. As for the phytochemical class screening, the results have been presented in Table 5. *L. pulcherrima*, *O. corymbosa*, *S. malaccensis*, *G. philippicum*, *H. populneus*, and *G. macrophylla* were found positive containing all phytochemical classes (steroids, terpenoids, flavonoids, alkaloids, phenols, and saponins). Several plant extracts, such as those from *A. elasticus*, *C. iners*, *M. diepenhorstii*, and *C. porrectum* were either negative containing steroids or saponins.

The phytochemical results revealed that the compound groups of terpenoids, flavonoids, alkaloids, and phenols were present in the extracted plants. Comparing our findings (Table 5) with those reported (Table 4), we conclude that the plant species contains the same predominant phytochemical classes under the same family. The previous phytocompounds have been associated with bacteriostatic and bactericidal activities of plant extracts (Cowan, 1999; Harahap et al., 2022).

Antibacterial activity of ethnomedicinal plants

The plant species were investigated for evaluate their antibacterial activity against a strain bacteria Gram-negative (*E. coli* ATCC 25922) and Gram-positive (*S. aureus* ATCC 25923). The results of the antibacterial activity of these plant extracts with a dose of 10 mg/mL have been presented in Fig. 2. From the highest to the lowest, *G. macrophylla*, *O. corymbosa*, and *A. elasticus*, were the top three bacterial growht inhibitor against both *E. coli* and *S. aureus*. Mostly, the extracts were more potent against Gram-positive *S. aureus* than that of Gram-negative *E. coli*, except in the case of *C. parectum*, *H. populneus,* and *M. diapenharstii*. Ethanolic extract from *G. macrophylla* stem barks achieved inhibition zones of 21.87 ± 0.47 and 23.97 ± 0.68 mm for *E. coli* and *S. aureus*, respectively. Further investigation was carried out using the extract from *G. macrophylla* stem barks due to its high antibacterial activities.

Inhibition zones against *E. coli* ATCC 25922 or *S. aureus* ATCC 25923 observed following the diffusion of *G. macrophylla* with concentration variation (1.25–15 mg/mL) have been presented in Fig. 3. At all concentrations, the activity was always higher in *S. aureus* as opposed to *E. coli.* Increasing trend of inhibition zones was found to be dependent to the concentration of *G. macrophylla* extract. At concentration of 15 mg/mL, the inhibition zones against *E. coli* and *S. aureus* were 24.33 ± 0.76 and 26.68 ± 0.7 mm, respectively. Meanwhile, at the lowest concentration, the inhibitions zones of 19.2±0.61 and 20.72±0.44 mm were obtained against *E. coli* and *S. aureus*, respectively. Herein, the MIC of the extracts against both *E. coli* and *S. aureus* was found to be 1.25 mg/mL.

The secondary metabolite content of the plant extract can act as an antibacterial. The steroids,

