第 48 卷 第 9 期
2021 年 9 月

湖南大学学报（自然科学版）
Journal of Hunan University（Natural Sciences）

Vol. 48. No. 9.
September 2021

Open Access Article

Polyphenolics and Antioxidant Potential of Five Medicinal Plants Found in East Kalimantan, Indonesia

Anton Rahmadi[1,4]*, Miftakhur Rohmah[1], Kartika Sari[1], Medi Hendra[2], Riris Novia Azemi[3], Miftakhul Rahmadani Alfitriyah[3], Fatchur Rohman[3]

[1] Department of Agricultural Products Technology, Faculty of Agiculture, Mulawarman University, Samarinda, East Kalimantan, 75119, Indonesia

[2] Department of Biology, Faculty of Mathematics and Natural Science, Mulawarman University, Samarinda, East Kalimantan, 75119, Indonesia

[3] Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Malang, East Java, 65145, Indonesia

[4] Research Center for Medicine and Cosmetics from Tropical Rain Forests (PUI-PT Oktal), Mulawarman University, Samarinda, East Kalimantan, 75119, Indonesia

Abstract: Following the 1998 forest fire disaster, the Taman Borneo–Mulawarman University Park (KRUS) in East Kalimantan, Indonesia, has served as an important source of germplasm to preserve the plant biodiversity in tropical rain forests, including under-utilized medicinal species. The present study quantified polyphenolics in the bark, leaves, and fruits of *Artocarpus dadah* (AD), *Clerodendrum disparifolium* (CD), *Spatholobus ferrugineus* (SF), *Pternandra azurea* (PA), and *Psychotria carthagenensis* (PC) found in the KRUS to validate the potential antioxidant activity of these species. Phenolics were quantified spectrophotometrically using gallic acid, tannic acid, and catechin as the standards. Antioxidant activity was measured in terms of the half maximal inhibitory concentration (IC_{50}) for 2,2-diphenyl-1-picrylhydrazyl scavenging activity. Among the five test species, PA exhibited the highest total phenolic content (692.51 ± 110.67 ppm gallic acid equivalent), PC leaves exhibited the highest tannin content (22.12 ± 5.34 ppm tannic acid equivalent), and CD bark exhibited the highest flavonoid content (35.06 ± 7.25 ppm catechin equivalent). Moreover, CD bark exhibited the highest antioxidant activity (IC_{50} = 21.8, R = 0.938). In conclusion, the bark, leaves, and fruits of AD, CD, SF, PA, and PC collected from the KRUS are the potential sources of antioxidants, including phenolics, tannins, and flavonoids. The novelty of the present short communication is the quantification of polyphenolics and their antioxidant potential in five medicinal plants, namely AD, CD, SF, PA, and PC, found in East Kalimantan, Indonesia.

Keywords: *Artocarpus dadah, Clerodendrum disparifolium,* polyphenolics, *Pternandra azurea, Psychotria carthagenensis, Spatholobus ferrugineus.*

印度尼西亚东加里曼丹发现的五种药用植物的多酚和抗氧化潜力

摘要：1998 年森林火灾之后，印度尼西亚东加里曼丹的婆罗洲穆拉瓦曼公园大学公园(克鲁斯)成为保护热带雨林植物生物多样性的重要种质来源，包括未充分利用的药用物种。本研究对克鲁斯中发现的蒿属药物（广告）、金银花(光盘)、铁锈病菌(顺丰)、紫薇(公共广播)和迦太基精神病(个人电脑)的树皮、叶子和果实中的多酚进行了量化，以进行验证这些物种的潜在抗氧化活性。酚类物质使用没食子酸、单宁酸和儿茶素作为标准进行分光光度法定量。根据2,2-二苯基-1-

Received: May 1, 2021 / Revised: June 6, 2021 / Accepted: July 27, 2021 / Published: September 30, 2021

