BIODIVERSITAS
Volume 23, Number 11, November 2022
Pages: 5551-5558

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d231102

Evaluation of non-timber forest products used as medicinal plants from East Kalimantan (Indonesia) to inhibit α-glucosidase and free radicals

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Manuscript received: 9 July 2022. Revision accepted: 25 October 2022.

Abstract. *Ramadhan R, Tosepu R, Phuwapraisirisan P, Amirta R, Phontree K, Firdaus YFH, Abdulgani N, Muttaqin MZ, Saparwardi. 2022. Evaluation of non-timber forest products used as medicinal plants from East Kalimantan (Indonesia) to inhibit α-glucosidase and free radicals. Biodiversitas 23: 5551-5558.* Non-timber forest products (NTFPs) have essential uses as medicines, food sources, and traditional ceremonies for the local people living in forest areas. Medicinal plants are one of the non-timber forest products used as traditional medicine by local people in East Kalimantan. This study was conducted to search for new natural antidiabetic and antioxidant resources from medicinal plants used traditionally in Mahakam Ulu District, East Kalimantan, based on ethnopharmacological information. The present study evaluates non-timber forest products as in vitro antidiabetic (rat intestinal α-glucosidase inhibitory activity) and antioxidant (free radical scavenging activity against DPPH, ABTS, and Nitric Oxide) activities. The antidiabetic and antioxidant activities were evaluated using α-glucosidase inhibition assay and free radical scavenging methods. This study demonstrated that methanol extracts of *Flacourtia rukam* Zoll. & Moritzi, *Syzygium chloranthum* (Duthie) Merr. & L.M. Perry and *Shorea balangeran* Burck exhibited strong α-glucosidase inhibitory activity with maltose as a substrate with IC_{50} values of 0.034 mg/mL, 0.039 mg/mL, and 0.039 mg/mL, respectively. On the other hand, methanol extract of *S. chloranthum* displayed the strongest α-glucosidase inhibitory activity in sucrose as a substrate, similar to the IC_{50} value of the quercetin as a positive control. Furthermore, the antioxidant test showed that all medicinal plant extracts from East Kalimantan are good sources of natural antioxidants indicated by their IC_{50} values. The results of this study support the scientific background of the uses of medicinal plant extracts from East Kalimantan as folk medicine.

Keywords: Antidiabetics, antioxidant, biodiversity, medicinal plants, tropical regions

INTRODUCTION

Non-timber forest products (NTFPs) are products other than timber produced in the forests, such as medicinal plants, honey, mushrooms, resins, fruit and nuts, vegetables, and various barks and natural fibers (Mipun et al. 2019). NTFPs have an important role in supporting the livelihood of local communities around forest areas (Shackleton et al. 2018). Medicinal plants as non-timber forest products (NTFPs) have been used to treat several diseases since ancient times (Mbopi et al. 2021) for therapeutic purposes. Medicinal plants are well-known storehouses of various bioactive secondary metabolites, such as phenolics, flavonoids, alkaloids, terpenes, and tannins, that are responsible for their therapeutic activity, such as anti-diabetic, antioxidant, anti-inflammation, wound-healing, and antibacterial (Khan et al. 2022; Moukette et al. 2015). East Kalimantan has vast tropical forest biodiversity, which includes medicinal plants that Dayak people traditionally used for generations. Several medicinal plants growing in the tropical forests of East Kalimantan have been reported to have biological activities, including antioxidant, antidiabetic, antibacterial, anti-tyrosinase, and anticancer activities (Arung et al. 2012; Sukara et al. 2014; Kusuma et al. 2014; Abuga et al. 2022). Regarding the search for the most potent traditional medicinal plants and phytotherapy, scientific approaches should be conducted to develop new effective, inexpensive, and less toxic traditional medications.

