The Review of *Baccaurea racemosa*: Neglected Plants, but Potential to be Developed

Lina Permatasari[1*], Sugeng Riyanto[1], and Abdul Rohman[1,2]

[1]*Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, Indonesia*
[2]*Institute of Halal Industry and Systems (IHIS), Universitas Gadjah Mada, Yogyakarta, Indonesia*
[*]*Corresponding author. Email: lina.permatasari09@gmail.com*

ABSTRACT
The *Baccaurea racemosa* was the plant that spread in the Southeast Asia. *B. racemosa* fruit had a sour taste, so that the economy of this plant was low. *B. racemosa* has almost been forgotten in people. If this plant bears fruit, the fruit is often neglected. If the fruit is sold, the price will be low even though many studies reported the biological activities of *B. racemosa*. This review aims to inform the identification of *B. racemosa*, its traditional uses, its biologic activities, and the detected compounds. The relevant source was searched in PubMed, Scopus, and google scholar. Searching of the article was using the highlight keywords, such as *Baccaurea racemosa*, traditional uses of *Baccaurea racemosa*, and the biological activity of *Baccaurea racemosa.* The relevant article that was downloaded and reviewed was analyzed. *B. racemosa* was the tall tree, had the yellowish-green fruit skin, had the pink to a purplish pulp with high water content. All part of *B. racemosa* was determined their antioxidant activity. The leaves of *B. racemosa* had the potent antioxidant activity. The DPPH was the popular method to analyze the antioxidant activity of *B. racemosa.* The leaves were traditionally utilized for antiinflammation. Other biological activities of *B. racemosa* were antidiabetic and antibacterial. The detected compounds in *B. racemosa* were phenolic, flavonoid, fatty acids, and terpenoid groups. This review will help the researcher develop the utilization and research of *B. racemosa* in terms of biological activity and its secondary metabolite.

Keywords: *Baccaurea racemosa, review, biological activity, compound, traditional utilization.*

1. INTRODUCTION

Baccaurea racemosa was the native plant from southeast asia (Thailand, Malaysia, Sumatra, Java, Nusa Tenggara, Kalimantan, Sulawesi and Maluku). *Baccaurea racemosa* have several local names, such as Kepundung, Menteng, Kemundung, Kisip, Moho Liok, rambai, and Tampoi [1,2]. This plant grew in the lower mainland until 1000 mdpl. *B. racemosa* has a good spread di Indonesian forests and grows in clusters [3]. All parts of *Baccaurea racemosa* were traditionally utilized to reduce menstruation pain. However, its plants were neglected. The pulp was a sour taste, so that the economic value of the fruit was low.

Antioxidants play a role in human health. The previous study reported the leaves, bark, skin, and pulp of *B. racemosa* have potential antioxidant activity. The *B. racemosa* leaves exhibited potent antioxidant activity [4]. Several diseases like cardiovascular and cancer were caused by over oxidation reaction that caused cell damage [5]. The antioxidant compounds were reported to prevent and reduce the incidence of cardiovascular, diabetes, arthritis, inflammation, aging, and cancer [6-8]. The compounds contained in *B. racemosa* played a role in their biological activity. The pulp of *B. racemosa* contained phenolic compounds [9]. In addition, the leaves of *B. racemosa* contained some fatty acids group.

The study of utilizing the *B. racemosa* was already developed. Several previous studies showed the biological activity of *B. racemosa* and their contributed compounds. However, there were no review article that summary all of the study about the *B. racemosa.* So, this review highlighted the identification of *Baccaurea racemosa*, biological activity, and its detected compounds.

2. MATERIALS AND METHODS

The information that related to the topics was collected from PubMed, Scopus, and google scholar. The keywords to search the article were identification of plant + *Baccaurea racemosa;* identification of compounds + *Baccaurea racemosa;* biological activities + *Baccaurea racemosa*.

3. RESULTS AND DISCUSSION

3.1. Identification of Baccaurea racemosa

Baccaurea racemosa from Indonesia has different local names in different locations. In Jakarta, the local name of *B. racemosa* was Menteng because this tree grew in Menteng, Central of Jakarta. Meanwhile, *B. racemosa* in Nusa Tenggara was often called kepundung. *B. racemosa* belongs to the family Phyllanthaceace and genus Baccaurea. The classification of *B. racemosa* was as follows:

Division	:	Magnoliopsida
Sub-Division	:	Malpighiales
Class	:	Magnoliopsida
Family	:	Phyllanthaceae
Genus	:	Baccaurea
Species	:	*Baccaurea racemosa* (Reinw. ex Blume) Müll. Arg.