About the authors: Anton Rahmadi, Department of Agricultural Products Technology, Faculty of Agiculture, Mulawarman University, Samarinda, Indonesia; Research Center for Medicine and Cosmetics from Tropical Rain Forests (PUI-PT Oktal), Mulawarman University, Samarinda, Indonesia; Miftakhur Rohmah, Kartika Sari, Department of Agricultural Products Technology, Faculty of Agiculture, Mulawarman University, Samarinda, Indonesia; Medi Hendra, Department of Biology, Faculty of Mathematics and Natural Science, Mulawarman University, Samarinda, Indonesia; Riris Novia Azemi, Miftakhul Rahmadani Alfitriyah, Fatchur Rohman, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Malang, Indonesia

Corresponding author Anton Rahmadi, arahmadi@unmul.ac.id

苦基胼清除活性的半数最大抑制浓度(我知道了50)测量抗氧化活性。在五个测试物种中，公共广播的总酚含量最高（692.51±110.67百万分之一没食子酸当量），个人电脑叶的单宁含量最高（22.12±5.34百万分之一单宁酸当量），光盘树皮的黄酮含量最高（35.06±7.25百万分之一儿茶素当量）。此外，光盘树皮表现出最高的抗氧化活性（我知道了50=21.8，电阻 = 0.938）。总之，从克鲁斯收集的广告、光盘、顺丰、公共广播和个人电脑的树皮、叶子和果实是抗氧化剂的潜在来源，包括酚类、单宁和类黄酮。本短文的新颖之处在于对印度尼西亚东加里曼丹发现的五种药用植物（即广告、光盘、顺丰、公共广播和个人电脑）中的多酚类物质及其抗氧化潜力进行了量化。

关键词：蒿属植物、杜鹃花、多酚、紫檀、迦太基精神病、铁锈病菌。

1. Introduction

Prior to the massive fire disaster in 1998 that destroyed much of the forest cover at the heart of East Kalimantan, this rain forest was home to over 280 plant species that found numerous applications for industrial, food, and medicinal purposes [1, 2]. Polyphenolics in various indigenous plants, including *Macaranga* species [3], *Syzygium leucoxylon* [4], and some Zingiberaceae plants [5], have been explored to promote the use of non-wood forest products while simultaneously conserving biodiversity. In a study in Borneo, polyphenolics in wild edible plants, including *Helminthostachys zeylanica*, *Schismatoglottis ahmadii*, *Heckeria umbellatum*, *Lasia spinosa*, *Gonostegia hirta*, and *Aniseia martinicensis*, were measured to assess their antioxidant properties [6]. Furthermore, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity of *Willughbeia coriacea*, *Phyllanthus urinaria*, *Eleutherine palmifolia*, *Eusideroxylon zwageri*, *Dendrophthoe pentandra*, *Passiflora foetida*, and *Vitex pinnata* has been documented [7].

Secondary succession following the 1998 fire disaster revealed several surviving plant species; therefore, a germplasm of those species has been established [8]. Recently, the Taman Borneo–Mulawarman University Park (KRUS) in East Kalimantan, Indonesia, was explored as the source of germplasm for tropical rain forest species, and these efforts have prompted further investigations on the potential applications of this germplasm.

The Kutai and Dayak communities in East Kalimantan, in addition to other Indonesian tribes, use *Artocarpus dadah* Miq. (AD), *Clerodendrum disparifolium* Blume (CD), *Spatholobus ferrugineus* (Zoll. & Moritzi) Benth. (SF), *Pternandra azurea* (DC.) Burkill (PA), and *Psychotria carthagenensis* Jacq. (PC) as herbal medicines [9, 10]. The medicinal properties of these plants have primarily been attributed to their phytochemical components, implicating antioxidant activity. However, the potential antioxidant activity of the bark, leaves, and fruits of AD, CD, SF, PA, and PC has been scarcely validated.

The bark of AD contains cycloarthobiloxanthone—a derivative of prenylated flavonoids in the C-3 group [11]. This compound has been reported to exhibit potent cytotoxicity against P-288 murine leukemia cells [12]. Further, a previous study has identified phenolic compounds with potential antioxidant properties in the stem epidermis and young stem of CD [13]. Additionally, alkaloids, flavonoids, polyphenols, and terpenoids in the stem of SF have been qualitatively analyzed [14]. The leaves of PC contain hallucinogenic alkaloids, which are often used by the Ayahuasca tribe [15]. However, the phytochemical properties of PA have been poorly documented.