Diabetes mellitus is a chronic disease characterized by hyperglycemia, primarily due to disproportionate insulin demand. Hyperglycemia causes numerous complications, including diabetic foot ulcers, heart disease, kidney failure, retinopathy, stroke, and pregnancy-related complications (Ji et al. 2021). The pathogenesis of type 2 diabetes mellitus is a complex metabolism involving the

overproduction of free radicals and oxidative stress, which contributes to previously mentioned complications (Liu et al. 2014). In curing diabetes, various strategies have been developed to lower blood sugar levels, such as insulin secretagogues, an insulin sensitizer, inhibitors of glucose recapture, and anti-hyperglycemia. Along with insulin treatment, previous studies have shown that inhibiting α-glucosidase is an effective strategy to control the development of diabetes via regulated postprandial blood glucose (Trinh et al. 2016). α-Glucosidase inhibitors such as acarbose, miglitol, and 1-deoxynojirimycin are well-known digestive enzyme inhibitors as synthetic drugs for type 2 diabetic patients. Although these drugs can reduce postprandial hyperglycemia and prevent impaired glucose intolerance, they still have side effects related to gastrointestinal problems (Lee et al. 2020). Fortunately, active secondary metabolites in medicinal plants have the potency to treat hyperglycemia and its complications by scavenging free radicals (Akyuz et al. 2022).

In this study, ten selected medicinal plants from Mahakam Ulu were traditionally used for blood sugar level therapy by local communities in Batu Majang Village. This study area has never been ethnobotanically explored; therefore, the present study is considered the first study on the ethnobotanical medicinal plants in this region. This study aims to evaluate the activity of α-glucosidase inhibition and free radical scavenging activity of medicinal plants from East Kalimantan. Therefore, it might be more beneficial than common antidiabetic drugs. To the best of the authors' knowledge, this study is the first report on antidiabetic and antioxidant activity screening of selected medicinal plants from the East Kalimantan tropical forest.

MATERIALS AND METHODS

Study site and plant collections

The study was conducted in Batu Majang Village, Long Bagun Sub-district, Mahakam Ulu District, Indonesia (Figure 1). The study site was chosen because the traditional local communities in this area use traditional medicinal plants to treat diseases, including blood sugar levels. Selected plant parts were collected, and the voucher specimens of ten selected medicinal plants were stored in the Laboratory of Forest Products Chemistry and Renewable Energy, Faculty of Forestry, Universitas Mulawarman. In addition, ten medicinal plants were identified at the Laboratory of Forest Dendrology, Faculty of Forestry, Universitas Mulawarman, Samarinda, Indonesia. These specimens are listed in Table 1.

Chemical reagents and instrument

ABTS (*2,2`-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid*) and DPPH (*1,1-diphenyl-2-picrylhydrazyl*) were procured from Tokyo Chemical Industry Co. Ltd. Potassium persulfate, ascorbic acid, naphthyl ethylenediamine dihydrochloride, sodium nitroprusside, and potassium perchlorate were purchased from Sigma Chemical Co (St. Louis, MO, USA). Rat intestinal acetone powder (Sigma Aldrich) and all other chemicals and solvents were of the highest commercial grade. Absorbance was taken using a microplate reader BIOCROM EZ Read 2000 (BioChrom Ltd, United Kingdom).

