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Enhanced Extraction of Total Polyphenols Content from *Mitragyna Speciosa* (Korth.) Havil Leaves using the Natural Deep Eutectic Solvent-based Microwave-assisted Extraction Method

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Keywords: Microwave-assisted Extraction, *Mitragyna Speciosa* (Korth.) Havil, Natural Deep Eutectic Solvent, Total Polyphenolic Content.

Abstract: Exploration of natural products is highly dependent on separation techniques, mainly solvent selection, one of which is using the green chemistry principle approach. *Mitragyna speciosa* (Koth.) Havil is an endemic plant of East Kalimantan which traditionally used for the treatment of various cases. On the other hand, this plant has an addictive effect. The study aims to determine the impact of using natural deep eutectic solvent-based microwave-assisted extraction (NADES-MAE) on total polyphenol content (TPC) extraction from *M. speciosa*. Natural deep eutectic solvent (NADES) made by malting two combination types include citric acid-glucose; choline chloride-sorbitol; malic acid-glucose; and lactic acid-sucrose. The extraction process was carried out using microwave-assisted extraction (MAE), and the determination of TPC was analyzed using Folin-Ciocalteu's reagent and measured with a spectrophotometer type including 246.70 mg GAE/g sample (citric acid-glucose), 227.33 mg GAE/g sample (malic acid-glucose), 222.26 mg GAE/g sample (lactic acid-sucrose), and 219.02 mg GAE/g sample (choline chloride-sorbitol). According to the results, the NADES-MAE method shows differences in TPC based on the NADES types.

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1 INTRODUCTION

Mitragyna speciosa [Korth.] Havil belongs to the family Rubiaceae, which is an endemic plant of Southeast Asia. It is spread in several countries such as Thailand, Vietnam, Malaysia, and Indonesia (Hassan et al., 2013). In Indonesia, this plant commonly found on Kalimantan island, mainly in East Kalimantan. Local community uses the leaves of *M. speciosa* for traditional medicine either with chewed up, smoked like cigarettes, and brewed like tea.

M. speciosa leaves are traditionally believed to have several medicinal properties such as a wound, fever, muscle aches, reduce appetite and diarrhea (Hassan et al., 2013; Raini, 2017). It has been scientifically proven to have pharmacological effects such as analgesic, stimulant, antidepressant, anti-

inflammatory, antinociceptive, antioxidant, and antibacterial activities. (Mossadeq et al., 2009; Parthasarathy et al., 2009; Luliana et al., 2018).

Besides, this plant is an export commodity for farmers in East Kalimantan. Although most European countries have banned their use because of the addictive effects of the compounds they have, such as mitragynine, 7-hydroxy-mitragynine, painantein, speciosin, and speciosiliatin (Horie et al., 2005; Chittrakarn, Penjamras and Keawpradub, 2012; Henningfield et al., 2018), this plant is also rich in polyphenols, terpenoids, and several types of glycosides (Takayama, 2004; Tohar et al., 2016; Chittrakarn, Penjamras, and Keawpradub, 2012; Brown, Lund, and Murch, 2017).

In some countries such as Malaysia, Thailand, Myanmar, and Australia, this plant is illegal. Meanwhile, New Zealand, Romania, Finland,

Germany, and Denmark are controlled and included in the Schedule 1 drug category (Saingam et al., 2013; Henningfield et al., 2018).

The exploration of active compounds from natural products is very dependent on the separation technique. One way is the approach of green chemistry principles. Natural deep eutectic solvent (NADES) is a green solvent that can be an alternative solvent to replace conventional organic solvents. NADES has an advantage compared to conventional solvents because it has low toxicity, biodegradability, biocompatible with many media, and edible (Savi et al., 2018; Gomez and Espino, 2018).

Some study have reported on the use of NADES as an alternative solvent and combined with non-conventional extraction methods (such as microwave, supercritical, and ultrasonic) namely extraction of caffeine and chlorogenic acid from coffee beans (Ahmad et al., 2018), baicalin extraction from *Sturellaria baicalensis* Gergi (Wang et al., 2018), alpha-cellulose, holo-cellulose, and acid-insoluble-lignin (Pan et al., 2017), anthocyanins (Dai et al., 2016), phenols extraction from *Cajanus cajan* (Wei et al., 2012) and olive cake, onion seed, tomato and pear (agro-industrial by-products) (Fernández et al., 2017), anthocyanins from *Catharanthus roseus* (Dai et al., 2016), resveratrol from *Morus alba* (Alishlah, Mun'in, and Jufri, 2019) and peanut (Chen et al., 2018), and so on. However, the extraction of total polyphenolic content from *M. speciosa* leaves has not reported.

