International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-10, Issue-10; Oct, 2023
Journal Home Page Available: https://ijaers.com/
Article DOI:https://dx.doi.org/10.22161/ijaers.1010.14

Essential Oil from Extraction of Pepper Leaves (*Piper Nigrum L.*) using Microwaves

Yuli Patmawati[1,2], Khairuddin Karim[2,3]

[1]Department of Chemical Engineering, Politeknik Negeri Samarinda, Indonesia
[2]Razak Faculty of Technology and Informatic, Universiti Teknologi Malaysia, Malaysia
[3]Department of Electrical Engineering, Politeknik Negeri Samarinda, Indonesia

Received: 21 Aug 2023,

Receive in revised form: 10 Oct 2023,

Accepted: 18 Oct 2023,

Available online: 30 Oct 2023

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***Keywords*— extraction, microwaves, pepper leaves, yield**

***Abstract*—** *Pepper plants are a commodity with high economic value. However, the problem is that pepper leaves are not widely used. When pruning for rejuvenation, 75% of pepper leaves are just thrown away. To overcome this problem, it is necessary to use and process pepper leaves into essential of pepper oil. One method of extracting essential pepper oil is a microwave-assisted extraction process. The aim of this research was to investigate the effect of extraction time on the yield of essential oil derived from pepper leaves. Pepper leaves that are wilted for 7 days are chopped to ± 1-2 cm, carry out extraction using a microwave using 200 ml water as a solvent, for 60, 90, 120, 150, 180 and 210 minutes. The research results showed that the optimum yield of essential pepper oil was obtained of 0.5937% at 180 minutes extraction process. The characteristic of essential oil derived from pepper leaves were obtained: a specific gravity of 0.8710, a refractive index of 1.4873 and an acid number of* 0.3809 *mg KOH/g.*

I. INTRODUCTION

The pepper plant (*Piper Nigrum L.)* is a spice plant that produces a spicy taste and distinctive aroma. Pepper plants can produce essential oil called pepper oil. Pepper plants can grow well in tropical areas with an altitude of 10 – 500 meters above sea level and temperatures ranging from 25 – 26.5 °C. One of the peppers producing areas is in East Kalimantan. In 2017, the pepper plantation area was 54.52 ha (Perkebunan, 2020).

Pepper plants have high potential to be utilized and processed into essential oils so that they will provide added value for pepper farmers. Moreover, the price of pepper essential oil is more stable than the price of pepper seeds. Pepper leaves contain several essential oils which are one of the organic compounds found in nature and come from plant tissue. Essential oils are one of the volatile secondary metabolite compounds and are not pure compounds but are composed of several components, the majority of which come from the terpenoid group. According to (Mulyati et al., 2015), essential oil from pepper leaves contains six main compounds, namely δ-Element 19.39%, Spatulenol 11.7%, γ-Element 10.59%, β-Selinen 6.82%, β- Elements 5.05%, and Caryophyllene 4.27%.

Pepper leaf oil is widely used as an aroma and flavor agent in various food industries. Apart from that, pepper oil is also used in the pharmaceutical and cosmetics industries. The very strong activity of pepper leaf oil can cause death to termites (Mulyati et al., 2015).

There exist multiple techniques that can be employed for the extraction of essential oils. Traditional techniques such as hydrodistillation (HD), solvent extraction, and soxlet extraction have been commonly employed. However, these methods suffer from several drawbacks, including prolonged extraction procedures, inefficiency, excessive energy consumption, and the use of potentially hazardous solvents (T. Liu et al., 2011). Hence, it is imperative to incorporate innovation into the extraction process to enhance its efficiency and minimize its environmental

impact. Notable examples of innovative extraction techniques include solvent-free microwave extraction (Boukhatem et al., 2022), ultrasound-assisted extraction (Alasalvar & Yildirim, 2021), microwave-assisted hydrodistillation (Jeyaratnam et al., 2016) and microwave-assisted extraction (Martínez-Abad et al., 2020).

Microwave technology is a lates extraction strategy, which could increase the yield of essential oils (Bagade & Patil, 2021). Microwave technology has been increasingly popular in comparison to conventional extraction methods. This can be attributed to its rapid energy transfer, high extraction rate, efficient performance, low energy consumption, and environmentally friendly nature (B. Liu et al., 2018).

This study aimed to extract the essential oil from pepper leaves using microwave-assisted extraction, with the goal of expediting the extraction process and so increasing the yield of essential oils. The study focused on examining the extraction findings and analyzing the physical properties of the essential oil using gas chromatography-mass spectrometry (GC-MS). The response variable used to identify the optimum extraction procedure was the yield of essential oil. The objective of this study was to investigate the impact of varying extraction durations on the overall yield of essential oil derived from pepper leaves.

II. METHODOLOGY

1.1 Material

The raw material used in this research was pepper leaves which came from plantations in the Loa Janan District, Kutai Kartanegara Regency, East Kalimantan.

2.2 Extraction of the essential oil from pepper leaves

Two hundred grams of pepper leaves that are wilted for 7 days are chopped to ± 1-2 cm, added together with 200 ml distilled water into the distillation flask and placed it in the microwave. The extraction process was carried out using a microwave with certain time variations (60, 90, 120, 150, 180, 210 minutes) and running water through a condenser. Extraction time is calculated from the first drop coming out of the condenser. The extract is collected, the essential oil is separated from the water using a separating funnel, then the essential oil is collected in a dark colored and closed sample bottle, stored in a freezer (temperature 0^{o}C) to obtain the essential oil that is free from water for further analysis.