Figure 1. *Baccaurea racemosa* plant. (a) tree; (b) fruit; (c) pulp.

Several genus Baccaurea were reviewed but did not specifically discuss the *Baccaurea racemosa*. This plant has a similarity with duku (*Lansium domesticum*). Still, the fruit stalks of *B. racemosa* were long, and for every single branch attached to the tree, there were many fruits, and the tree canopy was different. *Baccaurea racemosa* include trees with a height between 15-25 m with a diameter of 25-70 cm, rough skin, and whitish (Figure 1a). Leaves range from 7-20 cm long and 3-7.5 cm wide. Fruit skin yellowish-green, slightly rounded shape, measuring 2.25-2.65 x 2.22-2.50 cm, does not break when ripe, the outer skin surface is bald, pericarp thickness 0.25-0.34 cm, has a space of 1-4 (Figure 1b). Seeds were pale white, one seed per fruit chamber, seeds measuring 0.91-1.15 x 0.85-1.15 cm, flattened shape, with morphological variations that were evenly distributed to curved. Meanwhile, the pulp was pink to purplish (Figure 1c). The pulp tastes sour and sweet. *Baccaurea racemosa* pulp has a thickness of about 0.36 – 0.88 cm [10,11]. The cross-section of the *B. racemosa* pulp can be seen in Figure 2.

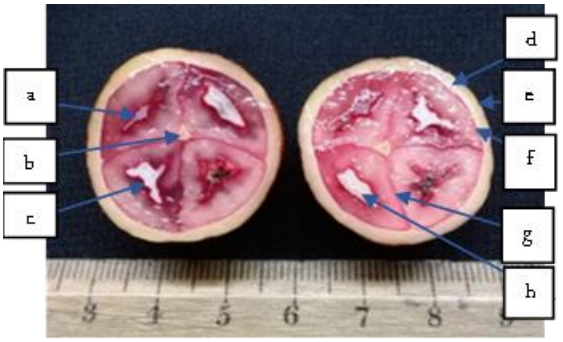

Figure 2. Cross-section of *Baccaurea racemosa* fruit. Aril/pulp (a); column of fruit (b); seed (c); Mesocarp (d); Pericarp (e); Endocarp (f); Septum of fruit (g); cotyledon (h)

3.2. Traditional uses and scientific explanation

Baccaurea racemosa stem was often utilized to overcome the inflammation in the eyes [12]. Furthermore, the bark was used as material to build the house. The leaves of *B. racemosa* were utilized to launch menstruation and treat diarrhea [10]. Meanwhile, the pulp was consumed to increase the quality of heart health. *B. racemosa* pulp contained high calcium and high-water content [13]. Calcium played a role in keeping the function of cells, increasing the quality of heart work, decreasing the risk of incidents of diabetes mellitus type 2, increasing the kidneys and intestines health [14]. The traditional use of *B. racemosa* to improve the quality of the heart was supported by their calcium content. The inflammation effect of the *B. racemosa* stem was predicted because of its alkaloid content [15]. The alkaloid decreased the inflammation mediator, such as interleukin-6 (IL-6) and Interleukin-1β (IL-1β) [16]. Meanwhile, the diarrhea effect of *B. racemosa* leaves was predicted by the presence of their phenolic compounds. *B. racemosa* leaves exhibited high total phenol content [17]. Phenolic compounds were reported to have antidiarrheal activity [18]. These compounds inhibited intestinal movement and reduced capillary permeability in the abdominal cavity. Quercetin that belonged to the phenolic compound could decrease the peristaltic of the intestinal [19]. In addition, ellagic acid belonging to the phenolic acid group reduced the mass of stool from mice and elevated their onset of diarrhea induced with castor oil. Ellagic acid has the capacity as an antioxidant agent [20]. The antioxidant activity correlates with antidiarrheal activity. The castor oil-induced oxidative

stress caused the damage of the ileum. Castor oil increased the malondialdehyde (MDA) and decreased the antioxidant enzyme such as glutathione peroxidase (GPx) and superoxide dismutase (SOD). So, the antidiarrhea activities of *B. racemosa were* related to their antioxidant activities.