To this end, the present study quantified polyphenolics in the bark, leaves, and fruits of AD, CD, SF, PA, and PC collected from the KRUS in East Kalimantan, Indonesia, and explored their antioxidant potential.

2. Materials and Methods

2.1. Materials

The raw materials used in the present study included the samples of fruits, leaves, and bark of AD, CD, SF, PA, and PC, which are used in traditional medicine, collected from the germplasm collection of the KRUS, East Kalimantan, Indonesia.

2.2. Species Identification

The species identity was confirmed following conventional taxonomic methods, as verified by Dr. Medi Hendra of the Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University.

2.3. Quantification of Total Phenolics

Total phenolics were quantified using the methodology described by Mu'nisa *et al*. [16], with

some modifications. Briefly, the plant parts (i.e., bark, leaves, or fruits) were accurately weighed to 0.3 g and dissolved in 10 mL of absolute ethanol (SmartLab, Indonesia) and distilled water (Soil Laboratory, Mulawarman University) at 1:1 ratio. Next, approximately 0.2 mL of the solution was added to 15.8 mL of distilled water, and 1 mL of 50% (v/v) aqueous Folin–Ciocalteu (Sigma-Aldrich, Germany) reagent was added to the sample. The sample was incubated for ±8 min at 28 ± 2°C. Then, 3 mL of 5% (w/v) aqueous Na_2CO_3 (Sigma-Aldrich, Germany) was added, and the sample was incubated for additional ±2 h in the dark at 28 ± 2°C. Finally, each sample was transferred to a cuvette, and absorbance was measured at 725 nm (UV/Vis BioSpectrophotometer, Eppendorf, Germany). The measured value of absorbance was extrapolated on the standard curve of gallic acid, which was prepared using the same protocol. Total phenolic content was expressed in parts per million of gallic acid equivalent (GAE).

2.4. Quantification of Total Tannins

Total tannins were quantified using the methodology described elsewhere [17], with some modifications. Briefly, the plant parts (0.5 g) were macerated in 10 mL of diethyl ether (Merck, Singapore) for 20 h at 28 ± 2°C, and the samples were filtered through a Whatman filter paper. The obtained residue was boiled in 100 mL of distilled water for 2 h at 100°C, cooled to room temperature (28 ± 2°C), and re-filtered. The extracts obtained were diluted 100 times. About 0.1 mL of the extract was added with 0.1 mL of 50% (v/v) aqueous Folin-Ciocalteu reagents and was homogenized with a vortex mixer. The sample was added to 2 mL of 2% (w/v) aqueous Na_2CO_3 and was homogenized. Each of the solutions was incubated for 30 min in a dark place at room temperature. The absorbance was measured at 760 nm (UV/Vis BioSpectrophotometer, Eppendorf, Germany). The readings were interpolated on the standard curve graph of tannic acid (Sigma-Aldrich, Germany) that was prepared in the same fashion. The total tannins were expressed in ppm of tannic acid equivalent (TAE).

2.5. Total Flavonoids

Total flavonoids were analyzed using specified modifications from previous research [18]. About 1 mg of each plant part was weighed and dissolved in 10 mL of absolute ethanol (SmartLab, Indonesia), and 0.7 mL of distilled water was added to the solution. To each sample, 0.1 mL of 5% aqueous $NaNO_2$ (Sigma-Aldrich, Germany) was added. The samples were allowed to stand for 5 minutes at room temperature (28 ± 2 °C). The sample was added to 0.1 mL of 10% aqueous $AlCl_3$ (Sigma-Aldrich, Germany). After being incubated for 6 minutes at room temperature, about 0.5 mL of 1 M NaOH (Merck, USA) was added. All ingredients were mixed evenly and allowed to stand for 10 minutes at room temperature. Each of the samples was prepared 1:1 (v/v) in absolute ethanol (SmartLab, Indonesia), and the absorbance was measured at 510 nm. The results obtained were interpolated on the standard curve graph of catechin (Sigma-Aldrich, Germany) prepared in the same way. Total flavonoids were expressed in ppm of the catechin equivalent (CAE).