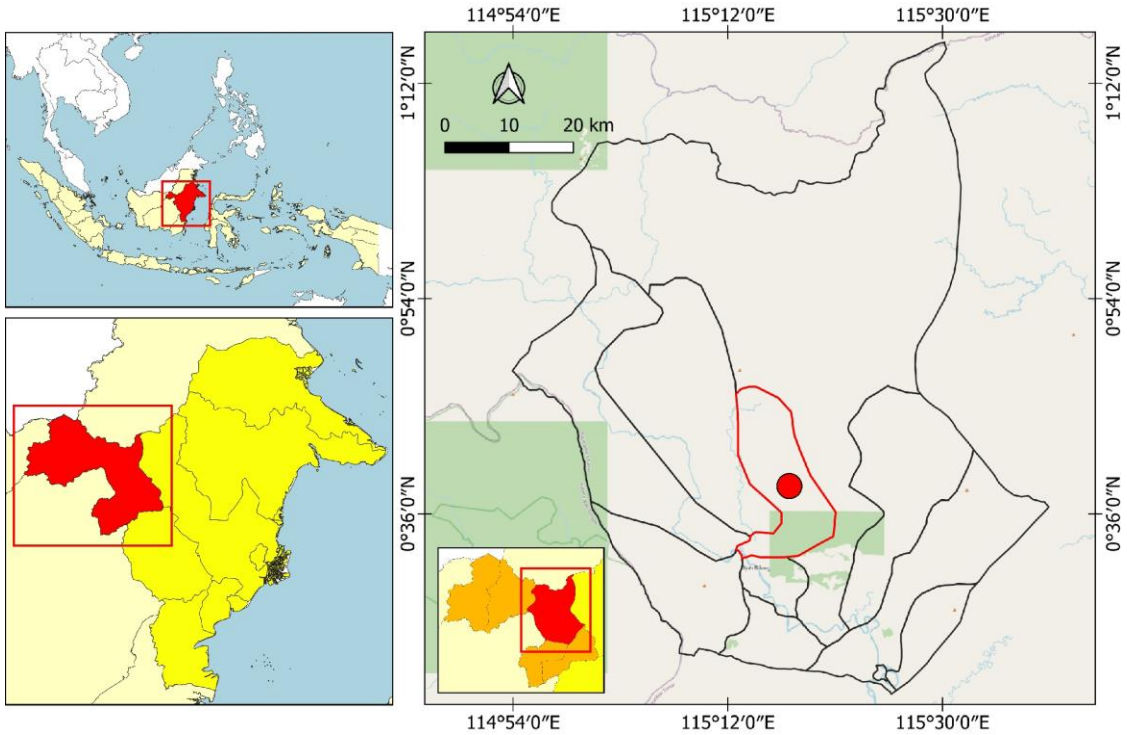

Figure 1. Study site in Batu Majang Village (red), Mahakam Ulu District, East Kalimantan, Indonesia

Table 1. Selected medicinal plants from East Kalimantan

Medicinal plants	Part used	Local names	Voucher specimens
Shorea balangeran Burck	Branch & Twig	Kahoi	LBTI-R-30
Syzygium chloranthum (Duthie) Merr. & L.M.Perry	Branch & Twig	Bumbun	LBTI-R-40
Lagerstroemia speciosa (L.) Pers.	Stem	Bungur	LBTI-T-22
Flacourtia rukam Zoll. & Moritzi	Stem	Rukam	LBTI-P-08
Gluta velutina Blume	Stem	Serengat	LBTI-S-09
Kleinhovia hospita L.	Branch & Twig	Tahongai	LBTI-R-05
Enterolobium cyclocarpum (Jacq.) Griseb.	Stem	Sengon Buto	LBTI-S-23
Vatica umbonata Burck	Branch & Twig	Masinstan	LBTI-S-27
Pertusadina eurhyncha (Miq.) Ridsdale	Stem	Kadamba	LBTI-P-33
Dillenia excelsa (Jack) Martelli ex Gilg.	Stem	Tanekara	LBTI-S-14

Extraction of medicinal plants

Plant stems, twigs, and branches were washed with distilled water and dried at room temperature in a well-ventilated room. The dried plant materials were ground into a fine powder using a grinder, then separately extracted in methanol (3 x 400 mL) and macerated at ambient temperature. The mixture was then filtered through filter papers. Next, the filtrate was dried under a vacuum in a rotary evaporator (Rotavapor R100, BUCHI) to obtain dried crude extracts, which were then transferred into amber bottles. After that, crude extracts were stored at 4°C for further bioassay analysis.

In vitro antidiabetic activity

Rat intestinal α-glucosidase inhibition assay

Rat intestinal α-glucosidase inhibition test in vitro following the methods by Ramadhan et al. (2020). In brief, 50 µl of phosphate buffer (pH 6.9) was mixed with crude enzyme solution, 10 µl of the sample at various concentrations, and a glucose kit before they were added into a 96-well plate and incubated for 10 minutes (maltose), and 40 minutes (sucrose) at 37°C, respectively. After incubation, the absorbance was recorded using a microplate reader BIOCROM EZ Read 2000. The percentage of inhibition (%) was calculated with the following formula:

% Inhibition = (Abs control - Abs sample)/ Abs control x 100.

