Indonesian Journal of Cosmetic
E-ISSN: 3026-3352

Comparison of Extraction Methods for Green Betel Leaf (*Piper betle* L.) Based on Stock Solution Concentration

Herayati[1*], Amalia Lathifah widyadari[1], Deviana Safitri[1], Firlina Liovita[1]

1. Department of Cosmetic Engineering, Institut Teknologi Sumatera, Jl. Terusan Ryacudu, Way Huwi, Kec. Jati Agung, Kabupaten Lampung Selatan, Lampung 35365

***Corresponding Email: herayati@km.itera.ac.id**

ABSTRACT

Green betel leaf (Piper betle L.) is a medicinal plant widely recognized for its bioactive compounds, including flavonoids, alkaloids, tannins, saponins, and essential oils, which exhibit antimicrobial, antioxidant, and anti-inflammatory activities. The extraction method plays a crucial role in determining the efficiency of bioactive compound recovery from plant materials. This study aimed to compare several extraction methods for green betel leaf based on the concentration of the resulting stock solution as an indicator of extraction efficiency. Fresh green betel leaves were processed into dried simplicia and extracted using five different methods: maceration, partition and fractionation, digestion, ultrasonic-assisted extraction (UAE), and Soxhlet extraction. Methanol, n-hexane, and distilled water were used as extraction solvents according to the characteristics of each method. The concentration of each stock solution was calculated from the dry extract residue obtained after solvent evaporation. The results showed that UAE produced the highest stock solution concentration (2.4% w/v), followed by Soxhlet extraction (0.8% w/v), digestion (0.04% w/v), maceration (0.01% w/v), and partition and fractionation (0.0003% w/v). The superior performance of UAE was attributed to acoustic cavitation, which enhanced mass transfer while minimizing thermal degradation of heat-sensitive bioactive compounds. These findings demonstrate that UAE is the most effective extraction technique among the evaluated methods for obtaining bioactive compounds from green betel leaves and has considerable potential for developing natural cosmetic ingredients.

Key words: *Piper betle L.; extraction method; ultrasonic-assisted extraction; natural active ingredients.*

INTRODUCTION

Green betel (*Piper betle* L.) is one of the medicinal plants widely cultivated in Indonesia and has long been utilized in traditional medicine. The leaves contain various secondary metabolites, including flavonoids, alkaloids, tannins, saponins, and essential oils (Intan Aprilliani et al., 2025), which exhibit antioxidant, antimicrobial, anti-inflammatory, and wound-healing properties (MAULANI & NABABAN, 2022). Owing to these biological activities, green betel leaf has attracted increasing attention as a potential raw material for pharmaceutical, food, and cosmetic applications.

Phytochemical screening studies have consistently reported that green betel leaves contain several bioactive compounds responsible for their pharmacological activities. Flavonoids and phenolic compounds are recognized for their strong antioxidant activity, while essential oils and tannins contribute significantly to antimicrobial effects. Consequently, efficient extraction of these compounds is an essential step in maximizing the utilization of green betel leaves.

Extraction is a separation process that isolates bioactive compounds from plant matrices using appropriate solvents. The effectiveness of extraction depends on several factors, including solvent polarity, extraction time, temperature, extraction technique, and the physicochemical properties of the target compounds. Various conventional and modern extraction methods have been developed to improve extraction efficiency while preserving the stability of heat-sensitive phytochemicals.

Conventional techniques such as maceration, digestion, and Soxhlet extraction are widely employed because of their simplicity and relatively low equipment costs. However, these methods often require prolonged extraction times and large solvent volumes, and in some cases involve elevated temperatures that may degrade thermolabile compounds. In contrast, modern techniques such as Ultrasonic-Assisted Extraction (UAE) utilize acoustic cavitation to disrupt plant cell walls, thereby enhancing solvent penetration and mass transfer while reducing extraction time and energy consumption.

Numerous studies have compared extraction methods for medicinal plants, demonstrating that UAE frequently provides higher extraction efficiency and better preservation of bioactive compounds than conventional techniques. Nevertheless, comparative evaluations involving multiple extraction methods applied to green betel leaves under similar experimental conditions remain limited. Furthermore, studies that compare extraction performance using stock solution concentration as a practical indicator of extraction efficiency are still scarce.