2.6. Antioxidant Activity

The antioxidant activity test was performed by calculating the inhibition of 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Sigma-Aldrich, Germany) reduction [19]. A total of 1 mL diluted plant part in ethanol was added to 1 mL of DPPH (0.15 mM in ethanol), and at the same time, a control consisting of 1 mL DPPH with 1 mL of ethanol was prepared. The solution was homogenized and then incubated in a dark place at room temperature for 30 minutes. Each solution was prepared in a cuvette, and the absorbance was measured at 517 nm. Vitamin C was used as a positive control, and ethanol was used as a blank. The DPPH radical scavenging activity of the extract was calculated using equation 1:

$$\text{\% antioxidant activity} = \frac{\text{control absorbance - sampel absorbance}}{\text{control absorbance}} \times 100 \quad (1)$$

The absorbance of the control was the absorbance of DPPH + ethanol.

The absorbance of the sample was the absorbance of the DPPH + sample.

The obtained data was presented with the IC_{50} value, and the value was obtained from nonlinear regressing %-DPPH reduction inhibition by sample at concentrations of 31.25; 62.5; 125; 250; and 500 ppm. The nonlinear regression analysis of the One Phase Decay curve fitting was completed with GraphPad Prism 6.0.

3. Results and Discussion

3.1. Total Phenolics

In light of the previous research, we have collected five species, namely AD, CD, SF, PA, and PC. The highest total phenolics were established in the bark of *Pternandra azurea*. XBased on the results (Table 1), total phenolics of barks in four species were higher than that of leaves. The phenolics of AD fruit was relatively the same as its leaf. The content of phenolics depends on species and the solvent used to dilute the samples, as indicated in previous research [19, 20].

3.2. Total Tannins

Tannins may have a positive association to human health or the opposite, depending upon its concentration [21]. Tannins were distributed in parts of plants, i.e., leaf, bark, fruit, and root. In contrast to total phenolics that were higher in barks of four species of

samples, tannin contents were varied in the observed parts of plants. Leaves of PC and PA had higher tannins than the bark. Tannins in bark and leaf of CD and SF were not significantly different. The same condition occurred with AD leaf and fruit (Table 1). However, tannins in the observed species should be further investigated to allow isolation of the pure compound in order to investigate its true nature.

3.3. Total Flavonoids

Flavonoid antioxidants are associated with the existence of 2- or 3-phenylchroman structures. These structures have been observed in pure constituents of plants and fruits [22], i.e., quercetin. For the five observed species, the highest contents of flavonoids were found in bark of CD, followed by bark of SF and PA. The other samples had flavonoid contents between 3.92 ± 0.20 and 5.44 ± 1.47 ppm (Table 1).

3.4. Antioxidant Activity

Wild plants in Borneo may contain high antioxidant activity. For example, more than 70% of DPPH radical was successfully scavenged by the extracts of six medicinal plants from Borneo [7]. In this research, antioxidant activity was measured with IC_{50} of DPPH radical scavenging activity. The lowest IC_{50} value was observed in SF leaf, followed by SF bark. All samples had higher scavenging activity than vitamin C. It was deduced that polyphenols, tannins, and flavonoids of the five observed species were associated with DPPH radical scavenging activity (Table 1).

Table 1 Recapitulation of total phenolics, tannins, flavonoids, and antioxidant activity of bark, leaf, and fruit of AD, CD, SF, PA, and PC

Sample	Code	TPC	HTC	TFC	IC50	
		GAE (ppm)	TAE (ppm)	CAE (ppm)	Value (ppm)	R-square
Fruit of *Artocarpus dadah*	AD fruit	288.26 ± 34.18	136.01 ± 30.99	4.17 ± 0.13	116.4	0.759
Leaf of *Artocarpus dadah*	AD leaf	269.57 ± 53.20	120.13 ± 61.90	4.65 ± 0.73	54.5	0.941
Bark of *Spatholobus ferrugineus*	SF bark	607.14 ± 78.80	164.06 ± 10.64	18.92 ± 7.28	25.0	0.938
Leaf of *Spatholobus ferrugineus*	SF leaf	507.82 ± 28.90	134.03 ± 44.19	4.51 ± 0.28	21.8	0.938
Bark of *Clerodendrum disparifolium*	CD bark	575.34 ± 22.99	196.07 ± 27.04	35.06 ± 7.25	92.5	0.994
Leaf of *Clerodendrum disparifolium*	CD leaf	466.53 ± 191.40	191.85 ± 10.14	5.44 ± 1.47	52.7	0.986
The bark of *Pternandra azurea*	PA bark	692.51 ± 110.67	126.58 ± 13.68	14.81 ± 4.71	45.4	0.797
Leaf of *Pternandra azurea*	PA leaf	628.62 ± 60.51	152.39 ± 8.69	4.06 ± 0.20	63.4	0.986
Bark of *Psychotria carthagenensis*	PC bark	581.19 ± 33.61	181.92 ± 32.41	4.10 ± 0.21	44.8	0.971
Leaf of *Psychotria carthagenensis*	PC leaf	283.24 ± 88.48	222.12 ± 5.34	3.92 ± 0.20	37.3	0.938