3.3. Biological activity and detected compounds

Several previous studies reported the biological activities of the *B. racemosa* plant. Its biological activity showed this plant could be further developed. The compounds in *B. racemosa* contributed to their biological activities. The compounds that were detected in the *B. racemosa* plant can be seen in Table 1.

Table 1. The detected compounds in Baccaurea racemosa

No	Sample	Analyze	Detected compounds	Reference
1	Leaves	GC-MS	1- butenyl keton, 2,4-Bis(terbutyl)-phenol; stearic acid; Bis(2-ethylmethyl)phathalat; Hydroxydodecana; 1-Hexacosene; 1-Hexadecena; n-Pentadecena; palmitic acid; and phytol isomer	[25]
2	Pulp	HRMS	Gallic acid, quercetin, diosmetin, isoferullic acid, quercetin-3β-D-glucoside, isovanillic acid, umbelliferone, pyrogallol, tartaric acid, 5-hydroxymethylfurfural	[9, 36]
3	Bark	TLC	Phenolic, alkaloid, flavonoid, terpenoid	[15]

3.4. Antioxidant

The strength of antioxidant activity was classified into 3, IC_{50} < 50 ppm classified as very strong, IC_{50} 50-100 ppm classified as strong, IC_{50} 101-150 ppm classified as moderate, and IC_{50} > 150 ppm classified as weak [21]. Several studies reported the antioxidant activity of *Baccaurea racemosa*. The methanol extract of *B. racemosa* leaves was reported to have antioxidant content with DPPH radical scavenging of 91.23 ± 0.02% at a concentration of 1000 ppm extract [22]. Meanwhile, Wulandari et al. investigated the antioxidant activity of methanol extract, ethanol extract, and ethyl acetate extract from *B. racemosa* leaves [4]. Their antioxidant activity can be seen in Table 2.

Table 2. Antioxidant activity of Baccaurea racemosa using DPPH method

No	Sample	extract	IC50 (ppm)	Category	Reference
1	Leaves	Methanol Ethanol Ethyl acetate	9.38 ± 0.15 10.55 ± 0.09 946.70 ± 0.09	Very strong Very strong Weak	[4]
2	Leaves	Methanol	4,298 ± 0.306	Very strong	[17]
3	Bark	methanol	10.627 ± 0.996	Very strong	[17]
4	Stem	Ethyl acetate	28.581 ± 1.103	Strong	[15]
5	peel	Ethanol	1396.88	Weak	[27]
		Acetonitrile	40.2 ± 3.9	Very strong	[26]
6	Seed	Acetonitrile	57.9 ± 5.8	Strong	[26]
7	Pulp	Methanol	391.790 ± 6.130	Weak	[36]
		Ethyl acetate	127.155 ± 4.311	Moderate	
		dichloromethane	1141.069 ± 151.184	Weak	
		n-hexane	948.710 ± 29.344	Weak	
		water	402.228 ± 8.748	Weak	

The methanol extract was classified as very strong antioxidant activity. Methanol was the universal solvent that could dissolve almost all the compounds from the plants [23]. The ethanol extract of *B. racemosa* leaves was also classified with very strong antioxidant activity because its IC_{50} <50 ppm. Ethanol also was the universal solvent. The compounds extracted with the solvent (methanol and ethanol) consisted of lipophilic and hydrophilic antioxidants, while ethyl acetate only consisted of hydrophilic antioxidants. The phytochemical screening with thin-layer chromatography (TLC) revealed the absence of polyphenol and flavonoid compounds in ethyl acetate extract. These compounds contributed to their antioxidant activity. So that, the antioxidant activity of ethyl acetate extract was low. In addition, methanol extract of *B. racemosa* leaves investigated by Widodo et al [17]. was also classified with very strong antioxidant activity (Table 2). The antioxidant activity of *B. racemosa* leaves was investigated using Trolox equivalent antioxidant capacity (TEAC) and ferric reducing antioxidant power (FRAP) methods. *Baccaurea racemosa* leaves showed higher antioxidant activity than other medicinal plants with TEAC value 354.88 ± 0.55 µM Trolox equivalent/ 100 µg and FRAP value 900.18 ± 15.41 mM Fe^{2+}/ 10 mg. Antioxidant activity in the plant significantly correlates

with total flavonoid and phenolic content [24]. The *B. racemosa* leaves contained 2,4-Bis(1,1-dimethylethyl)-phenol (Table 1) that was investigated with gas chromatography-mass spectrometry (GC-MS) [25]. This compound belonged to the phenolic group.