This study addresses this gap by comparatively evaluating five extraction methods—maceration, partition and fractionation, digestion, ultrasonic-assisted extraction, and Soxhlet extraction—for green betel leaves using stock solution concentration as the extraction efficiency indicator. The findings provide fundamental information for selecting an appropriate extraction method to obtain bioactive compounds from green betel leaves and support their utilization as natural ingredients in cosmetic formulations.

MATERIAL AND METHODS

2.1. Materials and Equipment

Fresh green betel leaves (*Piper betle* L.) were collected from local cultivation areas in Bandar Lampung, Indonesia. The chemicals used in this study included distilled water, 96% methanol, 99.9% methanol, 99% *n*-hexane, and Whatman filter paper (12.5 cm diameter). All chemicals were of analytical grade and used without further purification.

The equipment used in this study included beakers, graduated cylinders, measuring pipettes, volumetric flasks, glass funnels, watch glasses, separating funnels, ring stands and clamps, magnetic hotplate stirrer, ultrasonic bath (60 kHz), Erlenmeyer flasks, Soxhlet extraction apparatus, condenser, round-bottom flask, boiling stones, nylon thread, analytical balance, grinder, chopper, and glass sample vials.

2.2. Preparation of Plant Material

Fresh green betel leaves were harvested and subjected to wet sorting to remove dirt and foreign materials. The selected leaves were washed thoroughly under running water and drained before being cut into small pieces. The samples were then dried at room temperature for one week. During the drying process, the leaves were sprayed daily with ethanol to minimize fungal contamination. After drying, the plant material underwent dry sorting to remove impurities and damaged samples. The dried leaves were subsequently ground into powder using a grinder and sieved to obtain homogeneous simplicia powder. The powdered samples were packed in labeled plastic bags and stored at room temperature until extraction.

2.3. Maceration Extraction

Five grams of powdered green betel leaf were immersed in 50 mL of methanol (solid-to-solvent ratio of 1:10, w/v) and extracted by maceration for 60 min at room temperature. The mixture was filtered using Whatman filter paper (12.5 cm). One milliliter of the filtrate was transferred onto a watch glass and evaporated to dryness on a hotplate. The dry residue was weighed and used to calculate the stock solution concentration.

2.4. Liquid–Liquid Partition with n-Hexane

Fifty milliliters of methanolic extract obtained from the maceration process were transferred into a separatory funnel and mixed with an equal volume (50 mL) of *n*-hexane. The mixture was shaken for approximately 20 min with periodic venting to release internal pressure. After phase separation, two distinct layers were formed. The upper *n*-hexane layer contained non-polar compounds, while the lower methanol layer contained more polar constituents. The methanol fraction was collected for further analysis.

2.5. Digestion Extraction

Five grams of powdered simplicia were mixed with 50 mL of distilled water and heated at 60°C using a magnetic hotplate stirrer for 60 min. The mixture was subsequently filtered, and 1 mL of the filtrate was evaporated to dryness. The resulting residue was weighed to determine the stock solution concentration.

2.6. Ultrasound-Assisted Extraction

Five grams of powdered green betel leaves were mixed with 50 mL of methanol (1:10, w/v) in a 100 mL Erlenmeyer flask. The mixture was extracted using an ultrasonic bath operating at 60 kHz for 60 min. After sonication, the extract was filtered through Whatman filter paper. The filtrate was subjected to organoleptic evaluation, and the stock solution concentration was subsequently determined.

2.7. Soxhlet Extraction

Five grams of powdered simplicia were wrapped in filter paper to form an extraction thimble and placed inside a Soxhlet extractor. A total of 150 mL of 96% methanol was added to a round-bottom flask together with boiling stones. The extraction was performed for 2 h under the boiling temperature of methanol. Following extraction, the filtrate was collected for organoleptic observation and stock solution concentration analysis.

RESULT AND DISCUSSION

Piper betle L. is recognized as one of the most valuable medicinal plants worldwide due to its high nutritional value and diverse phytochemical constituents present in its leaves, pods, and seeds. The leaves contain various bioactive compounds, including alkaloids, flavonoids, saponins, and tannins, which have been reported to exhibit antimicrobial activity and contribute to the plant's pharmacological potential (MAULANI & NABABAN, 2022).

