

# The Extraction of White Ginger by Using Microwave Ultrasonic Steam Diffusion Method as the Essential Oil Substance

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**Abstract.** Zingiberene oil (C<sub>15</sub>H<sub>24</sub>) is one of diversification products which has a high level of economic values. However, the rate of export number toward the export number has just recently attained 0,3% . Moreover the number of ginger oil as the export product does not fulfill the export standart, such as the Essential Oil Association of USA (EOA). This condition happens since the Hydro Distillation is applied as one of the method in refining process. Nevertheless, this method is considered the best method in refining process although it takes more time to gain the result of the refining process. Another extraction process is called as Microwave Distillation and Simultaneous Solid-Phase Microextraction (MDSS-PM). By applying this method, the total time estimation is reduced significantly, but the final result in refining process is not as good as by applying Hydro Distillation. This research applies Microwave Distillation as the extraction process of white ginger. Furthermore, this kinds of method is modified in such a way by adding optical ultrasonic (MUSDf). The variable used in this research is Steam Diffusion (SDf), Microwave Extraction (ME), Microwave Steam Diffusion (MSDf), Microwave Ultrasonic Steam Diffusion (MUSDf). Moreover, this result takes 30, 50, 70, 90 and 110 minutes. Furthermore, the extraction temperature is 90, 95, 100 dan 105°C. The final research shows that MUSDf is considered the best method in extracting the ginger oil with the yield result about 0,952% and zingiberene 6,38%. Hence, the total price for each essential oil costs Rp 17.964 by gaining 100°C of the optimum extraction temperature.

## INTRODUCTION

Processing ginger becomes essential oil makes a high level of economic values for ginger plants. The specific aroma of ginger is predominantly related to zingiberene. Therefore, it takes an appropriate of extraction method to produce ginger oil with a good quantity and quality.

According to (Yu, Huang, Yang, Liu, & Duan, 2007), an efficient method in the extraction process is *Microwave Distillation and Simultaneous Solid-Phase Microextraction* (MDSS-PM). The advantages of this method are short extraction times and don't need for organic solvent, but the application of this method is limited. While (Sansan, Shuangming, Xiu, & Xiao, 2012) in patent CN102676299A, doing the research about the extraction of lavender using Ultrasonic Steam Extraction (USE) method. The result is USE method can produces more amounts of extract lavender than conventional distillation method and has a short extraction times, but energy consumption required is relatively large.

Thus, in this study auxiliary techniques as Ultrasonic Steam Extraction and *Microwave Distillation and Simultaneous Solid-Phase Microextraction* have been innovated a new method called Microwave Ultrasonic Steam Diffusion (MUSDf) in order to enhance extraction performances.

## MATERIALS AND METHODS

### Materials and Design of Equipment

In this study, materials used are dried gingers (moisture content was 10%) and water. For the equipment used in this study are ultrasonic scaler, steam generator, and microwave. Ultrasonic scaler with a frequency at  $30 \pm 3$  kHz, and output power 3-30 watt. Steam generator power is 1800 watt and microwave power is 450 watt. MUSDF method illustrated in Figure 1.

### Extraction Process

Ginger rhizome was pre-treated by cleaning its rhizome and dried at 80°C for 13 hours (moisture content was 6.7%). The raw material was 70 grams of dried ginger and the solvent was 500 mL of aquadest. Extraction of ginger was done by maceration for *Steam Diffusion* (SDf), *Microwave Extraction* (ME), *Microwave Steam Diffusion* (MSDf) for 30 minutes. In maceration process for the *Microwave Ultrasonic Steam Diffusion* (MUSDF) is added an ultrasonic wave for 30 minutes. After that, the extraction method of SDf, ME, MSDf, and MUSDF was performed using variation extraction time which are 30, 50, 70, 90 and 110 minutes. Then, continued with yield tests and equivalent relative amounts of zingiberene in ginger essential oil.

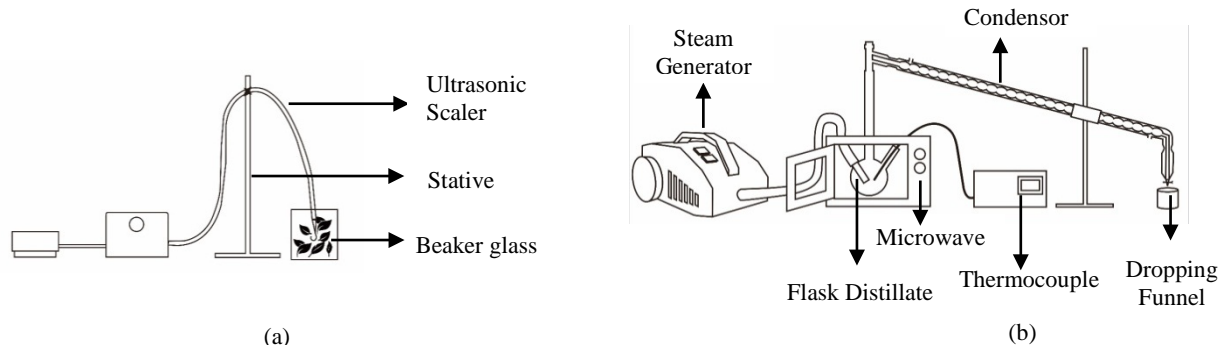


FIGURE 1. Schematic of (a) Ultrasonic Extraction and (b) Microwave Steam Diffusion Methods