The *Baccaurea racemosa* bark has a very strong capacity for scavenging the DPPH (Table 2). The antioxidant activity of *B. racemosa* bark correlates with its total phenolic content [17]. Fatmalah isolated the secondary metabolite from endophytic fungi of the *B. racemosa* stem [15]. Three endophytic fungi were successfully carried out. Secondary metabolites isolated from endophytic fungi with BK3 code were reported to have a very strong antioxidant activity (Table 2). These secondary metabolites belonged to the alkaloid, flavonoid, phenolic, and terpenoid compounds. The presence of flavonoid and phenolic compounds was contributed to their antioxidant activity.

The antioxidant activity of the peel of *Baccaurea racemosa* was reported by Fitri et al. and Juwita et al [26,27]. Antioxidant activity reported with both of them was very different. The study by Juwita et al. showed the antioxidant activity of *B. racemosa* peel was weak [27], but Fitri et al. revealed its antioxidant activity was very strong [26]. Several factors influenced the different antioxidant capacity strength. Process extraction was the factor that influenced the biological activities of the sample. Ethanol extract of *B. racemosa* peel investigated by Juwita et al. was extracted using the conventional method, namely maceration [27]. However, Fitri et al. extracted the *B. racemosa* peel using the QuEChERS method [26]. This method was quick, easy, cheap, effective, rugged, and safe. The QuEChERS steps were comminution & weighing, extraction & partitioning, and purifying with d-SPE. The purifying step removed the interfering compounds, such as polar pigments, sugars, and organic acid. The centrifuge process was included in the purifying steps. The centrifuge used a certain speed to maximize the compounds extracted to the solvent. The efficiency of extraction increased. The samples minimum contact with thermal, so that decreasing the compound damage. However, the maceration method only used the stirring method to extract the compounds.

The seed of *B. racemosa* has strong antioxidant activity (Table 2). Its extraction process also used the QuEChERS method. The antioxidant activity *B. racemosa* seed and peel was identified using the DPPH and lipid peroxidation methods. Lipid peroxidation was the marker that showed the presence of oxidative stress in tissues. The *B. racemosa* peel and seed have 50-80% capacity to inhibit lipid peroxidation [26].

Moreover, the pulp of *B. racemosa* also was investigated its antioxidant activity (Table 2). The ethyl acetate fraction showed higher antioxidant activity than another extract. Ethyl acetate sub-fraction with potent antioxidant activity showed several phenolic compounds (Table 1) [9].

3.5. Antidiabetes

Baccaurea racemosa leaves were investigated for their antidiabetic activity using the α-amylase enzyme inhibition method. The methanol and ethanol extract revealed IC_{50} 67.64 ± 0.36 µg/mL and 67.46 ± 1.23 µg/mL. The α-amylase enzyme played a role in breaking down the polysaccharides into glucose and maltose [28]. *B. racemosa* leaves contained high phenolic and flavonoid content. The flavonoid compounds (luteolin, quercetin, and diosmetin) have a high capacity to bind with the α-amylase enzyme. Luteolin has lower energy to bind with the α-amylase enzyme than acarbose [29]. The hydroxylation in ring C and methylation in hydroxyl group in ring B (Figure 3) of flavonoid compounds increased their binding to the α-amylase enzyme. Based on molecular docking, the flavonoid compounds were bound to the active site of the α-amylase enzyme. Their binding decreased the catalytic activity of the α-amylase enzyme [30]. In addition, the phenolic and flavonoid compounds inhibited the oxidation in β-Langerhans cells, so insulin production was optimal [31].