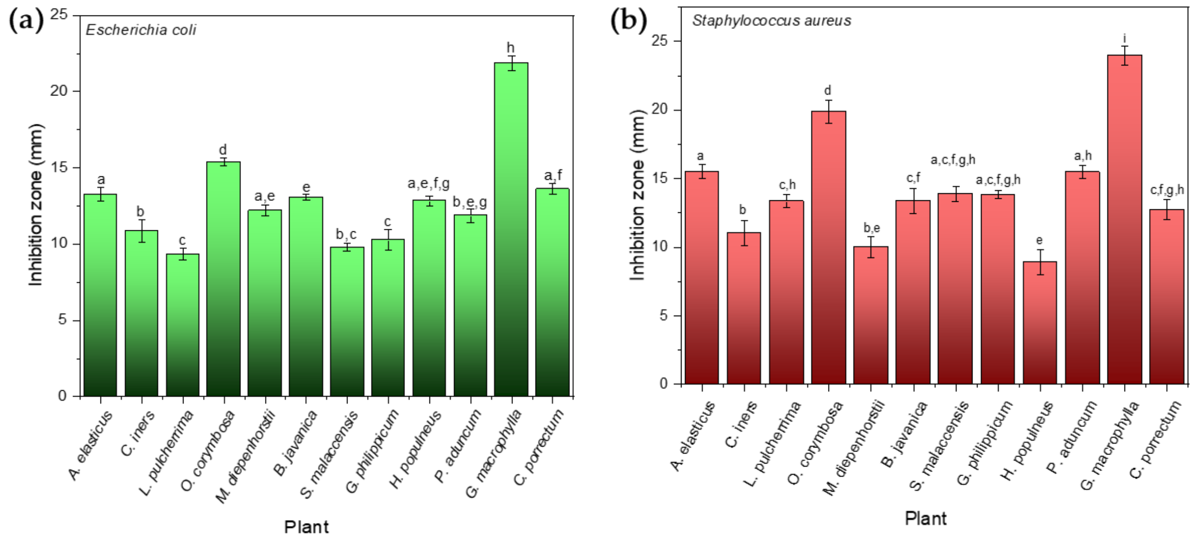

Figure 2. Inhibition zones of the investigated plants against *E. coli* **(a)** and *S. aureus* **(b)**.

Different alphabet indicates statistical significance at $p<0.05$ based on post hoc Tukey. Positive control (+) = Cephazolin 30 µg/mL (inhibition zones of 27.20 ± 0.52 mm for *E. coli* and 33.00 ± 0.87 mm for *S. aureus*). Negative control (-) = DMSO solvent (no inhibition zone).

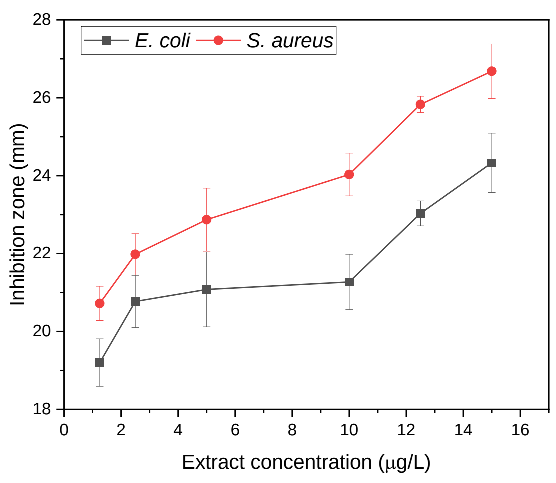

Figure 3. Inhibition zone of *G. macrophylla* extract against *E. coli* and *S. aureus* at various concentrations.

Positive control (+) = Cephazoline 30 µg/mL (inhibition zones of 27.70 ± 0.17 mm for *E. coli* and 33.30 ± 0.76 mm for *S. aureus*). Negative control (-) = DMSO solvent (no inhibition zone).

terpenoids and saponins have been demonstrated to disrupt and damage the cell membrane of bacteria (Doğan et al., 2017; Francis et al., 2002; Jasmine et al., 2011). The antibacterial actions of flavonoids have been displayed to inhibit nucleic acid synthesis, cytoplasmic membrane function, energy metabolism, and the porins on the cell membrane (Xie et al., 2015). The antibacterial mechanism of alkaloids has been investigated through inhibitions of nucleic acid synthesis and the work of enzymes (Cushnie et al., 2014). The phenols have shown a role in inhibiting growth by denaturing and coagulating proteins (Sabbineni, 2016).

Based on the interview results, the plants were used to treat diseases among the local community in Gayo Lues Regency. These diseases could be associated to bacterial infections such as diarrhea and wound infections. About 80% of the area of Gayo Lues District are a forest area. Therefore, all of these plants are easily found in the forest surrounding to community settlements (Tetra Tech ARD, 2013). Some plants with the same family group in Gayo Lues, namely *Annonaceae*, *Euphorbiaceae*, *Phyllanthaceae* *Clusiaceae*, *Lauraceae*, *Moraceae*, and *Piperaceae* were previously reported as a source of medicine in the management of diseases caused by bacteria (Elliott and Brimacombe, 1987).

The bioactive test results on the growth of *E. coli* and *S. aureus* demonstrated that the plant extract tested were in the zone of moderate activity inhibition based on the classification of antimicrobial strength as weak, moderate, and strong activity (indicated by inhibition zones of <12, 12-20, and >20 mm, respectively) (Shaaban et al., 2017). The extract of *C. iners* on both bacteria showed weak antibacterial activity. Although the extract of *C. iners* stem barks was weak in inhibiting the microbial growth, it is often used as medicine by the Gayo Lues community. This plant could be found around residential areas on house fences (Buru et al., 2014). The extract of *G. macrophylla* showed strong activity against the *E. coli* and *S. aureus*. Therefore, evaluations of its antibacterial activity using various concentrations of 1.25, 2.50, 5.00, 10.00, 12.50, and 15.00 mg/mL against *E. coli* and *S. aureus* were performed. At the lowest concentration (1.25 mg/mL), the extract had moderate and strong activities against *E. coli* (19.20 ± 0.61 mm) and *S. aureus* (20.72 ± 0.44), respectively. This activity could suggest *G. macrophylla* role in managing healing diarrhea, dysentery and external and internal wounds.