Previous phytochemical screening studies have demonstrated that *Piper betle* L. leaf simplicia contains flavonoids, tannins, and saponins in both purified and unpurified extracts. Similarly, phytochemical identification of *Piper betle* L.leaf extracts has confirmed the presence of flavonoids, saponins, tannins, terpenoids, and alkaloids (Intan Aprilliani et al., 2025). These findings indicate that an appropriate extraction process is essential for recovering these valuable bioactive constituents.

To evaluate the effectiveness of different extraction techniques, *Piper betle* L. leaves were extracted using five methods: maceration, liquid–liquid partition and fractionation, digestion, ultrasound-assisted extraction (UAE), and Soxhlet extraction. The extraction process aims to isolate one or more target compounds from plant materials using an appropriate solvent (Kartika et al., 2024). The concentrations of the resulting stock solutions obtained from each extraction method are presented in Figure 1.

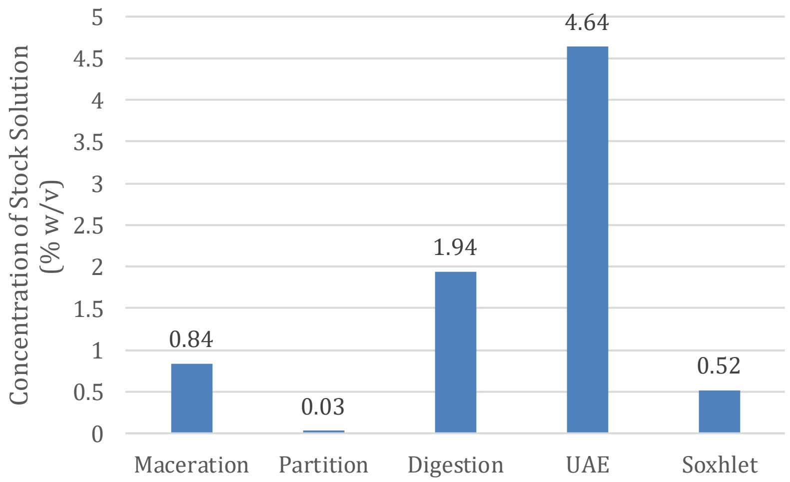

Figure 1 Comparison of extract concentrations obtained using different extraction methods

As shown in Figure 1, ultrasound-assisted extraction (UAE) produced the highest extract concentration (4.64% w/v), followed by digestion (1.94% w/v). UAE employs ultrasonic waves ranging from 20 to 2000 kHz to enhance mass transfer between the solvent and plant matrix (Triyastuti & Djaeni, 2019). The superior extraction efficiency of UAE can be attributed to the cavitation effect, which disrupts plant cell walls and facilitates the release of intracellular metabolites while operating at relatively low temperatures. Consequently, thermal degradation of heat-sensitive bioactive compounds is minimized, leading to improved extract quality.

The choice of solvent also plays a critical role in determining extraction efficiency. Maceration using methanol produced a relatively low extract concentration (0.84% w/v). Methanol has been widely employed for extracting flavonoids from plant leaves because of its high polarity and its ability to dissolve a broad range of organic compounds. In addition, methanol is volatile, making it easy to remove after extraction. Nevertheless, the passive diffusion mechanism of maceration limits extraction efficiency compared with assisted extraction techniques.

Liquid–liquid partitioning using *n*-hexane resulted in the lowest concentration (0.03% w/v). This outcome is expected because *n*-hexane is a non-polar solvent primarily used to extract lipophilic compounds. Polar phytochemicals such as flavonoids and phenolic compounds exhibit poor solubility in *n*-hexane and therefore remain predominantly in the polar fraction. Similar findings have been reported for *Syzygium aromaticum*, where the *n*-hexane fraction contained lower flavonoid levels than the ethyl acetate and aqueous fractions(Wahyulianingsih et al., 2016).

Soxhlet extraction with 96% methanol produced a relatively high extract concentration (0.52% w/v). Continuous solvent reflux enhances extraction efficiency by repeatedly exposing the plant material to fresh solvent. However, prolonged extraction at the boiling point of methanol may lead to degradation of thermosensitive phytochemicals, making Soxhlet extraction less favorable for preserving certain bioactive compounds than UAE.

