Extraction of Garlic Oil using Microwave Ultrasonic Assisted Extraction Method

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Abstract: Garlic production depends on the garlic harvest season, which triggers prices to fluctuate. Furthermore, peeling garlic can cause a burning sensation on our hands caused by Alliin substance. Extraction of natural materials conventionally takes a long time, and thus, we need a faster method that is by using Microwaves-Assisted Extraction (MAE) and Microwaves-Assisted Ultrasonic Extraction (MUAE) methods. Garlic slices were mixed with 96% ethanol and put into an extraction flask. The maceration process lasted 30 minutes before being put into the microwaves. The same treatment was carried out on the MUAE method by adding ultrasonic waves. Extraction time lasted from 30 minutes to 240 minutes. The results of the research show that the best method obtained was MUAE with an optimum yield of 14,09% for 150 minutes, organosulfur levels of 22,95%, and could reduce energy consumption to 65%.

1 INTRODUCTION

Garlic (Allium sativum) is used in most Indonesian cuisine. The Ministry of Agriculture's self-sufficiency roadmap in 2017 showed the estimated production in 2018 increased by 199,565 tons and estimated production in 2019 by 603,281 tons (Kementrian Pertanian, 2017). The abundance of garlic production causes the selling price to be quite low at only Rp. 18,000/kg. While out of the harvest season, the price can reach Rp. 58,000/kg. The fluctuating prices cause farmers to lose, especially garlic, which cannot be stored for a long time. Besides that, peeling garlic for too long will cause a hot sensation on hands caused by the organosulfur content (allicin) in garlic, and it's also time-consuming when cooking (Hernawan, 2003). Therefore, it is necessary to innovate the processing of garlic by extracting the garlic oil that can be used for cooking and can increase farmer's incomes.

The process of extracting garlic oil has been developed in various methods. Previous research was conducted by Valle (2006) using the Extraction of Garlic with Supercritical CO2 method. From this research, the highest yield was obtained at 0.9% at 50oC and a pressure of 400 bars. However, this method used very complex technology with a long extraction time and high energy consumption (Valle, 2006). Then, Yang (2012) conducted a study using a simple method with relatively faster extraction time so that the energy consumption was low by using the Microwaves-Assisted Extraction (MAE) method at a temperature of 30-45oC for 1 to 2 hours and 0.478% yield was obtained (Yang, 2012). However, the disadvantage of this method is that it had a lower yield compared to the Extraction of Galic with Supercritical CO2 method.

In this research, extraction of garlic oil was conducted by using the MAE method with the addition of ultrasonic waves, and it's called Microwaves Ultrasonic Assisted Extraction (MUAE) to obtain a more efficient extraction process with lower energy consumption and higher yield.

2 METHOD

2.1 Equipment and Materials

The equipment used in this research were Electrolux EMM2308X Microwave, Ultrasonic Sonode Woodpecler USD-J, Type K Thermocouple, Stative, and Clamp, Condensor, Hotplate, Extractor Flask, and Erlenmeyer. The materials used were Garlic (Allium sativum L.) and ethanol 96%.

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2.2 Pretreatment

Pretreatment of raw materials began with peeling and cutting garlic into small pieces to expand the garlic's surface so that optimal oil could be produced. Then Garlic that had been sliced was weighed as much as 100 grams.

2.2.1 Microwave-Assisted Extraction (MAE) Method

At this step, 100 grams of garlic had been weighed in the pretreatment step was placed into the extractor flask then 300 ml of ethanol was added. The next step was the maceration process for 30 minutes. After the maceration process was completed, the extractor flask containing garlic and ethanol solvent was put into the microwaves, which functioned as the heater. The extraction process took place at the temperature of 40oC and pressure of 1 atm, then after the extraction process was completed in accordance with the time variable, the separation of garlic oil with ethanol solvent was done by evaporating ethanol at 50-55oC for 12 hours to obtain garlic oil.

2.2.2 Microwave Ultrasonic Assisted Extraction (MUAE) Method

MUAE method had the same treatment with MAE method, but in the maceration process of MUAE method, ultrasonic waves were added for 30 minutes. These ultrasonic waves were generated by a transducer. This equipment can change a form of energy into another form of energy. Ultrasonic application has several advantages, including reducing the solvent used and accelerating the extraction process compared to conventional extraction. Moreover, this ultrasonic method is safer, shorter, and suitable for the extraction of compounds that are thermolabile (Mukhriani, 2014) (Chen, 2008).