CONCLUSION

The ethanol extract from the uncommonly used ethnomedicinal plants from Gayo Lues Highlands showed weak to strong inhibitory activity against *E. coli* bacteria ATCC 25922 and *S. aureus* ATCC 25923. The extract from *G. macrophylla* stem barks was revealed to possess the strongest antibacterial activity among other extracts. The study concludes these ethnomedicinal plant species have the potency in the field of medicine to overcome bacterial infectious diseases.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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REFERENCES

Ajaib M, Khan ZUD (2012) *Bischofia javanica*: A new record to the Flora of Pakistan. Biologia (Pakistan) 58(1-2): 179-183.

Aththorick TA, Berutu L (2018) Ethnobotanical study and phytochemical screening of medicinal plants on Karonese people from North Sumatra, Indonesia. J Phys Conf Ser 1116(5): 052008. https://doi.org/10.1088/1742-6596/1116/5/052008

Attiq A, Jalil J, Husain K (2017) Annonaceae: Breaking the wall of inflammation. Front Pharmacol 8: 752. https://doi.org/10.3389/fphar.2017.00752

Barnes PJ (2010) Inhaled corticosteroids. Pharmaceuticals (Basel) 3(3): 514–540. https://doi.org/10.3390/ph3030514

Barreto de Deus T, Barros LSS, Mendes da Silva R, Karine da Silva Lima W, Virgens Lima DD, Dos Santos Silva A (2017) *Staphylococcus aureus* and *Escherichia coli* in Curd cheese sold in the Northeastern Region of South America. Int J Microbiol 2017: 8173741. https://doi.org/10.1155/2017/8173741

Batan A, Daniel D, Simanjuntak P (2018) Isolation of chemical active compounds antioxidant from ethyl acetate fraction of betel leaf forest (*Piper aduncum* L.). J Atomik 3(2): 83–90.

Bouzada MLM, Fabri RL, Nogueira M, Konno TUP, Duarte GG, Scio E (2009) Antibacterial, cytotoxic and phytochemical screening of some traditional medicinal plants in Brazil. Pharm Biol 47(1): 44–52. https://doi.org/10.1080/13880200802411771

BPS (2015) Profile of Gayo Lues 2015, in: BAPPEDA (Ed.). Central Bureau of Statistics and Agency for Regional Development of Gayo Lues Regency, Blangkejeren.

BPS (2020) Gayo Lues Regency in Numbers. Central Bureau of Statistics of Gayo Lues, Blangkejeren.

Buru AS, Pichika MR, Neela V, Mohandas K (2014) *In vitro* antibacterial effects of *Cinnamomum* extracts on common bacteria found in wound infections with emphasis on methicillin-resistant *Staphylococcus aureus*. J Ethnopharmacol 153(3): 587–595. https://doi.org/10.1016/j.jep.2014.02.044

Chahal J, Ohlyan R, Kandale A, Walia A, Puri S (2011) Introduction, phytochemistry, traditional uses and biological activity of genus Piper: A review. Int J Curr Pharm Rev Res 2: 131–144.

Che Hassan NKN, Taher M, Susanti D (2018) Phytochemical constituents and pharmacological properties of *Garcinia xanthochymus*- a review. Biomed Pharmacother 106: 1378–1389. https://doi.org/10.1016/j.biopha.2018.07.087

Chen WC, Liou SS, Tzeng TF, Lee SL, Liu IM (2012) Wound repair and anti-inflammatory potential of *Lonicera japonica* in excision wound-induced rats. BMC Complement Altern Med 12: 226. https://doi.org/10.1186/1472-6882-12-226

Cowan MM (1999) Plant products as antimicrobial agents. Clin Microbiol Rev 12(4): 564–82. https://doi.org/10.1128/CMR.12.4.564

Cushnie TP, Cushnie B, Lamb AJ (2014) Alkaloids: an overview of their antibacterial, antibiotic-enhancing and antivirulence activities. Int J Antimicrob Agents 44(5): 377–386. https://doi.org/10.1016/j.ijantimicag.2014.06.001

Djufri D (2015) Leuser Ecosystem of Aceh Province as a natural laboratory for the study of biodiversity to find the raw materials of drugs. Pros Sem Nas Masy Biodiv Indon 1: 1543–1552.