4. Conclusion

Phenolics, tannins, flavonoids, and DPPH scavenging activity were successfully measured from bark, leaf, and fruit of AD, CD, SF, PA, and PC collected from Taman Borneo - Mulawarman University Park (KRUS), East Kalimantan, Indonesia. The highest total phenolics was observed in bark of PA with a value of 692.51±110.67 ppm GAE. PC leaf had the highest total tannins of 222.12±5.34 ppm TAE. Flavonoids were densely populated in bark of CD with a value of 35.06±7.25 ppm CAE. From the five observed species, the highest antioxidant activity was found in bark of CD, with IC_{50} of DPPH scavenging activity of 21.8 and an R-value of 0.938. The limitation of this study is related to the initial finding, that it should be further followed up by thorough research on the possibility of using AD, CD, SF, PA, and PC as potential sources of traditional medicinal plants from Indonesian native tropical rain forests. Our findings further confirm the use of *Artocarpus dadah* (AD), *Clerodendrum disparifolium* (CD), *Spatholobus ferrugineus* (SF), *Pternandra azurea* (PA), and *Psychotria carthagenensis* (PC) as a potential germ plasm bank that can be further characterized as an effective and potential source of antioxidants.

Acknowledgment

The authors thank the Ministry of Research, Technology, and Higher Education for the research fund in the Student Credit Transfer – Joint Research Supervision scheme. Authors thank to PIU-IDB of Universitas Negeri Malang and Mulawarman University.

References

[1] KEβLER P. J. A., SIDDIYASA K., AMRIANSYAH, & ZAINAL A. *Checklist of secondary forest trees in East and South Kalimantan - Indonesia.* Tropenbos Indonesia, Bogor, 1994. https://www.tropenbos-indonesia.org/resources/publications/checklist+of+secondary+forest+trees+in+east+and+south+kalimantan+-+indonesia

[2] KEβLER P. J. A., PELSER P. B., RIDSDALE C. E., & SIDIYASA K. *Secondary Forest Trees of Kalimantan, Indonesia: A Manual to 300 Selected Species.* MOFEC Tropenbos, Balikpapan, 2000.

[3] LIM T. Y., LIM Y. Y., & YULE C. M. Distribution and Characterisation of Phenolic Compounds in *Macaranga*