Among the five extraction techniques evaluated, ultrasound-assisted extraction demonstrated the highest extraction efficiency for *Piper betle* L. leaves. In addition to yielding the highest extract concentration, UAE offers several advantages, including reduced solvent consumption, shorter extraction time, enhanced extraction efficiency, and improved selectivity compared with conventional extraction methods. These findings are consistent with previous reports highlighting UAE as an effective and sustainable extraction technology for recovering plant-derived bioactive compounds (Oprescu et al., 2022). Overall, the results suggest that UAE is a promising extraction method for obtaining bioactive compounds from *M. oleifera* leaves for potential pharmaceutical, nutraceutical, and cosmetic applications.

CONCLUSION

This study evaluated the effectiveness of different extraction methods for obtaining extracts from *Piper betle L.* L. leaves, which are recognized as a promising source of phytochemicals for cosmetic applications. Five extraction techniques, namely maceration, liquid–liquid partition and fractionation, digestion, ultrasound-assisted extraction (UAE), and Soxhlet extraction, were compared based on the concentration of the resulting extracts.

Among the evaluated methods, UAE produced the highest extract concentration (**4.64% w/v**), followed by digestion (**1.94% w/v**), while maceration, soxhletation, and liquid–liquid partition yielded considerably lower concentrations. The higher extraction efficiency observed for UAE may be attributed to the cavitation effect generated by ultrasonic waves, which enhances solvent penetration and mass transfer while operating at relatively low temperatures, thereby minimizing thermal degradation during extraction. Overall, the results indicate that the extraction method has a significant influence on extract yield. Under the conditions employed in this study, UAE proved to be the most effective technique for extracting *Piper betle* L.leaves. These findings provide a useful basis for selecting suitable extraction methods in the preparation of plant extracts for further phytochemical characterization and the development of natural cosmetic ingredients.

REFERENCES

Intan Aprilliani, Livia Syafnir, & Gita Cahya Eka Darma. (2025). Skrining Fitokimia Daun Sirih Hijau (Piper betle L.). *Bandung Conference Series: Pharmacy*, *5*(2). https://doi.org/10.29313/bcsp.v5i2.20726

Kartika, M., Ghozaly, R. M., & Mahayasih, G. P. dan. (2024). Pengaruh Metode Ekstraksi Ultrasonic-Assisted Extraction (UAE) terhadap Kadar Flavonoid Total dan Aktivitas Antioksidan Ekstrak Etanol Daun Kecombrang (Etlingera elatior (Jack.) R. M. Smith). *Archives Pharmacia*, *6*(2).

MAULANI, N., & NABABAN, L. (2022). PENGARUH KOMPRES DAUN SIRIH HIJAU (PIPER BETLE L) TERHADAP PENURUNAN PEMBENGKAKKAN PAYUDARA PADA IBU PASCA SEKSIO SESAREA

DI WILAYAH PUSKESMAS JALAN GEDANG. *Journal Of Midwifery*, *10*(1). https://doi.org/10.37676/jm.v10i1.2315

Oprescu, E. E., Enascuta, C. E., Radu, E., Ciltea-Udrescu, M., & Lavric, V. (2022). Does the ultrasonic field improve the extraction productivity compared to classical methods – Maceration and reflux distillation? *Chemical Engineering and Processing - Process Intensification*, *179*. https://doi.org/10.1016/j.cep.2022.109082

Triyastuti, M. S., & Djaeni, M. (2019). Perbaikan Proses Produksi Antosianin dari Kelopak Bunga Rosella dengan Ekstraksi Berbantuan Ultrasound. *TEKNIK*, *40*(2). https://doi.org/10.14710/teknik.v39i3.23258

Wahyulianingsih, W., Handayani, S., & Malik, Abd. (2016). PENETAPAN KADAR FLAVONOID TOTAL EKSTRAK DAUN CENGKEH (Syzygium aromaticum (L.) Merr & Perry). *Jurnal Fitofarmaka Indonesia*, *3*(2). https://doi.org/10.33096/jffi.v3i2.221