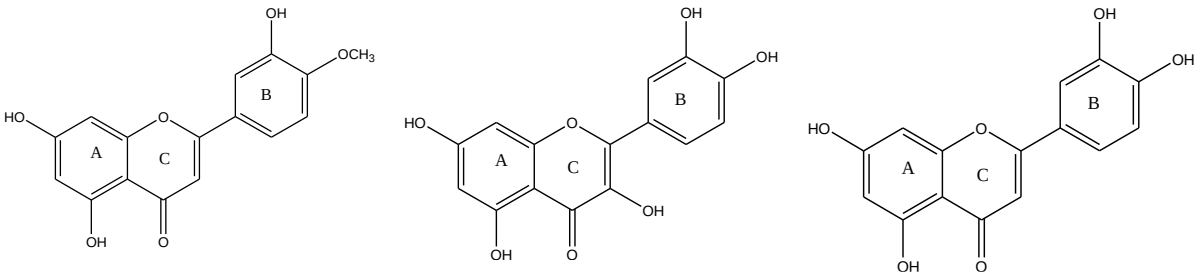

Figure 3. Flavonoid compounds [29].

3.6. Antibacterial

The leaves of *Baccaurea racemosa* were investigated for their antibacterial activity using the agar diffusion method [25]. The methanol extract of *B. racemosa* leaves was reported to have a higher capacity to inhibit the *Staphylococcus aureus* growth than the n-hexane extract and dichloromethane extract. The methanol extract

contained palmitic acid and phytol isomer identified using GC-MS. Palmitic acid was the unsaturated fatty acid reported to have antibacterial activity [32]. The unsaturated double bond in palmitic acid played the role to lysis the bacterial membrane cells [33].

Bachtiar et al. investigated the antibacterial activity of endophytic fungi of *B. racemosa* leaves [34]. Three endophytic fungi were extracted their secondary metabolites using ethyl acetate solvent. Ethyl acetate extracts from 3 endophytic fungi were examined for their antibacterial activity using the microdilution method. The ethyl acetate of endophytic fungi DK2 (100 µg/mL) and DK3 (100 µg/mL) inhibited the 34.55 ± 1.61% and 26.47 % *Staphylococcus aureus* growth, respectively. Flavonoid, alkaloid, and terpenoid compounds in *B. racemosa* leaves contributed to their antibacterial activity investigated using contact bioautography TLC. Phenolic compounds detected in *B. racemosa* leaves did not inhibit the *Staphylococcus aureus* growth. Junaidi and Anwar [35]. showed gallic acid belonging to the phenolic also did not have antibacterial activity toward the *Staphylococcus aureus* and *Escherichia coli.*

4. CONCLUSION

Baccaurea racemosa was a plant with tall trees and seasonal trees with pink to a purplish color. *B. racemosa* leaves were traditionally used as antiinflammation. The previous study showed antioxidant, antidiabetic, and antibacterial of *Baccaurea racemosa.* The antioxidant activity of *B. racemosa* leaves was potent. Most compounds in *B. racemosa* were phenolic detected using HRMS, GC-MS, and TLC. These compounds were predicted to contribute to the biological activity of *B. racemosa*. This plant was potentially to develop as herbal medicine and could increase the economic value of *B. racemosa*. Further research on *B. racemosa* needs to be done.

CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHORS' DECLARATION

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

ACKNOWLEDGMENTS

The authors Lina Permatasari, Sugeng Riyanto, and Abdul Rohman thanks the financial support from Universitas Gadjah Mada through the program of Rekognisi Tugas Akhir (RTA) year 2021 with contract number 3143/UN1.P.III/DIT-LIT/PT/2021

REFERENCES

[1] Setyowati S. One hope: *menteng aka kepundung, an increasingly rare local fruit* [Online]. SatuHarapan.com. 2016 [cited 2018 Dec 12]. Available from: http://www.satuharapan.com/read-detail/read/menteng-alias-kepundung-buah-lokal-yang-kian-langka

[2] Sivadasan S. Pharmacological potential of baccaurea. *J. Crit. Rev*. 2020; 7(10):2354–2362.

[3] Sadewa AE, Wiyono W. *Natural distribution of natural saplings of the kepundung type (Baccaurea racemosa) in Bawukan Village*, Kemalang District, Klaten Regency [Online]. Yogyakarta: Universitas Gadjah Mada; 2016 [cited 2021 Jun 10]. Available from: http://etd.repository.ugm.ac.id/penelitian/detail/105538

[4] Wulandari L, Nugraha AS, Azhari NP. Determination of the antioxidant and antidiabetic activity of kepundung leaf extract (*Baccaurea racemosa* Muell.Arg.) *In Vitro. J Sains Farm Klin*. 2020; 7(1): 60–66.