IC_{50} is the concentration required to inhibit 50% of rat intestinal α-glucosidase activity. Quercetin was used as a positive control.

Antioxidant properties

DPPH radical scavenging activity

The ability of selected plant extracts to scavenge free radical DPPH was determined based on Khongkarat et al. (2020) methods with minor modification. First, the DPPH solution was prepared by dissolving free radical DPPH powder in 100 mL of methanol to obtain a concentration of 0.10 mM. Next, the 0.10 mM DPPH solution was added to 20 µL of extracts of various concentrations sequentially and then incubated for 30 min in the darkness. After incubation, the absorbance was measured at 517 nm. Finally, the free radical scavenging activity of samples was expressed as a percentage of inhibition (PI) using the following equation (1):

% Scavenging activity = (Abs control – Abs sample) / Abs control x 100.

The concentration of samples required to inhibit 50% free radical DPPH is IC_{50}. The test was performed in triplicate for each sample concentration, and ascorbic acid was used as a positive control.

ABTS radical scavenging activity

The ABTS radical scavenging activity assay was carried out using the free radical ABTS method employed by Seyrekoglu et al. (2022) with a slight modification. The free radical ABTS solution was prepared by mixing equal quantities of ABTS solution and potassium persulfate solution, allowing it to react for 24 hours at room temperature. Various concentrations of respective test samples (extract and positive control) were prepared and individually mixed in 100 µL of $ABTS^{\bullet+}$ solution. After a 30-minute of incubation, the absorbance of the mixture was measured spectrophotometrically at 750 nm. The scavenging activity was calculated using the formula (1).

Nitric oxide radical scavenging activity

Nitric oxide was generated from sodium nitroprusside in an aqueous solution and examined using the Griess test. The method of Ramadhan et al. (2019) was adopted to examine the scavenging activity of the plant extract against radical nitric oxide. Briefly, 20 µL of various extract concentrations was mixed with 5 mM sodium nitroprusside, then 100 µL of Griess reagent was added to the mixture. After a 30-minute incubation, the absorbance of the mixture was measured spectrophotometrically at 540 nm. The percentage of free radical nitric oxide scavenging activity was calculated using the formula (1). Ascorbic acid was used as a positive control.

Data analysis

All data were expressed as the mean±SD of three measurements and analyzed with nonlinear regression analysis. The obtained quantitative data were analyzed descriptively. All measurements were conducted in triplicate.

RESULTS AND DISCUSSION

In vitro antidiabetic activity

The present study was carried out to evaluate the antidiabetic and antioxidant potency of 10 selected medicinal plants from the East Kalimantan tropical forest. The antidiabetic activity was carried out using rat intestinal α-glucosidase on maltase and sucrase as substrates. The α-glucosidase enzyme (EC 3.2.1.20, α-D-glucoside glucohydrolase) is the main enzyme located in the small intestine vital to cleave maltose and sucrose into glucose to be further absorbed into the blood. One of the most therapeutic approaches to control postprandial blood sugar levels is to inhibit intestinal α-glucosidase, which is highly similar to human α-glucosidase (Pyner et al. 2017).

In this study, we comprehensively investigated the part of plants such as stems, branches, and twigs instead of leaves traditionally used to treat blood sugar levels in the communities. It is the first study that investigated extracts of ten tropical, medicinal plants concerning rat intestinal α-glucosidase inhibition (maltase and sucrase). The inhibitory activity of extracts is presented in Table 2. Rat intestinal enzymes can only hydrolyze maltose and sucrose. The principle of the assay is to inhibit carbohydrate-hydrolyzing enzymes from delaying the absorption of glucose that mimics the metabolism system (Seo et al. 2015). Methanol extracts of *Flacourtia rukam* Zoll. & Moritzi, *Syzygium chloranthum* (Duthie) Merr. & L.M.Perry, and *Shorea balangeran* Burck exhibited strong inhibition activity against maltase with IC_{50} values of 0.034 mg/mL, 0.039 mg/mL and 0.039 mg/mL, respectively. Meanwhile, quercetin is a positive control has an IC_{50} value of 0.040 mg/mL. Proença et al. (2017) and Indrianingsih et al. (2015) reported that quercetin could be used as a positive control since it has a high inhibitory effect on α-glucosidase for its aromatic ring with *ortho* -OH position in the flavonoid structure and it is a natural inhibitor with low side effects.