pruinosa and Associated Soils in a Tropical Peat Swamp Forest. *Journal of Tropical Forest Science*, 2017, 29(4): 509–518. https://doi.org/10.26525/jtfs2017.29.4.509518
[4] SHAMSUDIN K. J., PHAN C. S., KULIP J., HATAI K., VAIRAPPAN C. S., & KAMADA T. Leucoxenols A and B, two new phenolics from Bornean medicinal plant *Syzygium leucoxylon*. *Journal of Asian Natural Products Research*, 2018, 21(5): 435-441. https://doi.org/10.1080/10286020.2018.1440391
[5] SHAHID-UD-DAULA A. F. M., KUYAH M. A. A., KAMARIAH A. S., LIM L. B. L., & AHMAD N. Phytochemical and pharmacological evaluation of methanolic extracts of *Etlingera fimbriobracteata (Zingerberaceae)*. *South African Journal of Botany*, 2019, 121: 45–53. https://doi.org/10.1016/j.sajb.2018.10.013
[6] WONG J. Y., MATANJUN P., OOI Y. B. H., & CHIA K. F. Evaluation of Antioxidant Activities in Relation to Total Phenolics and Flavonoids Content of Selected Malaysian Wild Edible Plants by Multivariate Analysis. *International Journal of Food Properties*, 2014, 17(8): 1763-1778. https://doi.org/10.1080/10942912.2012.724756
[7] ARUNG E. T., KUSUMA I. W., CHRISTY E. O., SHIMIZU K., & KONDO R. Evaluation of medicinal plants from Central Kalimantan for antimelanogenesis. *Journal Natural Medicine*, 2009, 63(4): 473-480. https://doi.org/10.1007/s11418-009-0351-7
[8] YASSIR I., VAN DER KAMP J., & BUURMAN P. Secondary succession after fire in *Imperata* grasslands of East Kalimantan, Indonesia. *Agriculture, Ecosystems & Environment*, 2010, 137(1–2): 172-182. https://doi.org/10.1016/j.agee.2010.02.001
[9] RUPA D. *Identifikasi Struktur Sekretori dan Analisis Histokimia serta Fitokimia Tumbuhan Obat Anti-Infeksi di Kawasan Taman Nasional Bukit Duabelas Jambi*. Sekolah Pascasarjana Institut Pertanian Bogor, Bogor, 2015. https://repository.ipb.ac.id/handle/123456789/78946
[10] SUSILO A., & DENNY D. Diversity and potential use of plants in secondary natural forest in RPH Cisujen KPH Sukabumi, West Java. *Seminar Nasional Masyarakat Biodiversitas Indonesia*, 2016, 2(2): 256-262. https://doi.org/10.13057/psnmbi/m020223
[11] INDARTO I. Isolasi dan Identifikasi Senyawa Fenolik dari Kulit Akar Tumbuhan *Artocarpus dadah* Miq. *Jurnal Ilmiah Pendidikan Fisika Al-BiRuNi*, 2015, 4(2): 145-153. https://doi.org/10.24042/jpifalbiruni.v4i2.93
[12] SUHARTATI T., & YANDRI A. S. Sikloartobilosanton dari Kulit Batang dan Flavonoid dalam Beberapa Bagian Tumbuhan *Artocarpus dadah* yang Tumbuh di Lampung. *Jurnal Sains MIPA*, 2007, 13(2): 82-86.
[13] PHOSRITHONG N., & NUCHTAVORN N. Antioxidant and anti-inflammatory activities of *Clerodendrum* leaf extracts collected in Thailand. *European Journal of Integrative Medicine*, 2016, 8(3): 281-285. https://doi.org/10.1016/j.eujim.2015.10.002
[14] MARLIANA E. Analisis senyawa metabolit sekunder dari batang *Spatholobus ferrugineus* (Zoll & Moritzi) Benth yang berfungsi sebagai antioksidan. *Jurnal Penelitian MIPA*, 2007, 1(1): 23-29. https://siafif.com/kuliah/sukma/semester%208/SKRIPSI%20KAKAK%20TINGKAT/lumut222/kpm-des2007-1%20(2).pdf
[15] LEAL M. B., & ELISABETSKY E. Absence of alkaloids in *Psychotria carthagenensis* Jacq. (Rubiaceae). *Journal of Ethnopharmacology*, 1996, 54(1): 37-40. https://doi.org/10.1016/0378-8741(96)01448-1
[16] MU'NISA A., WRESDIYATI T., KUSUMORINI N., and MANALU W. Aktivitas Antioksidan Ekstrak Daun Cengkeh (Antioxidant Activity of Clove Leaf Extract). *Jurnal Veteriner*, 2012, 13(3): 272-277. https://ojs.unud.ac.id/index.php/jvet/article/view/6015
[17] MALANGNGI L. P., SANGI M. S., and PAEDONG J. J. E. Penentuan Kandungan Tanin dan Uji Aktivitas Antioksidan Ekstrak Biji Buah Alpukat (*Persea americana* Mill.). *Jurnal Mipa Unsrat Online*, 2012, 1(1): 5-10. https://doi.org/10.35799/jm.1.1.2012.423
[18] ZOU Y., LU Y., & WEI D. Antioxidant Activity of Flavonoid Rich Extract of *Hypericum pertoratum* L. in Vitro. *Journal Agriculture and Food Chemistry*, 2004, 52(16): 5032-5039. https://doi.org/10.1021/jf049571r
[19] FARHAN H., RAMMAl H., HIJAZI A., HAMAD H., DAHER A., REDA M., & BADRAN B. In vitro Antioxidant Activity of Ethanolic and Aqueous Extracts from Crude *Malva parviflora* L. Grown in Lebanon. *Asian Journal of Pharmaceutical and Clinical Research*, 2012, 5(3): 234-238.
[20] HIDAYATI J. R., YUDIATI E., PRINGGENIES D., ARIFIN Z., & OKTAVIYANTL D. T. Antioxidant Activities, Total Phenolic Compound and Pigment Contents of Tropical *Sargassum sp.* Extract, Macerated in Different Solvents Polarity. *Jurnal Kelautan Tropis*, 2019, 22(1), 73-80. https://doi.org/10.14710/jkt.v22i1.4404
[21] SHARMA K., KUMAR V., KAUR J., TANWAR B., GOYAL A., SHARMA R., GAT Y., & KUMAR A. Health effects, sources, utilization, and safety of tannins: a critical review. *Toxin Reviews*, 2019. https://doi.org/10.1080/15569543.2019.1662813
[22] GRIFFITHS K., AGGARWAL B. B., SINGH R. B., BUTTAR H. S., WILSON D., & DE MEESTER F. Food Antioxidants and Their Anti-Inflammatory Properties: A Potential Role in Cardiovascular Diseases and Cancer Prevention. *Diseases*, 2016, 4(3): 28. https://doi.org/10.3390/diseases4030028