## RESULT AND DISCUSSION

### Effect of SDf, ME, MSDf, and MUSDF Methods to Ginger Oil Yield

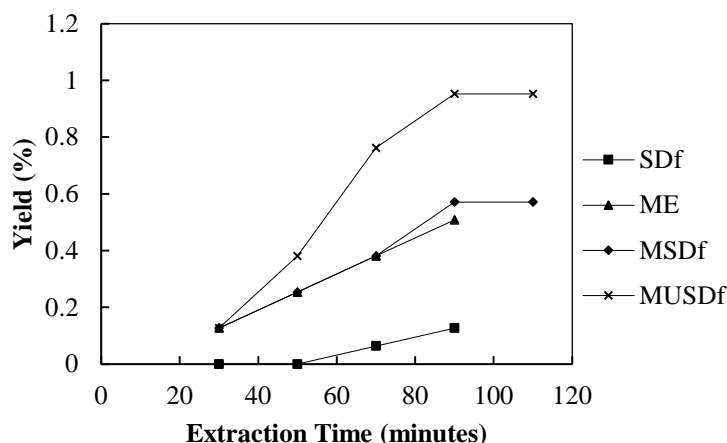
This researches involves the extraction methods of ginger oil by using four methods, they are *Steam Diffusion* (SDf), *Microwave Extraction* (ME), *Microwave Steam Diffusion* (MSDf), and *Microwave Ultrasonic Steam Diffusion* (MUSDF) in variable of time extraction about 30, 50, 70, 90, and 110 minutes.

*Steam Diffusion* (SDf) methods is a conventional extraction method with heater by steam which produced by steam generator. This method used for extracted bioactive components. ME method is a extraction method that developed and applied to volatile and active compound in plant that use micro wave energy. Furthermore, MSDf method that used the microwave as heater. In order to micro wave that fuction as heater with equitable distribution, combined by steam also use for this method. The combination between micro wave with steam can help the release of the compound essential oil that trapped in a plant cell. MUSDF method is doing by the same process with MSDf method however at the maceration process added ultrasonic wave simultaneously. By applying SDf, ME, MSDf, and MUSDF methods, the process of extraction can be seen in Table 1.

**TABLE 1.** Yield of Ginger Oil by Using Sdf, ME, MSDf, and MUSDf Methods

Extraction Time (minutes)	Yield (%)			
	Sdf	ME	MSDf	MUSDf
30	0	0,127	0,127	0,127
50	0	0,254	0,254	0,381
70	0,0635	0,381	0,381	0,762
90	0,127	0,508	0,571	0,952
110	-	-	0,571	0,952

In Table 1. is shown that extraction process of ginger oil during 90 minutes using Sdf, ME, MSDf, and MUSDf methods, each of them produces yield about 0,127%, 0,508%, 0,571%, and 0,952%. The quality of extraction method can be seen in Fig 2.

**FIGURE 2.** The Yield of Ginger Oil by Using Sdf, ME, MSDf, and MUSDf methods in Variable of Time Extraction

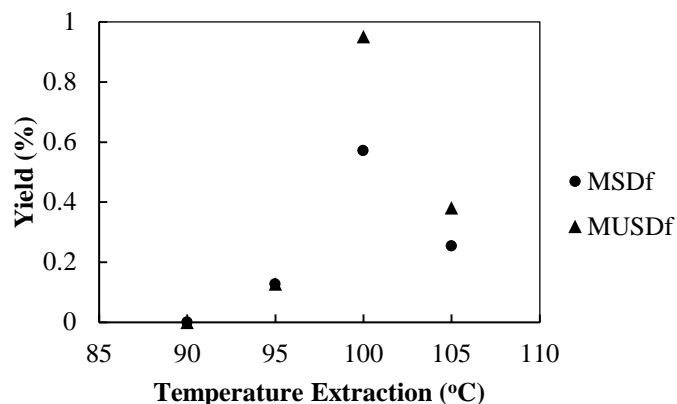
Based on Figure 2. can be known that extraction methods using microwave as heater is produces a good quality of yield than conventional extraction (Sdf). It is caused by the synergy combination of the two transfer phenomena mass and heat acting. For microwave extraction, the two transport phenomena are in the same direction from the inside to the outside, which facilitates oil diffusion from the inside of the ginger to the outside.