In the present study, the extraction of total polyphenolic content (TPC) was performed by using NADES with some combination type different and combined with microwave-assisted extraction (MAE). The study aims to determine the effect of using natural deep eutectic solvent-based microwave-assisted extraction (NADES-MAE) on total polyphenol content (TPC) extraction from *M. speciosa* leaves.

2 MATERIALS AND METHODS

2.1 Materials

The sample of *M. speciosa* leaf was obtained from Melak, Kutai Barat, East Kalimantan, Indonesia and authenticated at Laboratory of Dendrology, Faculty of Forestry, Universitas Mulawarman, Samarinda, East Kalimantan, Indonesia. The sample specimen was achieved at the Laboratory of Pharmaceutical Research and Development "FARMAKA TROPIS," Faculty of Pharmacy,

Universitas Mulawarman, Samarinda, East Kalimantan, Indonesia. Citric acid, lactic acid, sucrose, glucose, malic acid, choline chloride, sorbitol were purchased from V. Chlorogreen, Bandung, West Java, Indonesia. Gallic acid standard, Folin-Ciocalteu reagent, and sodium carbonate were purchased from Sigma-Aldrich, USA (via PT. Elo Karsa Utama, Indonesia).

2.2 Extraction Process

2.2.1 Preparation of Natural Deep Eutectic Solvent (NADES)

In this study, for screening of NADES was used including citric acid–glucose (CAG), malic acid–glucose (MAG), lactic acid–sucrose (LAS), and choline chloride–sorbitol (CCS) with ratio of 4:1 g/g, 1:2 g/g, 1:1 g/g, and 1:2 g/g, respectively. The NADES component is weighed according to each ratio, then melted on a magnetic stirrer hotplate. Aqua demineralization is added according to the number of comparisons used. The mixture is stirred until homogeneous. The solution is stored in a closed bottle (Ahmad et al., 2018).

2.2.2 Extraction using NADES

A natural deep eutectic solvent-based microwave-assisted extraction (NADES-MAE) was performed to obtain total polyphenol content (TPC) according to some literature (Z. F. Wei et al., 2015; Z. Wei et al., 2015; Dai et al., 2016; Ahmad et al., 2017b; Savi et al., 2018). Briefly, the powder simplicial of *M. speciosa* (5 gram) was extracted for 10 minutes (with 30% microwave power) using NADES-MAE method which some combination types of NADES. The sample residue and extract solution were separated using the Buchner funnel. The extract was deposited at a cold temperature and until ready to use. Whereas extraction using ethanol solvents was carried out by maceration. Samples are immersed in a solvent for 1 x 24 hours continuously, maceration is stopped when the solvent has begun to clear. The extract solution and the sample residue are separated using a separating funnel, then evaporated to obtain a dry extract.

2.3 Total Polyphenolic Content (TPC) Determination

The TPC was estimated by using spectrophotometer UV-Vis method based on the literature (Bobo-García et al., 2014; Do et al., 2014; Ahmad et al., 2015) with

slight modification. Briefly, the sample and standard solution (1 mL) was added to 5 mL aqua demineralization and 0.5 mL Folin-Ciocalteu reagent, homogenized and allowed for 5 minutes. Next, a 2 mL sodium carbonate solution was added, homogenized, and incubated for 30 minutes. The absorbance was measured using spectrophotometer UV-Vis with 770 nm. The standard solution of gallic acid (with a concentration of 12.5 ppm, 25 ppm, 50 ppm, 100 ppm, and 200 ppm, respectively) was used to obtain the regression formula: $Y = a + bX$, where X is concentration, and Y is absorbance.