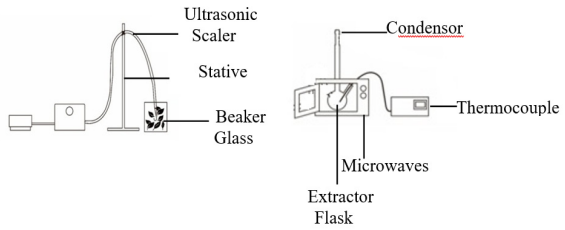

Figure 1. Set of Equipment of Microwaves Ultrasonic Assisted Extraction (MUAE) method

$$\text{Yield} = \frac{\text{Mass of Garlic Oil}}{\text{Mass of Garlic}} \text{ X } 100\% \quad (1)$$

2.2.3 Analysis of Garlic Oil Yield

Garlic oil that had been produced in MAE and MUAE methods was calculated to compare the yield of garlic oil produced from the two methods. The calculation of garlic oil yield is written in the following formula.

2.2.4 Analysis of Garlic Oil Compound

Analysis of garlic oil components was used to determine the composition of garlic oil produced from both methods. Analysis of garlic oil components used GCMS quantitatively.

2.2.5 Analysis of Energy Consumption

Energy consumption analysis was used to determine the economic value of the two methods, which were not only seen from the yield and extract yield levels but also the calculation of the energy needed during the process. The calculation of energy consumption can be written in the following formula.

$$\text{Energy Consumption} = \text{Total Power Input x Time of Extraction} \quad (2)$$

3 RESULTS AND DISCUSSION

3.1 Analysis of the Effect of the Addition on Ultrasonic Waves on the MAE Method to Garlic Oil Yield

This research used two extraction methods, Microwaves-Assisted Extraction (MAE), which used a microwave heating system and microwave Ultrasonic Assisted Extraction (MUAE), which was an innovation of MAE method by adding of ultrasonic waves.

The effect of ultrasonic addition in MAE method on garlic oil yield, it is illustrated in Figure 2

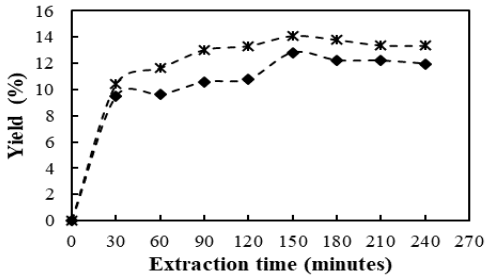

Figure 2. The yield of Garlic Oil using MAE and MUAE Methods

Based on the data in Figure 2, it can be seen that the longer the extraction, the yield of garlic oil obtained in the MAE and MUAE methods tends to increase. However, after 150 minutes, the yield produced in both methods also tends to decrease. The optimum time for both methods of extracting garlic oil was 150 minutes. The yield on the MAE method was 12.82%, and on the MUAE method amounted to 14,09%.

An increase in the extraction process time from 30 minutes to 150 minutes caused an increase of garlic oil yield because the length of extraction time made the protective membrane of material soft, which then facilitated the penetration of the solvent into the raw material (Pratiwi, 2016). The solubility of the components of garlic oil ran slowly in accordance with the increase in time. However, if the extraction time was too long, it caused the components in the garlic oil to be degraded so that the garlic oil yield decreased, which could also be caused by the limited ability of the solvent used to dissolve the existing material (Lin, 2010).

The difference of MAE and MUAE methods existed in the addition of ultrasonic waves at the maceration stage of the material with 96% ethanol. The MUAE method produced higher oil yields than the MAE method. The increase in yield in the MUAE method was due to the addition of ultrasonic waves at the maceration stage. The use of ultrasonic waves caused the pores of plant cells to open due to the cavitation bubbles, which maximized the penetration of solvents into the solute, and increased the diffusion process. Thus this would increase the process of mass transfer. High pressure and high temperatures can destroy the cell of the garlic, and the content in garlic cells can be released into the surface so as to increase the yield product (Bilgin, 2013) (Khan, 2010).