MUSDf method produces the highest oil yield compared to the other three methods. Furthermore, if the MUSDf method compared with MSDf method will produces the highest yield about 0,952% and 0,571%. The results explain that MUSDf method have the highest yield compared MSDf method at the same time.

The increasing yield on the MUSDf method caused by addition of ultrasonic wave in maceration process. Ultrasonic power in the chemical process is not directly contact with substrate sample, but through the liquid media. Ultrasound wave resulting from electrical power (through transducer), continued by the liquid media to the substrate sample through cavitation phenomena. Ultrasonic cavitation creates shear forces that break cell walls mechanically and improve material transfer. This effect is being used in the extraction of liquid compounds from solid cells. That explanation is appropriate with the research by (Khan, Abert-Vian, Fabiano-Tixier, Dangles, & Chemat, 2010) about extraction of polyphenols from orange peel by using Ultrasound-assisted Extraction. The result showed that the extraction of bioactive compounds under ultrasound irradiation is one of the upcoming extraction techniques that can offer high reproducibility in shorter times.

### Effect of Extraction Time to Ginger Oil by Using MSDf and MUSDf Methods

For the process extraction by using MSDf and MUSDf methods have been explained in Materials and Method Subbab in variable of temperature extraction about 90, 95, 100, dan 105°C during 90 minutes. By applying variable of temperature extraction in MSDf and MUSDf methods, the result can be seen in Figure 3.



**FIGURE 3.** The Yield of Ginger Oil by Using MSDf and MUSDF methods in Variable of Temperature Extraction

Based on Figure 3. can be known that for 90°C is produces about 0% of ginger oil's yield by using MSDf and MUSDF method. For the MSDf and MUSDF methods of ginger extraction with 95°C is produces about 0,127% and 0,254% of ginger oil's yield. For the MSDf and MUSDF methods of ginger extraction with 100°C is produces about 0,571% and 0,952% of ginger oil's yield. For the MSDf and MUSDF methods of ginger extraction with 105°C is produces about 0,254% and 0,381% of ginger oil's yield. The result shows that the temperature extraction which produces the optimum yield of ginger oil by using MSDf and MUSDF methods is 100°C.

### Analysis of Ginger Oil's Quality by Using MSDf and MUSDF Methods

Ginger oil's quality is determined by various parameter, one is increased zingiberene value in ginger oil. Its composition was determined using GC-MS (*Gass Chromatography Mass Spectrometry*) test. The GC-MS test result can be seen in Table 2.

**TABLE 2.** GC-MS Test Result of Components in Ginger Oil by Using MSDf and MUSDF Methods

No.	Components	Value (%)	
		MSDf	MUSDF
1	Zingiberene	8,93	6,38
2	Curcumene	26,25	21,31
3	$\beta$ -Bisabolene	7,72	8,59
4	$\beta$ -Sesquiphellandrene	7,92	9,42
5	Borneol	4,03	5,94
Identified Components		45	62

Based on the GC-MS test result in Table 2 showed that the zingiberene value in the ginger oil extracted has a different percentage amounts by using MSDf about 8,93% and MUSDF about 6,38%. This result showed decrease zingiberene value amount in ginger oil  $\pm$  2%. Thus, ultrasonic irradiation accelerate the oxidation zingiberene's process. If the oxidation process were continuous over time. Moreover, ultrasonic irradiation caused extreme conditions that cause degradation of chemical compounds.

### Energy Consumption and Cost Analysis by Using MSDf and MUSDF Methods

Energy consumption and costs during the extraction process is also important to know besides yield and zingiberene value. Comparison of energy consumption and costs either MSDf and MUSDF methods showed in Table 3.

**TABEL 3.** Energy Consumption and Cost Required in MSDf and MUSDf Methods

Parameter	Method	
	MSDf	MUSDf
Extraction Time (minutes)	110	110
Yield (%)	0,571	0,952
Input Power (Watt)	2050	2070
Energy (kWh)	3,075	3,105
Cost (Rp/gr ginger oil)	32.400	19.500

Table 3 shows that MUSDf method gave the minimum energy and low cost than MSDf method at the same time of extraction. The energy consumption to perform the two extraction methods are 3,105 kWh for MUSDf and 3,075 kWh for MSDf method. From that explained, the cost required for 1 gram of ginger oil by using MUSDf and MSDf methods are Rp 19.500 and Rp 32.400.

From the explained showed that the energy consumption of MUSDf method is more efficient 66% than the MSDf. This further confirms that MUSDf better in terms of yield and cost rather than MSDf. Furthermore, the cost required for 1 gram of ginger oil by using MUSDf method is also cheaper than ginger oil in market about Rp 19.500 and Rp 56.300.

## CONCLUSION

The result showed that MUSDf is the best methods in terms of ginger oil's yield about 0,952% with zingiberene value about 6,83%. This method is more efficient 66% for energy consumption and cost required for 1 gram of ginger oil about Rp 19.500.

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