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3 RESULTS AND DISCUSSION

3.1 Extraction Process

The application of NADES to extract target secondary metabolite compounds from natural materials is expected to be an alternative solvent option to be able to replace conventional organic solvents. At this stage, it only focuses on the selection of NADES combination types that refer to previous studies (García et al., 2016; Fernández et al., 2017; Z. F. Wei et al., 2015; Dai et al., 2016; Wang et al., 2018; Ahmad et al., 2018; Alishlah, Mun'im, and Jufri, 2019; Yin-Leng and Suyin, 2019; Yuniarti, Saputri, and Mun'im, 2019). The NADES combination types were used in this study include citric acid–glucose (CAG), malic acid–glucose (MAG), lactic acid–sucrose (LAS), and choline chloride–sorbitol (CCS) with ratio of 4:1 g/g, 1:2 g/g, 1:1 g/g, and 1:2 g/g, respectively. While other factors such as extraction time, solvent and sample ratios, microwave power, and concentration of aqua demineralization were carried out under constant conditions.

In this study, the TPC extraction was performed by using the NADES-MAE method. The selection of the extraction method is based on the effectiveness of the use of the solvent, the extraction time, the cost efficiency, and the stability of the target compound. NADES-MAE was chosen because it is environmentally friendly, safe, inexpensive, low toxicity, and fast.

3.2 Total Polyphenolic Content (TPC)

The determination of the TPC was performed by using spectrophotometer UV-VIS at 746 nm with Folin-Ciocalteu reagent. The measurement results of standard gallic acid shown in Table 1. According to the results, it shows that the absorbance measurement results at each concentration are outstanding namely

in the absorbance range of 0 up to 1 and following the literature (Bobo-García et al., 2014; Ahmad et al., 2017a).

Table 1: The absorbance results of the gallic acid standard.

Concentration (ppm)	Absorbance	Average Absorbance	Standard Deviation
12.5	0.024 0.025 0.025	0.024	0.0006
25	0.053 0.058 0.067	0.059	0.0071
50	0.092 0.106 0.107	0.101	0.0084
100	0.229 0.238 0.233	0.233	0.0045
200	0.430 0.445 0.446	0.440	0.0090

Based on the calculation results of the linear regression analysis shown in Figure 1, the equation obtained $Y = 0.0022X - 0.00095$ with a correlation coefficient (R^2) of 0.998 (Figure 1). Where Y is absorbance value, and X is the concentration of gallic acid standard. The equation formula was used to calculate the TPC from *M. speciosa* leaves by using different NADES combination types compared conventional organic solvent and extraction method.

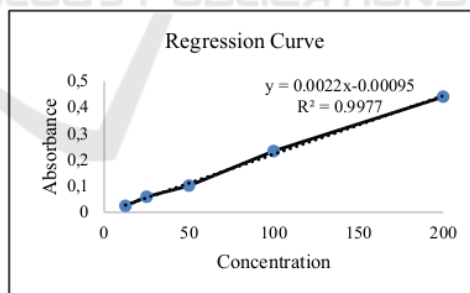


Figure 1: Regression curve of gallic acid standard.

According to the absorbance measurements for each extract (NADES combination type and ethanol), different absorbances were obtained and were in the absorbance range of 0 to 1 (at the concentration of the diluted sample) shown in Table 2. The TPC was calculated based on sample weight (mg GAE/g sample).

Table 2: Total polyphenolic content (TPC) of *M. speciosa* leaves based on the solvent type used.

Solvent Types	Absorbance	Average Absorbance	Standard Deviation	TPC (mg GAE/g sample)
CAG	0.929 0.845 0.853	0.875	0.0466	246.70
MAG	0.651 0.662 0.668	0.660	0.0084	227.33
LAS	0.850 0.861 0.921	0.877	0.0382	222.26
CCS	0.738 0.798 0.795	0.777	0.0338	219.02
Ethanol	0.560 0.526 0.528	0.538	0.0191	23.12

Based on the obtained TPC results (as can be seen in Figure 2), shows that the NADES combination type of CAG has a maximum yield of TPC (with a TPC value of 246.70 mg GAE/g sample) compared to other NADES combination types. But in general, it shows that the use of the NADES-MAE method is beneficial for extracting target secondary metabolites (mainly TPC) compared to conventional organic solvents.

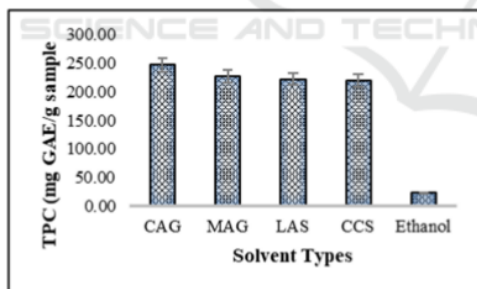


Figure 2: Efficiency extraction of TPC from *M. speciosa* leaves.