The present study showed the inhibitory activity of *F. rukam*, *S. chloranthum* and *S. balangeran* are comparable to quercetin as a positive control. Afifi et al. (2021) found that the bark and leaves of *F. rukam* contains phenolic. Thai et al. (2020) reported several isolated secondary metabolites, including rukamtenol, chaulmoogric acid, flacourtin, 3,4,5-trimethoxyphenyl-β-D-glucopyrano-side, and daucosterol. Elfita et al. (2019) also reported the stem bark of *F. rukam* contain friedelin, poliothrysoside, and β-sitosteryl-3β-glucopyranoside. The previous studies show the phytochemical presence in the extract of *F. rukam* can be responsible for the biological activity against α-glucosidase. As far as we know, there is no report on the α-glucosidase inhibitory activity of *F. rukam*, *S. chloranthum*, and *S. balangeran*.

Table 2 showed that *Lagerstroemia speciosa* (L.) Pers., *Vatica umbonata* Burck, *Pertusadina eurhyncha* (Miq.) Ridsdale, and *Gluta velutina* Blume have moderate inhibitory activity against maltase. The order of inhibitory activity of the ten medicinal plant extracts against maltase α-glucosidase from the lowest to the strongest was as follows: *Kleinhovia hospita* L. > *Enterolobium cyclocarpum* (Jacq.) Griseb. > *Dillenia excelsa* (Jack) Martelli ex Gilg > *G. velutina* > *V. umbonata* > *P. eurhyncha* > *L. speciosa* > *S. chloranthum* > *S. balangeran*. This finding is in line with Li et al. (2021), who reported that resorcinol derivatives in *Syzygium latilimbum* had the potency to inhibit α-glucosidase. Furthermore, Hu et al. (2021) also stated that resorcinol derivatives isolated from *Syzygium samarangense* had antidiabetic activity by inhibiting α-glucosidase. Moreover, Kissinger et al. (2016) showed that *S. balangeran* had antidiabetic activity by inhibiting α-glucosidase, possibly due to oligostilbenoids that contain the -OH group.

Moreover, the results showed that *S. chloranthum* extract showed good antidiabetic activity against sucrase with IC_{50} values of 0.042 mg/mL and exhibited quite similar IC_{50} values with quercetin as a positive control (Table 2.). On the other hand, *F. rukam*, *G. velutina*, *V. umbonata*, *P. eurhyncha* and *D. excelsa* extracts have no inhibition against sucrase.

Table 2. The IC_{50} values of α-glucosidase inhibitory activity of selected medicinal plants

Medicinal plants	Part used	IC_{50} (mg/mL)	
		Maltase	Sucrase
Shorea balangeran Burck	Branch & Twig	0.039 ± 0.02	0.075 ± 0.01
Syzygium chloranthum (Duthie) Merr. & L.M.Perry	Branch & Twig	0.039 ± 0.01	0.042 ± 0.01
Lagerstroemia speciosa (L.) Pers.	Stem	0.051 ± 0.01	0.062 ± 0.01
Flacourtia rukam Zoll. & Moritzi	Stem	0.034 ± 0.01	NI
Gluta velutina Blume	Stem	0.076 ± 0.02	NI
Kleinhovia hospita L.	Branch & Twig	NI[b]	0.161 ± 0.08
Enterolobium cyclocarpum (Jacq.) Griseb.	Stem	0.139 ± 0.01	0.086 ± 0.02
Vatica umbonata Burck	Branch & Twig	0.060 ± 0.01	NI
Pertusadina eurhyncha (Miq.) Ridsdale	Stem	0.075 ± 0.01	NI
Dillenia excelsa (Jack) Martelli ex Gilg.	Stem	0.111 ± 0.02	NI
Quercetin[a]		0.040 ± 0.01	0.030 ± 0.02