[5] Padayatty SJ, Katz A, Wang Y, Eck P, Kwon O, Lee J-H, Chen S, Corpe C, Dutta A, Dutta SK, Levine M. Vitamin C as an antioxidant: evaluation of its role in disease prevention. *J Am Coll Nutr*. 2003; 22(1): 18–35.

[6] Hajhashemi V, Vaseghi G, Pourfarzam M, Abdollahi A. Are antioxidants helpful for disease prevention? *Res Pharm Sci*. 2010; 5(1): 1–8.

[7] Rajendran P, Nandakumar N, Rengarajan T, Palaniswami R, Gnanadhas EN, Lakshminarasaiah U, Gopas J, Nishigaki I. Antioxidants and human diseases. *Clinica Chimica Acta*. 2014; 436(9): 332–347.

[8] Verma P, Mishra S. Antioxidants and disease prevention. *Int. J. Adv. Sci. Res.* 2014; 4(2): 902–911.

[9] Permatasari L, Riyanto S, Rohman A. Identification of phenolic compound from active subfraction of *Baccaurea racemosa* pulp by high resolution mass spectrometry. *Int. J. Pharm. Res*. 2020; 13(01): 1065–1072.

[10] Maskur. *Kepundung/Menteng (Baccaurea racemosa (Reinw.))* [Online]. Informasi Tanaman Kehutanan. 2014 [cited 2018 Dec 8]. Available from: https://forestryinformation.wordpress.com/2014/04/10/kepundungmenteng-baccaurea-racemosa-reinw/

[11] Mertha IG. *Visualization of Forest Trees of Lombok*. Vol. 1. Mataram: Agra Puji Press; 2012. 479 p.

[12] Fern K. *Baccaurea racemosa - Useful Tropical Plants* [Online]. Useful Tropical Plants. 2014 [cited 2018 Dec 12]. Available from: http://tropical.theferns.info/viewtropical.php?id=Baccaurea+racemosa

[13] Rohyani IS, Aryanti E, Suripto. Potential nutritional value of local food plants on the island of Lombok as a basis for strengthening national food security. *Proceedings of Seminar Masyarakat Biodiversitas Indoneasia*. 2015; 1(7): 1698–1701.

[14] Stone MS, Martyn L, Weaver CM. Potassium Intake, Bioavailability, Hypertension, and Glucose Control. *Nutrients*. 2016; 8(7): 1–13.

[15] Fatmalah J. *Penelusuran dan isolasi fungi endofit batang kepundung (Baccaurea racemosa (reinw.) muell. arg) serta penetapan aktivitas antioksidan dengan metode DPPH*. Universitas jember: Jember; 2020. 46 p.

[16] Yang M, Wang Y, Fan Z, Xue Q, Njateng GSS, Liu Y, Cao J, Khan A, Cheng G. Chemical constituents and anti-inflammatory activity of the total alkaloid extract from *Melodinus cochinchinensis* (Lour.) Merr. and its inhibition of the NF-κB and MAPK signaling pathways. *Phytomedicine*. 2021; 91(10):1-13.

[17] Widodo H, sismindari S, Asmara W, Rohman A. Antioxidant activity, total phenolic and flavonoid contents of selected medicinal plants used for liver diseases and its classification with chemometrics. *J App Pharm Sci*. 2019; 9(6): 99–105.

[18] Zhang W, Chen B, Wang C, Zhu Q, Mo Z. Mechanism of quercetin as an antidiarrheal agent. *Di Yi Jun Yi Da Xue Xue Bao*. 200; 23(10): 1029–1031.

[19] Gharzouli K, Holzer P. Inhibition of guinea pig intestinal peristalsis by the flavonoids quercetin, naringenin, apigenin and genistein. *Pharmacology*. 2004; 70(1): 5–14.

[20] Singh BN, Singh BR, Singh RL, Prakash D, Dhakarey R, Upadhyay G, Singh HB. Oxidative DNA damage protective activity, antioxidant and anti-quorum sensing potentials of *Moringa oleifera*. *Food and Chemical Toxicology*. 2009; 47(6): 1109–1116.