Doğan A, Otlu S, Çelebi Ö, Aksu Kiliçle P, Gülmez Sağlam A, Doğan ANC, Mutlu N (2017) An investigation of antibacterial effects of steroids. Turk J Vet Anim Sci 41: 302–305. https://doi.org/10.3906/vet-1510-24

Elliott S, Brimacombe J (1987) The medicinal plants of Gunung Leuser National Park, Indonesia. J Ethnopharmacol 19(3): 285–317. https://doi.org/10.1016/0378-8741(87)90006-7

Espineli DL, Agoo EMG, Shen CC, Ragasa CY (2013) Chemical constituents of *Cinnamomum iners*. Chem Nat Compd 49: 932–933. https://doi.org/10.1007/s10600-013-0783-x

Fitrianti Y, Wahyudi A, Saifullah and Pratiwi NL (2012) Gayo Ethnic of Tetingi Village, Blang Pegayon Sub-District, Gayo Lues District, Nanggroe Aceh Darussalam Province. Health Research and Development Agency, Ministry of Health of the Republic of Indonesia, Surabaya.

Francis G, Kerem Z, Makkar HP, Becker K (2002) The biological action of saponins in animal systems: a review. Br J Nutr 88(6): 587–605. https://doi.org/10.1079/BJN2002725

Frickmann H, Hahn A, Berlec S, Ulrich J, Jansson M, Schwarz NG, Warnke P, Podbielski A (2019) On the etiological relevance of *Escherichia coli* and *Staphylococcus aureus* in superficial and deep infections - A hypothesis-forming, retrospective assessment. Eur J Microbiol Immunol 9(4): 124–130. https://doi.org/10.1556/1886.2019.00021

Guvenalp Z, Ozbek H, Kuruuzum-Uz A, Kazaz C, Demirezer LO (2012) Chemical constituents of *Lonicera etrusca*. Chem Nat Compd 48: 693–695. https://doi.org/10.1007/s10600-012-0353-7

Hammid SA, Assim Z, Ahmad F (2016) Chemical composition of *Cinnamomum* species collected in Sarawak. Sains Malaysiana 45: 627–632.

Harahap D, Niaci S, Mardina V, Zaura B, Qanita I, Purnama A, Puspita K, Rizki DR, Iqhrammullah M (2022) Antibacterial activities of seven ethnomedicinal plants from family Annonaceae. J Adv Pharm Technol Res 13(3): 148–153. https://doi.org/10.4103/japtr.japtr_111_22

Hemshekhar M, Sunitha K, Santhosh MS, Devaraja S, Kemparaju K, Vishwanath BS, Niranjana SR, Girish KS (2011) An overview on genus garcinia: phytochemical and therapeutical aspects. Phytochem Rev 10: 325–351. https://doi.org/10.1007/s11101-011-9207-3

Hosseinzadeh S, Jafarikukhdan A, Hosseini A, Armand R (2015) The application of medicinal plants in traditional and modern medicine: A review of *Thymus vulgaris*. Int J Clin Med 6: 635–642. http://dx.doi.org/10.4236/ijcm.2015.69084

Huang D, Shi F, Chai M, Li R, Li H (2015) Interspecific and intersexual differences in the chemical composition of floral scent in *Glochidion* species (Phyllanthaceae) in South China. J Chem 2015: 865694. https://doi.org/10.1155/2015/865694

Istiawan ND, Kastono D (2019) Effect of plant elevation on yield and quality of clove oil (*Syzygium aromaticum* (L.) Merr. & Perry.) in Samigaluh District, Kulon Progo. Vegetalika 8: 27–41.