Note: [a] Positive control; [b] No inhibition, inhibitory effects less than 30% at 0.0625 mg/mL; Each value represents mean ± S.D (n=3)

Plant extracts of *E. cyclocarpum*, *S. balangeran*, and *L. speciosa* have inhibitory activity against sucrase with IC_{50} values of 0.086 mg/mL, 0.075 mg/mL, and 0.062 mg/mL, respectively while quercetin as positive control with IC_{50} value of 0.030 mg/mL. A previous Kolakul and Sripanidkulchai (2017) study reported that *L. speciosa* contains phenolic groups such as ellagic acid, epicatechin gallate, and gallic acid. In addition, a previous study by Riyanti et al. (2020) reported *Lagerstroemia loudonii* Teijsm. & Binn exhibited inhibitory activity against yeast α-glucosidase. Our results are in agreement with the previous study by Ratnadewi et al. (2020) showed that *L. speciosa* had the potency as an antidiabetic agent. This study is the first report on the biological activities of ten medicinal plants' methanol extracts from East Kalimantan tropical forests against maltase and sucrase. It indicates that medicinal plants from the tropical forest in Kalimantan had the potential as natural antidiabetic agents. However, further in-depth studies are required to analyze and isolate the chemical compounds responsible for their antidiabetic activity.

Antioxidant properties

Recent studies reported that chronic hyperglycemia generates excessive reactive radicals due to glucose autooxidation and contributes to cell damage (Kanwugu et al. 2021). Therefore, three methods were used to determine the antioxidant activity of selected medicinal plant extracts, i.e., DPPH, ABTS, and Nitric oxide scavenging activities. In addition to the antioxidant activity assay, α-glucosidase inhibition activity was also performed to screen ten medicinal plant extracts as antidiabetic and its complication by free radicals.

The DPPH radical scavenging activity of ten medicinal plant extracts and standard ascorbic acid is shown in Table 3. The percentage of inhibition of ten medicinal plants is presented in Figure 2. These results showed that *S. balangeran* and *G. velutina* had a good inhibition percentage of 79.5 % and 83.1 % at 1 mg/mL extract concentration. The greater the inhibitory activity against DPPH free radicals, the higher the antioxidant activity and the lower the 50% inhibition concentration (IC_{50}) (Adouni et al. 2022). Among ten medicinal plant extracts tested, *S. balangeran* and *G. velutina* displayed the highest antioxidant activity with IC_{50} values of 0.05 mg/mL and 0.04 mg/mL, respectively, which are similar to the IC_{50} value of ascorbic acid as a positive control (0.05 mg/mL). Marjoni and Zulfisa (2017) stated that antioxidant activity is categorized as strong if the IC_{50} value is 0.05-0.1 mg/mL and very strong if the IC_{50} value is less than 0.05 mg/mL. DPPH radical is stabilized by atoms that can donate hydrogen to form a stable reduced DPPH molecule (Arroussi et al. 2022). Subramanian et al. (2013) showed that the methanol extract of *Shorea roxburghii* stem bark has radical scavenging activity against DPPH. In addition, Subramanian et al. (2015) isolated hopeaphenol, a polyphenol group composed of resveratrol units that exhibit free radical scavenging activity against DPPH. This study showed that *S. chloranthum* and *D. excelsa* had moderate antioxidant activity against DPPH free radical, indicating the potency as natural antioxidant activity.