III. RESULT AND DISCUSSION

1.2 The characteristic of the pepper leaves essential oil

The essential oil was derived from the extraction process of pepper leaves using the microwave-assisted extraction method. The duration of the extraction process is presented in Table 1.

Table.1: The characteristic of pepper leaves essential oil

Time (min)	Yield (%)	s.g (25°C)	Refractive Index (brix)	Acid Number (mg/g)
60	0.2399	0.8735	1.4842	0.4790
90	0.4087	0.8651	1.4864	0.3799
120	0.5172	0.8834	1.4523	0.4782
150	0.5763	0.8805	1.4923	0.4803
180	0.5937	0.8710	1.4873	0.3809
210	0.5947	0.8635	1.4875	0.4751
ISO 3061: 2008	-	0.861-0.885	1.480-1.493	Max 1.1

There are several parameters that are usually used as standards to identify the quality of essential oils, such as specific gravity (s.g), refractive index and acid number. Specific gravity is one of the criteria in determining the purity of pepper leaf essential oil. According to the ISO 3061:2008 standard, the specific gravity value of pepper oil (*Piper nigrum L.*) is 0.861 – 0.885. From the results obtained in Table 1, can be seen that the specific gravity of pepper leaf essential oil in the time variation of 60 minutes to 210 minutes has fulfilled ISO 3061:2008, namely with a value of 0.8635–0.8834. Likewise, the refractive index and acid number values obtained from the pepper leaves extraction process by assisted microwave with various of time was fullfilled the ISO 3061:2008 standard.

1.3 The effect of extraction time on the yield of essential oil derived from pepper leaves.

Fig.1 shows that the yield of pepper leaf essential oil increased over time. The longer the extraction time, the yield of essential oil increases until at 180 minutes the yield was obtained tends to be constant as seen in Fig. 1. It is due to the solvent's ability to extract oil from the pepper leaves has reached its maximum condition so that it can no longer increase the yield. The optimum yield was ontained in this research of 0.5937% at 180 minutes of extraction time process.

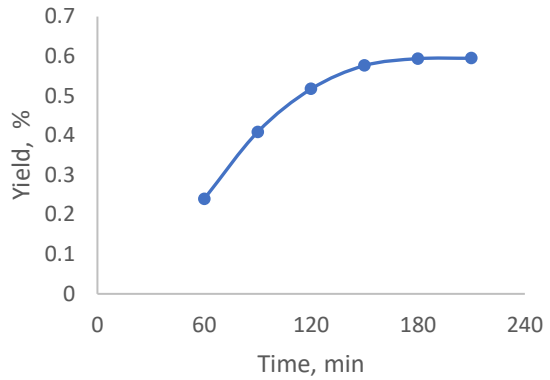

Fig. 1: The effect of extraction time on the yield of essential oil of pepper leaves

1.4 The effect of various extraction techniques on the quantity of essential oils obtained

As depicted in Fig. 2, the utilization of the alternative extraction technique resulted in a superior yield of essential oil compared to the standard extraction method, while also drastically reducing the extraction time.

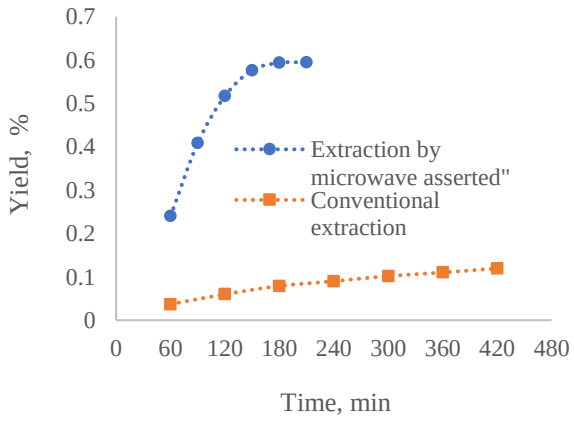

Fig. 2: The comperation of extraction by microwave-assisted extraction and conventional method on the yield of essential oil of pepper leaves.

Based on the Fig. 2 can be seen that with the microwave assisted method, the yield obtained is greater than the conventional method. The optimum yield obtained with the microwave method was 0.5937%, while with the conventional method the yield obtained was only 0.1195%. The extraction time required for the microwave assisted method to produce optimum yield was 180 minutes (3 hours), whereas for the conventional method the time required is 7 hours. Microwave power is a heating method that operates at a moderate level, facilitating the quick increase in temperature and inducing vibrations in the molecules of the reagent. This energy input can effectively contribute to the process of dissolving pepper leaves cellulose. Therefore, the magnitude of microwave power plays a pivotal role in determining the quantity of essential oils produced. The use of increased microwave energy has the potential to cause the rupture of pepper leaves cells, resulting in excessive release of the mixture, hence impeding the collection of substantial quantities of volatile components.

IV. CONCLUSION

The optimum yield was obtained using a microwave-assisted extraction pepper leaf of 0.5937% at 180 minutes extraction time. The characteristic of essential oil derived from pepper leaves were obtained: a specific gravity of 0.8710, a refractive index of 1.4873 and an acid number of 0.3809 mg KOH/g.

ACKNOWLEDGEMENTS

The authors thank the Chemical Engineering Department, Politeknik Negeri Samarinda, Indonesia, and the Research & Development Department of Politeknik Negeri Samarinda for facilitating the study. The authors also thank Chemical Engineering Laboratory, for instrumental support during the sample characterization and analysis.

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