Jagtap UB, Bapat VA (2010) Artocarpus: A review of its traditional uses, phytochemistry and pharmacology. J Ethnopharmacol 129: 142–166. https://doi.org/10.1016/j.jep.2010.03.031

Jambak K, Nainggolan M, Dalimunthe A (2019) Antioxidant activity of ethanolic extract and n-hexane fraction from sikkam (*Bischofia javanica* blume) stem bark. Asian J Pharm Res Dev 7: 1–5. https://doi.org/10.22270/ajprd.v7i2.486

Jasmine R, Selvakumar BN, Daisy P (2011) Investigating the mechanism of action of terpenoids and the effect of interfering substances on an Indian medicinal plant extract demonstrating antibacterial activity. Int J Pharm Stud Res II(II): 19–24.

Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, Daszak P (2008) Global trends in emerging infectious diseases. Nature 451(7181): 990–993. https://doi.org/10.1038/nature06536

Kadhim WA, Kadhim MJ, Hameed IH (2016) Antibacterial activity of several plant extracts against Proteus species. Int J Pharm Clin Res 8: 1673–1684.

Kartika R, Sudrajat, Bustanussalam, Simanjuntak P (2019) Hydrochalcone compounds from Indonesian medicinal plant, 'sirih hutan', *Piper aduncum* (piperaceae). Rasayan J Chem 12: 1022–1026. http://dx.doi.org/10.31788/RJC.2019.1235186

Khan UA, Rahman H, Niaz Z, Qasim M, Khan J, Tayyaba, Rehman B (2013) Antibacterial activity of some medicinal plants against selected human pathogenic bacteria. Eur J Microbiol Immunol 3(4): 272–274. https://doi.org/10.1556/EuJMI.3.2013.4.6

Lastari W, Agustina ZA (2018) Meta-ethnography of delivery cultures in Indonesian. J Masy Budaya 20(1): 49–60.

Lipkovskaya NA, Barvinchenko VN, Fedyanina TV, Rugal AA (2014) Physicochemical properties of quercetin and rutin in aqueous solutions of decamethoxin antiseptic drug. Russian J Appl Chem 87: 36–41. https://doi.org/10.1134/S1070427214010054

MagadulaJoseph JJ (2014) Phytochemistry and pharmacology of the genus Macaranga: A review. J Med Plant Res 8: 489–503. https://doi.org/10.5897/JMPR2014.5396

McCarthy JF (2002) Power and interest on Sumatra's rainforest frontier: clientelist coalitions, illegal logging and conservation in the Alas valley. J Southeast Asian Stud 33: 77–106.

Mostafa AA, Al-Askar AA, Almaary KS, Dawoud TM, Sholkamy EN, Bakri MM (2018a) Antimicrobial activity of some plant extracts against bacterial strains causing food poisoning diseases. Saudi J Biol Sci 25(2): 361–366. https://doi.org/10.1016/j.sjbs.2017.02.004

Nabavi SF, Di Lorenzo A, Izadi M, Sobarzo-Sánchez E, Daglia M, Nabavi SM (2015) Antibacterial effects of Cinnamon: From farm to food, cosmetic and pharmaceutical industries. Nutrients 7(9): 7729–7748. https://doi.org/10.3390/nu7095359

Ngule MC, Ndiku HM (2014) Antidiarrheal activity of *Tetradenia riparia* and *Wubergia ugandensis* antidiarrheal activity ethnobotanical plants in Kenya. World J Pharm Scie 2: 1180–1183.

Oliveira Filho A, Fernandes H, Assis T (2015) Lauraceae's family: A brief review of cardiovascular effects. Int J Pharmacogn Phytochem Res 7: 22–26.

Pacheco FV, Alvarenga ICA, Junior PMR, Pinto JEBP, Avelar RdP, Alvarenga AA (2014) Growth and production of secondary compounds in monkey-pepper (*Piper aduncum* L.) leaves cultivated under altered ambient ligh. Australian J Crop Sci 8: 1510–1516.

Pascal OA, Bertran AEV, Esaïe T, Sylvie HAM, Eloi AY (2017) A review of the ethnomedical uses, phytochemistry and pharmacology of the Euphorbia genus. Pharma Innov J 6(1): 34–39.

Potgieter MJ, Schori M, Utteridge TMA (2016) Stemonuraceae. In: Kadereit, J.W., Bittrich, V. (Eds.), Flowering Plants. Eudicots. Springer Switzerland, pp. 367–376.