Furthermore, the antioxidant capacity of selected medicinal plants was also performed against $ABTS^{\bullet+}$ free radical. $ABTS^{\bullet+}$ free radical solution was generated by reacting with an oxidizing agent, i.e., potassium persulfate, which took approximately 16 hours and neutralized the radicals based on electron transfer (Xiao et al. 2020). Results of the $ABTS^{\bullet+}$ assay showed that selected medicinal plant extracts at 1 mg/mL had the potency to scavenge radicals (Figure 2.). The extracts of *S. balangeran*, *S. chloranthum* and *F. rukam* demonstrated the highest scavenging activity against $ABTS^{\bullet+}$ free radical, i.e., 90.2%, 88.3%, and 91.4%, respectively. Table 3 shows the SC_{50} values of $ABTS^{\bullet+}$ free radical scavenging activity of selected medicinal plant extracts in the following order: *G. velutina* > *V. umbonata* > *P. eurhyncha* > *E. cyclocarpum* > *L. speciosa* = *D. excelsa* > *K. hospita* > *S. chloranthum* > *S. balangeran* > *F rukam*. The greater the scavenging activity of the selected medicinal plant extracts against $ABTS^{\bullet+}$, the higher their antioxidant activity and the lower their 50% scavenging concentration (SC_{50}). *Flacourtia* species contain phenolic compounds. Bourjot et al. (2012) showed that *F rukam* stem bark contained phenolic glycosides (Flacourtosides A-F). Sashidhara et al. (2014) also discovered poliothrysoside from *Flacourtia indica*. It is the first study on the antioxidant and scavenging activity of selected medicinal plants collected from East Kalimantan against $ABTS^{\bullet+}$.

Moreover, the antioxidant efficiency of selected medicinal plants was also evaluated against nitric oxide free radicals. Nitric oxide (NO) plays an important role in inflammatory processes. The overproduction of NO leads to tissue damage and acute and chronic inflammation. Chronic inflammation by nitric oxide free radicals is associated with various diseases, such as juvenile diabetes, arthritis, and ulcerative colitis (Venkatachalam and Muthukrishnan 2012). Therefore, nitric oxide free radical inhibitory agents (selected medicinal plants) might be beneficial in treating inflammatory responses. In this study, *S. balangeran*, *F. rukam* and *G. velutina* had similar antioxidant activity against nitric oxide free radicals with IC_{50} values shown in Table 3. Ascorbic acid used as a positive control for nitric oxide radical scavenger in this assay showed a scavenging percentage of 77.5% with an IC_{50} value of 0.05 mg/mL. The order of IC_{50} values of selected medicinal plants from the lowest to the highest is as follows: *S. chloranthum* > *K. hospita* > *L. speciosa* > *S. balangeran* = *F. rukam* = *G. velutina*. The selected medicinal plant extract inhibits nitric oxide free radicals by inhibiting nitrite formation in the radical-generating process through competition with oxygen (Habu and Ibeh 2015).

This study is the first work on ten selected medicinal plants from East Kalimantan that exhibit scavenging activity against several free radicals, such as DPPH, ABTS, and Nitric Oxide.

Table 3. Antioxidant activity of selected medicinal plants against free radicals

	Part used	SC_{50} (mg/mL)		
		DPPH	ABTS	Nitric oxide
Shorea balangeran Burck	Branch & Twig	0.05 ± 0.01	0.08 ± 0.01	0.11 ± 0.03
Syzygium chloranthum (Duthie) Merr. & L.M.Perry	Branch & Twig	0.11 ± 0.01	0.21 ± 0.01	0.16 ± 0.01
Lagerstroemia speciosa (L.) Pers.	Stem	0.26 ± 0.05	0.28 ± 0.07	0.12 ± 0.01
Flacourtia rukam Zoll. & Moritzi	Stem	0.39 ± 0.01	0.05 ± 0.01	0.11 ± 0.01
Gluta velutina Blume	Stem	0.04 ± 0.01	0.95 ± 0.05	0.11 ± 0.01
Kleinhovia hospita L.	Branch & Twig	0.78 ± 0.41	0.25 ± 0.05	0.13 ± 0.02
Enterolobium cyclocarpum (Jacq.) Griseb.	Stem	NI[b]	0.43 ± 0.19	NI
Vatica umbonata Burck	Branch & Twig	NI	0.63 ± 0.10	NI
Pertusadina eurhyncha (Miq.) Ridsdale	Stem	0.89 ± 0.02	0.45 ± 0.11	NI
Dillenia excelsa (Jack) Martelli ex Gilg.	Stem	0.13 ± 0.01	0.28 ± 0.07	NI
Ascorbic acid[a]		0.05 ± 0.01	0.12 ± 0.01	0.05 ± 0.02