This research is the early step in developing an extraction method to obtain target secondary metabolites from *M. speciosa* leaves efficiently, easily, quickly, and safely. Furthermore, optimization of the NADES-MAE method will be carried out using the response surface methodology, identification of active secondary metabolites, and the scale-up extraction based on NADES-MAE.

4 CONCLUSIONS

According to the above results, the use of NADES-MAE method based on NADES combination type is beneficial to obtain TPC value compared with the other NADES combination type and conventional extraction method. The highest TPC value of 246.7; 227.33; 222.26; and 219.02 mg GAE/g sample was obtained by using citric acid-glucose (4:1 g/g); malic acid-glucose (1:2 g/g); lactic acid-sucrose (1:1 g/g), and choline chloride-sorbitol (1:2 g/g), respectively. This result was new data for the next study based on NADES-MAE methods efficiently, easily, quickly, and safely.

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REFERENCES

- Ahmad, A., Husain, A., Mujeeb, M., Khan, S. A., Alhadrami, H. A. A., Bhandari, A. 2015. Quantification of total phenol, flavonoid content and pharmacognostical evaluation including HPTLC fingerprinting for the standardization of *Piper nigrum* Linn fruits. *Asian Pacific Journal of Tropical Biomedicine*, 5(2), pp. 101–107.
- Ahmad, I., Yanuar, A., Mulia, K., Mun'im, A. 2017a. Extraction of polyphenolic content from *Peperomia pellucida* (L) Kunth herb with 1-ethyl-3-methylimidazolium bromide as a green solvent. *Indian Journal of Pharmaceutical Sciences*, 79(6), pp. 1013–1017.
- Ahmad, I., Yanuar, A., Mulia, K., Mun'im, A. 2017b. Optimization of ionic liquid-based microwave-assisted extraction of polyphenolic content from *Peperomia pellucida* (L) Kunth using response surface methodology. *Asian Pacific Journal of Tropical Biomedicine*, 7(7), pp. 660–665.
- Ahmad, I., Pertiwi, A.S., Kembaren, Y.H., Rahman, A., Mun'im, A. 2018. Application of natural deep eutectic solvent-based ultrasonic assisted extraction of total polyphenolic and caffeine content from Coffe Beans (*Coffea Beans* L.) for instant food products. *Journal of Applied Pharmaceutical Science*, 8(8), pp. 138–143.
- Alishlah, T., Mun'in, A., Jufri, M. 2019. Optimization of urea-glycerin based NADES-UAE for oxyresveratrol extraction from *Morus alba* roots for preparation of