参考文:

[1] KEβLER P. J. A.、SIDDIYASA K.、AMRIANSYAH 和 ZAINAL A. 印度尼西亚东加里曼丹和南加里曼丹的次生林树清单。特罗彭波斯印度尼西亚，茂物，1994。https://www.tropenbos-indonesia.org/resources/publications/checklist+of+secondary+forest+trees+in+east+and+south+kalimantan+-+indonesia
[2] KEβLER P. J. A.、PELSER P. B.、RIDSDALE C. E. 和 SIDIYASA K. 印度尼西亚加里曼丹的次生林树：300 种选定树种手册。外经贸部热带森林，巴厘巴板，2000 。
[3] LIM T. Y.、LIM Y. Y. 和 YULE C. M. 热带泥炭沼泽森林中猕猴桃和相关土壤中酚类化合物的分布和表征。热带森林科学杂志，2017，29（4）：509-518。 https://doi.org/10.26525/jtfs2017.29.4.509518
[4] SHAMSUDIN K. J.、PHAN C. S.、KULIP J.、HATAI K.、VAIRAPPAN C. S. 和 KAMADA T. 白藜芦醇一种和乙，来自婆罗洲药用植物白木合子的两种新酚类物质。亚洲天然产物研究杂志， 2018, 21(5): 435-441。https://doi.org/10.1080/10286020.2018.1440391

[5] SHAHID-UD-DAULA A. F. M.、KUYAH M. A. A.、KAMARIAH A. S.、LIM L. B. L. 和 AHMAD N. 无花果（姜科）甲醇提取物的植物化学和药理学评价。南非植物学杂志，2019，121：45-53。https://doi.org/10.1016/j.sajb.2018.10.013

[6] WONG J. Y., MATANJUN P., OOI Y. B. H., & CHIA K. F. 通过多元分析评估与所选马来西亚野生食用植物的总酚类和黄酮类化合物含量相关的抗氧化活性。国际食品特性杂志，2014，17(8)：1763-1778。https://doi.org/10.1080/10942912.2012.724756

[7] ARUNG E. T.、KUSUMA I.W.、CHRISTY E. O.、SHIMIZU K. 和 KONDO R. 对来自中加里曼丹的药用植物抗黑色素生成的评价。自然医学杂志，2009，63（4）：473-480。https://doi.org/10.1007/s11418-009-0351-7

[8] YASSIR I., VAN DER KAMP J., & BUURMAN P. 印度尼西亚东加里曼丹白茅草草原火灾后的二次演替。农业、生态系统与环境，2010，137(1-2)：172-182。https://doi.org/10.1016/j.agee.2010.02.001