Note: [a] Positive control. [b] No inhibition, inhibitory effects less than 45% at 1 mg/mL. Each value represents the mean ± S.D (n=3)

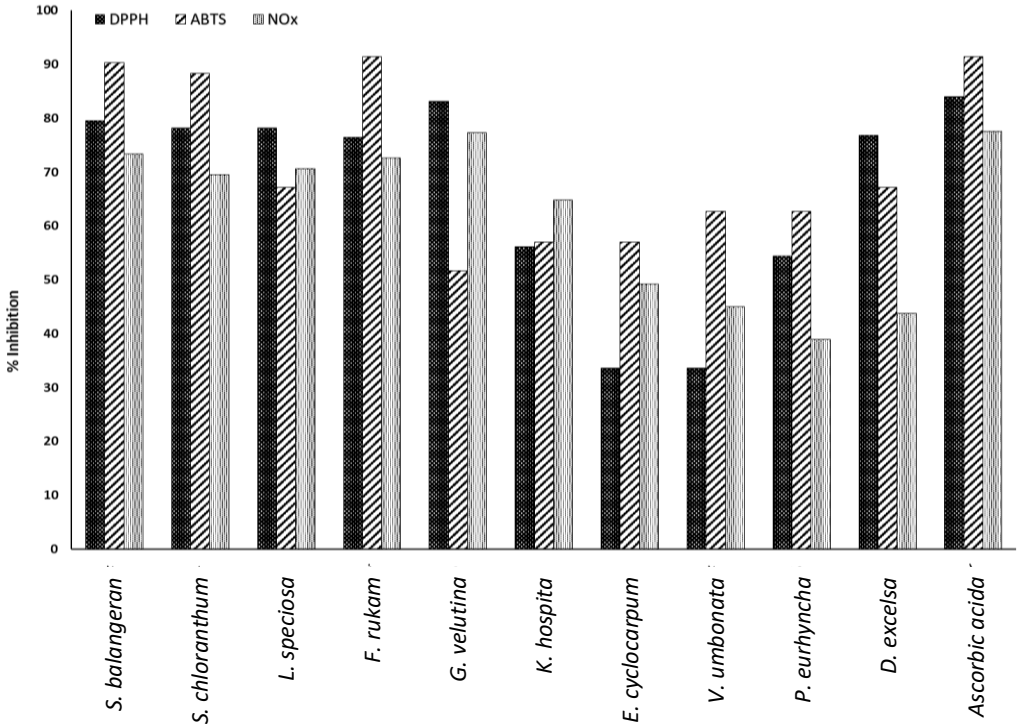

Figure 2. Inhibition percentage of medicinal plant extracts against free radicals (at extract concentration of 1 mg/mL)

In summary, the results in this study indicate that ten selected medicinal plant extracts from East Kalimantan exhibited dual functions as antidiabetic and antioxidant through both rat intestinal α-glucosidase (maltase and sucrase) inhibitory activity and free radical scavenging activity against DPPH, ABTS, and nitric oxide. However, the study area has never been explored ethnobotanically. In this regard, the present study can be considered the first one, which deals with an ethnobotanical study guided by biological activities on medicinal plants in this region. Hence, these medicinal plant extracts might be used as natural agents with great importance as therapeutic agents in preventing the progress of hyperglycemia associated with oxidative stress related to degenerative diseases. In addition, this study provides important findings for the bio-assay guide to isolate bioactive secondary metabolites from selected medicinal plants. Therefore, further studies are needed to investigate individual constituents from some actively selected medicinal plant extracts that may be responsible for anti-diabetes and its complications caused by free radicals.

ACKNOWLEDGEMENTS

R.R is grateful to the Universitas Airlangga, Surabaya, Indonesia, for providing research funds through the *Hibah Riset Mandat Kolaborasi Mitra Luar Negeri* (797/UN3.15/PT/2021) program. Furthermore, R.R is thankful to the Laboratory of Forest Products Chemistry and Renewable Energy, Faculty of Forestry, Universitas Mulawarman, Samarinda, Indonesia, for its plant deposit.

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