[21] Sukweenadhi J, Yunita O, Setiawan F, Kartini, Siagian TM, Danduru PN, Avanti C. Antioxidant activity screening of seven Indonesian herbal extract. *Biodiversitas*. 2020; 21(5): 2063–2067.

[22] Wulansari D, Chairul. Screening of antioxidant activity and several indonesian medicinal plants using radical 2, 2-diphenyl-1-picrylhydrazyl (DPPH) antioxidant screening activity of several indonesian medicinal. *Trad. Med. J.* 2011; 16(1): 22–25.

[23] Mahasuari NPS, Paramita NLPV, Yadnya Putra AAGR. Effect of methanol concentration as a solvent on total phenolic and flavonoid content of beluntas leaf extract (*Pulchea indica* L.). *Phar. Sci. Appl. J*. 2020; 2(2): 77-84.

[24] Puspitasari AD, Wulandari RL. Antioxidant activity, determination of total phenolic and flavonoid content of *Muntingia calabura* L. extracts. *Pharmaciana*. 2017; 7(2): 147–158.

[25] Elsa C. *Uji aktivitas antibakteri dan analisis GC-MS ekstrak daun kepundung (Baccaurea racemosa (Reinw. Ex Blume) Mull. Arg) terhadap Escherichia coli dan Staphylococcus aureus*. Universitas Mataram: Mataram; 2020. 75 p.

[26] Fitri A, Andriani M, Sudarman A, Toharmat T, Yonekura L, Tamura H, Ramli N. Screening of antioxidant activities and their bioavailability of tropical fruit byproducts from Indonesia. Int. J. pharm. *pharm. sci*. 2016; 8(4): 96–100.

[27] Juwita DA, Mukhtar H, Putri RK. Antioxidant test of ethanol extract of fruit peel and flesh of menteng (*Baccaurea racemosa* (Blume) Mull. Arg.) with DPPH method (2.2 Diphenyl-1-picrylhydrazyl). *J .Far. Kes*. 2020; 10(1): 56–62.

[28] Kaur N, Kumar V, Nayak SK, Wadhwa P, Kaur P, Sahu SK. Alpha-amylase as molecular target for treatment of diabetes mellitus: A comprehensive review. *Chem. Biol. Drug*. Des. 2021; 98(4): 539–560.

[29] Martinez-Gonzalez AI, Díaz-Sánchez ÁG, de la Rosa LA, Bustos-Jaimes I, Alvarez-Parrilla E. Inhibition of α-amylase by flavonoids: Structure activity relationship (SAR). *Spectrochim. Acta A Mol. Biomol. Spectrosc*. 2019; 206(1): 437–47.

[30] Yuan E, Liu B, Wei Q, Yang J, Chen L, Li Q. Structure activity relationships of flavonoids as potent α-amylase inhibitors. *Nat. Prod. Commun*. 2014; 9(8): 1173-1176.

[31] Panjuantiningrum F. *Pengaruh pemberian buah naga merah (hylocereus polyrhizus) terhadap kadar glukosa darah tikus putih yang diinduksi aloksan*. Universitas Sebelas Maret: Surakarta; 2009. 46 p.

[32] Karimi E, Jaafar HZ, Ghasemzadeh A, Ebrahimi M. Fatty acid composition, antioxidant and antibacterial properties of the microwave aqueous extract of three varieties of *Labisia pumila* Benth. *Biol. Res*. 2015; 48(1): 1–6.

[33] McGaw LJ, Jäger AK, van Staden J. Antibacterial effects of fatty acids and related compounds from plants. *S. Afr. J. Bot*. 2002; 68(4): 417–423.

[34] Bachtiar MF. *Skrining fitokimia dan uji aktivitas antibakteri ekstrak etil asetat hasil fermentasi fungi endofit daun kepundung* (*Baccaurea racemosa* (Reinw.) Muell. Arg.). Universitas Jember: East Java; 2020. 84 p.

[35] Junaidi E, Anwar YAS. Enzymatic production of gallic acid from local fruit peels in Lombok. *Jurnal Penelitian Kimia*. 2017; 13(2): 264–275.

[36] Permatasari L, Riyanto S, Rohman A. *Baccaurea racemosa* (Reinw. ex Blume) Müll. Arg. pulp: a potential natural antioxidant. *Food Res*. 2019; 3(6): 713–719.