- skin whitening lotion. *Journal of Young Pharmacist*, 11(2), pp. 155–160.
- Bobo-García, G., Davidov-Pardo, G., Arroqui, C., Marin-Arroyo, M. R., Navarro, M., Virseda, P. 2014. Intra-laboratory validation of microplate methods for total phenolic content and antioxidant activity on polyphenolic extracts, and comparison with conventional spectrophotometric methods. *Journal of Science Food and Agriculture*, 95(1), pp. 204–209.
- Brown, P. N., Lund, J. A., Murch, S. J. 2017. A botanical, phytochemical and ethnomedicinal review of the genus *Mitragyna korth*: Implications for products sold as kratom. *Journal of Ethnopharmacology*, 202, pp. 302–325.
- Chen, J., Jiang, X., Yang, Guolong, Bi, Y., Liu, W., 2018. Green and efficient extraction of resveratrol from peanut roots using deep eutectic solvents. *Journal of Chemistry*, 2018, pp. 1–10.
- Chittarakam, S., Penjamras, P., Keawpradub, N. 2012. Quantitative analysis of mitragynine, codeine, caffeine, chlorpheniramine and phenylephrine in a kratom (*Mitragyna speciosa* Korth.) cocktail using high-performance liquid chromatography. *Forensic Science International*, 217(1–3), pp. 81–86.
- Dai, Y., Rozema, E., Verpoorte, R., Choi, Y.H. 2016. Application of natural deep eutectic solvents to the extraction of anthocyanins from *Catharanthus roseus* with high extractability and stability replacing conventional organic solvents. *Journal of Chromatography A*, 1434, pp. 50–56.
- Do, Q. D., Angkawijaya, A. E., Tran-Nguyen, P. L., Huynh, L. H., Soetaredjo, F. E., Ismajli, S. 2014. Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of *Limnophila aromatica*. *Journal of Food and Drug Analysis*, 22(3), pp. 296–302.
- Fernández, M. Á., Espino, M., Gomez, F. J. V., Silva, M. F. 2017. Novel approaches mediated by tailor-made green solvents for the extraction of phenolic compounds from agro-food industrial by-products. *Food Chemistry*, 239, pp. 671–678.
- García, A., Rodríguez-Juan, E., Rodríguez-Gutiérrez, G., Rios, J. J., Fernández-Bolanos, J. 2016. Extraction of phenolic compounds from virgin olive oil by deep eutectic solvents (DESs). *Food Chemistry*, 197, pp. 554–561.
- Gomez, F. J. V., Espino, M. 2018. A greener approach to prepare natural deep eutectic solvents. *Analytical Chemistry*, 3, pp. 6122–6125.
- Hassan, Z., Muzaimi, M., Navaratnam, V., Yusoff, N. H. M., Suhaimi, F. W., Vadevelu, R., Vicknasingam, B. K., Amato, D., von Horsten, S., Ismail, N. I. W., Jayabalan, N., Hazim, A. I., Mansor, S. M., Muller, C. P. 2013. From Kratom to mitragynine and its derivatives: Physiological and behavioural effects related to use, abuse, and addiction. *Neuroscience and Biobehavioral Reviews*, 37, pp. 138–151.
- Henningfield, J. E., Fant, R. V., Wang, D. W. 2018. The abuse potential of kratom according to the 8 factors of the controlled substances act: implications for regulation and research. *Psychopharmacology*, pp. 573–589.
- Horie, S., Koyama, F., Takayama, H., Ishikawa, H., Aimi, N., Ponglux, D., Matsumoto, K., Murayama, T. 2005. Indole alkaloids of a Thai medicinal herb, *Mitragyna speciosa*, that has opioid agonistic effect in guinea-pig ileum. *Planta Medica*, 71(3), pp. 231–236.
- Luliana, S., Robiyanti, Islamy, M. R. 2018. Antinociceptive activity of dichloromethane fraction of Kratom leaves (*Mitragyna speciosa* Korth.) by oral route in male swiss mice. *Pharmaceutical Sciences and Research*, 5(2), 58–64.
- Mossadeq, W. M. S., Sulaiman, M. R., Tengku Mohamad, T. A., Chiong, H. S., Zakaria, Z. A., Jabit, M. L., Baharuldin, M. T. H., Israf, D. A. 2009. Anti-inflammatory and antinociceptive effects of *Mitragyna speciosa* Korth methanolic extract. *Medical Principles and Practice*, 18, 378–384.
- Pan, M., Zhao, G., Ding, C., Wu, B., Lian, Z., Lin, H. 2017. Physicochemical transformation of rice straw after pretreatment with a deep eutectic solvent of choline chloride/urea. *Carbohydrate Polymers*, 176(5), pp. 307–314.
- Parthasarathy, S., Azizi, J., Ramanathan, S., Ismail, S., Sasidharan, S., Mohd. Said, M.I., Mansor, S.M. 2009. Evaluation of antioxidant and antibacterial activities of aqueous, methanolic and alkaloid extract from *Mitragyna speciosa* (Rubiaceae Family) leaves, *Molecules*, 14, 3964–3974
- Saingam, D., Assanangkornchai, S., Geater, A. F., Balthip, Q. 2013. Pattern and consequences of kratom (*Mitragyna speciosa* Korth.) use among male villagers in southern Thailand: A qualitative study. *International Journal of Drug Policy*, 24(4), pp. 351–358.
- Savi, L. K., Dias, M. C. G. C., Carpine, D., Waszcynskij, N., Ribani, R. H., Haminiuk, C. W. I. 2018. Natural deep eutectic solvents (NADES) based on citric acid and sucrose as a potential green technology: a comprehensive study of water inclusion and its effect on thermal, physical and rheological properties. *International Journal of Food Science and Technology*, 54(3), pp. 898–907.
- Takayama, H. 2004. Chemistry and pharmacology of analgesic indole alkaloids from the rubiaceae plant, *Mitragyna speciosa*. *Chemical & pharmaceutical bulletin*, 52(8), pp. 916–928.
- Tohar, N., Shilpi, J. A., Sivasothy, Y., Ahmad, S., Awang, K. 2019. Chemical constituents and nitric oxide inhibitory activity of supercritical carbon dioxide extracts from *Mitragyna speciosa* leaves. *Arabian Journal of Chemistry*, 12(3) pp. 350–359.
- Wang, H., Ma, X., Cheng, Q, Xi, X., Zhang, L. 2018. Deep eutectic solvent-based microwave-assisted extraction of baicalin from *Scutellaria baicalensis* Georgi. *Journal of Chemistry*, 2018, pp. 1–10.
- Wei, W., Fu, Y.J., Zu, Y.G., Wang, W., Luo, M., Zhao, C.J., Li, C.Y., Zhang, L., Wei, Z.F. 2012. Ionic liquid-based microwave-assisted extraction for the determination of flavonoid glycosides in pigeon pea leaves by high-performance liquid chromatography-diode array