Pulingam T, Parumasivam T, Gazzali AM, Sulaiman AM, Chee JY, Lakshmanan M, Chin CF, Sudesh K (2022) Antimicrobial resistance: Prevalence, economic burden, mechanisms of resistance and strategies to overcome. Eur J Pharm Sci 170: 106103. https://doi.org/10.1016/j.ejps.2021.106103

Rizk AFM (1987) The chemical constituents and economic plants of the Euphorbiaceae. Bot J Linn Soc 94: 293–326. https://doi.org/10.1111/j.1095-8339.1987.tb01052.x

Rosita S, Wani R (2018) The relationship of social cultural and exposure to information toward use of traditional medicine for parturition at district of Teragun regency the Gayo Lues. Maj Kesehat Masy Aceh 1(2): 86–93.

Sabbineni J (2016) Phenol-An effective antibacterial agent. J Med Org Chem 3(2): 182–191.

Saetan P, Usawakesmanee W, Siripongvutikorn S (2016) Influence of hot water blanching process on phenolic profile and antioxidant activity of *Cinnamomum porrectum* herbal tea. Funct Foods Health Dis 6: 836–854. https://doi.org/10.31989/ffhd.v6i12.315

Shaaban HA, Ali HS, Bareh GF, Al-Khalifa ARS, Amer MM (2017) Antimicrobial activity of two polysaccharide edible films incorporated with essential oils against three pathogenic bacteria. J Appl Sci 17: 171–183. http://dx.doi.org/10.3923/jas.2017.171.183

Somashekhar M, Nayeem N, Mahesh A (2013) Botanical study of four ficus species of family Moraceae: A review. Int J Universal Pharm Bio Sci 2: 558–570.

Takos AM, Rook F (2013) Towards a molecular understanding of the biosynthesis of Amaryllidaceae alkaloids in support of their expanding medical use. Int J Mol Sci 14: 11713–11741. https://doi.org/10.3390/ijms140611713

Tetra Tech ARD (2013) Indonesia forest and climate support: conservation plan for nature of Gayo Lues district Aceh. USAID-IFACS, Jakarta, pp. 93.

Tiwari PK, Kumar B, Kaur M, Kauer G, Kaur H (2011) Phytochemical screening and extraction: A review. Int Pharm Sci 1: 98–106.

Torres-Pelayo VR, Fernandez MS, Carmona-Hernandez O, Molina-Torres J, Lozada-Garcia JA (2016) A phytochemical and ethnopharmacological review of the genus Piper: as a potent bio-insecticide. Res Rev: Res J Biol 4(2): 45–51.

Utami S (2016) Antibacterials patentability of plant Garcinia. J Kedokteran Yarsi 24: 69–79.

Wasis B (2012) Soil Properties in Natural Forest Destruction and Conversion to Agricultural Land,in Gunung Leuser National Park, North Sumatera Province. J Man Hut Trop 18: 206–212. http://dx.doi.org/10.7226/jmht.18.3.206

Wink M (2003) Evolution of secondary metabolites from an ecological and molecular phylogenetic perspective. Phytochemistry 64: 3–19. https://doi.org/10.1016/S0031-9422(03)00300-5

Xie Y, Yang W, Tang F, Chen X, Ren L (2015) Antibacterial activities of flavonoids: structure-activity relationship and mechanism. Curr Med Chem 22: 132–149. https://doi.org/10.2174/0929867321666140916113443

Zhao W, Gong XW, Duan YX, Yang J, Wu X, Jiang XJ, Xu XH, Chen YK., Yang L, Wang F, Yang XL (2019) Two new triterpenoids with antimicrobial activity from the leaves and twigs of *Orophea yunnanensis*. Nat Prod Res 33: 3472–3477. https://doi.org/10.1080/14786419.2018.1481843

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Contribution	Cane HPCA	Musman M	Yahya M	Saidi N	Darusman D	Nanda M	Rizki DR	Puspita K
Concepts or ideas	x	x	x	x	x			
Design	x	x				x	x	x
Definition of intellectual content	x	x	x	x	x			
Literature search	x	x	x	x	x		x	x
Experimental studies	x						x	x
Data acquisition	x						x	x
Data analysis	x	x	x	x	x	x	x	x
Statistical analysis	x	x	x	x			x	x
Manuscript preparation						x		
Manuscript editing						x		
Manuscript review	x	x	x	x	x	x	x	x

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