[9] RUPA D. 武吉杜阿贝拉斯占碑国家公园地区抗感染药用植物的分泌结构鉴定及组织化学和植物化学分析。茂物农业大学研究生院，茂物，2015。https://repository.ipb.ac.id/handle/123456789/78946

[10] SUSILO A. 和 DENNY D. 西爪哇RPH西苏仁KPH苏加文次生天然林中植物的多样性和潜在用途。研讨会印度尼西亚国家生物多样性协会， 2016, 2(2): 256-262。https://doi.org/10.13057/psnmbi/m020223

[11] INARDO I. 黄果树根皮酚类化合物的分离鉴定。期刊铝铋合金. 科学物理教育， 2015， 4(2): 145-153。https://doi.org/10.24042/jpifalbiruni.v4i2.93

[12] SUHARTATI T., & YANDRI A. S. 来自楠榜的药用木果属植物的茎皮和黄酮类化合物中的环花生四烯酮。杂志赛恩斯米帕, 2007, 13(2): 82-86。

[13] PHOSRITHONG N., & NUCHTAVORN N. 在泰国收集的仙茅叶提取物的抗氧化和抗炎活性。欧洲中西医结合杂志，2016，8(3)：281-285。https://doi.org/10.1016/j.eujim.2015.10.002

[14] MARLIANA E. 分析学报代谢物次生铁锈病菌(佐尔和莫里齐)本斯的茎，作为抗氧化剂。杂志佩尼利特米帕， 2007, 1(1): 23-29。https://siafif.com/kuliah/sukma/semester%208/SKRIPSI%20KAKAK%20TINGKAT/lumut222/kpm-des2007-1%20(2).pdf

[15] LEAL M. B., & ELISABETSKY E. 精神分裂症迦太基中不存在生物碱。（茜草科）。民族药理学杂志，1996，54（1）：37-40。https://doi.org/10.1016/0378-8741(96)01448-1

[16] MU'NISA A.、WRESDIYATI T.、KUSUMORINI N. 和 MANALU W. 丁香叶提取物抗氧化活性（丁香叶提取物的抗氧化活性）。兽医杂志，2012，13（3）：272-277。https://ojs.unud.ac.id/index.php/jvet/article/view/6015

[17] MALANNGI L. P.、SANGI M. S. 和 PAEDONG J. J. E. 鳄梨籽提取物（美洲磨坊.）单宁含量的测定及抗氧化活性试验。期刊米帕·乌斯拉特在线的， 2012， 1(1): 5-10。https://doi.org/10.35799/jm.1.1.2012.423

[18] ZOU Y., LU Y., & WEI D. 金丝桃富含黄酮提取物的体外抗氧化活性。农业与食品化学杂志，2004，52(16)：5032-5039。https://doi.org/10.1021/jf049571r

[19] FARHAN H.、RAMMAl H.、HIJAZI A.、HAMAD H.、DAHER A.、REDA M. 和 BADRAN B. 黎巴嫩生长的小花锦葵粗制乙醇和水提取物的体外抗氧化活性。亚洲药物与临床研究杂志，2012，5(3)：234-238。

[20] HIDAYATI J. R.、YUDIATI E.、PRINGGENIES D.、ARIFIN Z. 和 OKTAVIYANTL D.T. 热带马尾藻的抗氧化活性、总酚类化合物和色素含量。提取物，浸渍在不同极性的溶剂中。期刊基劳丹热带，2019, 22(1), 73-80。https://doi.org/10.14710/jkt.v22i1.4404

[21] SHARMA K.、KUMAR V.、KAUR J.、TANWAR B.、GOYAL A.、SHARMA R.、GAT Y. 和 KUMAR A. 单宁的健康影响、来源、利用和安全性：批判性审查 . 毒素评论，2019。https://doi.org/10.1080/15569543.2019.1662813

[22] GRIFFITHS K.、AGGARWAL B. B.、SINGH R. B.、BUTTAR H. S.、WILSON D. 和 DE MEESTER F. 食物抗氧化剂及其抗炎特性：在心血管疾病和癌症预防中的潜在作用。 疾病， 2016， 4(3): 28. https://doi.org/10.3390/diseases4030028