- detector with pentafluorophenyl column. *Journal of Separation Science*, 35(21), pp. 2875–2883.
- Wei, Z., Qi, X., Li, T., Luo, M., Wang, W., Zu, Y., Fu, Y.
15. Application of natural deep eutectic solvents for extraction and determination of phenolics in *Cajanus cajan* leaves by ultra performance liquid chromatography. *Separation and Purification Technology*, 149, pp. 237–244.
- Wei, Z. F., Wang, X. Q., Xiao, P., Wei, W., Zhao, C. J., Zu, Y. G., Fu, Y. J. 2015. Fast and green extraction and separation of main bioactive flavonoids from *Radix Scutellariae*. *Industrial Crops and Products*, 63, pp. 175–181.
- Yin-Leng, K., Suyin, G. 2019. Natural deep eutectic solvent (DES) as a greener alternative for the extraction of hydrophilic (Polar) and Lipophilic (Non-Polar) phytonutrients. *Key Engineering Materials*, 797, pp. 20–28.
- Yuniarti, E., Saputri, F. C., Mun'im, A. 2019. Application of the natural deep eutectic solvent choline chloride-sorbitol to extract chlorogenic acid and caffeine from green coffee beans (*Coffea canephora*). *Journal of Applied Pharmaceutical Science*, 9(03), pp. 82–90.

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29 www.jyoungpharm.org

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30 Kingsley C. Duru, ElenaG. Kovaleva, IrinaG. Danilova, AnnaV. Belousova. "Production and assessment of novel probiotic fermented oat flour enriched with isoflavones", LWT, 2019

Publication

31 jurnal.ugm.ac.id

Internet Source

32 Eman Shawky, Sarah S. Takla, Hala M. Hammada, Fikria A. Darwish. "Evaluation of the influence of green extraction solvents on the cytotoxic activities of *Crinum* (Amaryllidaceae) alkaloid extracts using in-vitro-in-silico approach", Journal of Ethnopharmacology, 2018

Publication

33 M. Elena Alañón, Milena Ivanović, Sandra Pimentel-Mora, Isabel Borrás-Linares et al. "A Novel sustainable approach for the extraction of

value-added compounds from hibiscus sabdariffa l. calyces by natural deep eutectic solvents", Food Research International, 2020

Publication

34

www.mdpi.com

Internet Source

<1%

35

Islamudin Ahmad, Neneng Silfi Siti Ambarwati, Muhammad Arifuddin, Laode Rijai, Abdul Mun'im. "Pharmacognostic and Cytotoxicity Evaluation of Indonesia Native Plant of Piper acre Blume Leaves (Piperaceae)", Pharmacognosy Journal, 2017

Publication

<1%

36

Nina Dewi Oktaviyanti, Kartini, Abdul Mun'im. "Application and optimization of ultrasound-assisted deep eutectic solvent for the extraction of new skin-lightening cosmetic materials from Ixora javanica flower", Heliyon, 2019

Publication

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37

Bharat Singh, Ram Avtar Sharma. "Secondary Metabolites of Medicinal Plants", Wiley, 2020

Publication

<1%

38

Alexandre Paiva, Rita Craveiro, Ivo Aroso, Marta Martins, Rui L. Reis, Ana Rita C. Duarte. "Natural Deep Eutectic Solvents – Solvents for the 21st Century", ACS Sustainable Chemistry & Engineering, 2014

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39

"Structure Characterization of Alkaloid Scorodocarpines Derivative from Fruits of Scorodocarpus borneensis Becc (Olacaceae)", Asian Journal of Chemistry, 2014.

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