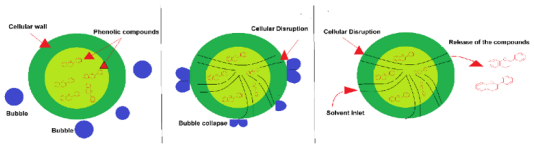

Figure 3. Mechanism of Ultrasound Waves

3.2 Effect of MAE and MUAE Methods to Garlic Oil Quality

Analysis of the quality of garlic oil obtained is an important determinant to determine a good method for extracting garlic oil. The quality of garlic oil can be determined from various parameters, one of which is the levels present in garlic oil. To determine the levels of compounds in garlic oil, Gas Chromatography-Mass Spectrometry (GC-MS) test was performed.

The following are GC-MS test results on garlic oil with MAE and MUAE methods.

Table 1. Results of Organosulphur Compound Analysis in Garlic Oil by using GC-MS

No	Compound	%	
		MAE	MUAE
1	1-Propene, 3,3-thiobis-	3,34	2,78
2	Formyltrimenthyl-urea	1,29	0,99
3	Disulfide, methyl 2-propenyl	1,61	2,75
4	Phenyl acetaldehyde	1,33	0,97
5	Disulfide, di-2-propenyl	7,89	11,24
6	3-Piperidinol	0,39	2,72
7	Trisulfide, methyl 2-propenyl	2,64	5,99
8	Hydrazinecarbodithioic acid, 1-methyl-, methyl ester	1,50	6,08
9	2-Furancarboxaldehyde, 5-(hydroxymethyl)	1,99	1,24
10	o-Methylisourea hydrogen sulfate	3,28	0,81
11	Trisulfide, di-2-propenyl	7,12	2,97
12	1,2,4,6-Tetrathiepane	2,87	6,67
13	Cyclopentanol	33,48	22,00
14	Piperidine	8,54	12,00
15	Quinoline	1,80	2,00
16	Propanoic acid	4,09	4,32
17	4H-Pyran-4-one, 2,6-dimethyl	3,72	0,91

The GC-MS results in Table 1 show that most of the garlic oil obtained by the MAE and MUAE methods are organosulfur compounds (disulfide, trisulfide, tetrasulfide). The percentage of

organosulfur content produced in MAE and MUAE methods has the difference. The percentage of organosulphur content in the MAE method was disulphide methyl 2-propenyl (1,61%), disulphide di-2-propenyl (7,89%), trisulfide methyl 2-propenyl (2,64%), trisulfide di-2-propenyl (7,12%). Whereas in the MUAE method, the percentage content of organosulphur produced is disulphide methyl 2-propenyl (2,75%), disulphide di-2-propenyl (11,24%), trisulfide methyl 2-propenyl (5,99%), trisulfide di-2-propenyl (2,97%). If the organosulfur compound is totaled, the percentage obtained is 19,26% for the MAE method and 22,95% for the MUAE method. Therefore, additions of ultrasonic waves on garlic oil extraction with the MAE method are able to increase the organosulphur content obtained.

3.3 Effect of MAE and MUAE Methods to Energy Consumption

The energy consumption factor during the process needs to be calculated to determine the economic value of the method used. Here is a table about the comparison of energy consumption between the MAE and MUAE methods.

Table 2. Energy Consumption by Using MAE and MUAE Methods

Parameters	Method	
	MAE	MUAE
Yield (%)	10,4	10,58
Extraction Time (min)	90	30
Power Input (Watt)	1250	1285
Energy (kWh)	1,87	0,64

From Table 1. it can be seen that at different extraction times, the yield is almost the same. MAE method with 90 minutes of extraction time has 10.4% yields. Whereas the MUAE method with 30 minutes of extraction time produces a yield of 10.58%. The energy needed to perform the MAE and MUAE methods is 1.87kWh and 0.64 kWh, respectively. Therefore it can be concluded that the MUAE method can reduce energy consumption by 65% when compared to the MAE method.

4 CONCLUSIONS

From the results of the research conducted, the following conclusions are obtained:

1. The addition of ultrasonic waves can increase the yield of garlic oil. In the MUAE method yields a yield of 14.09%, while the MAE method produces a yield of 12.82%. This proves that the yield on the MUAE method is higher than the MAE method with the same time ratio.
2. The effect of the addition of ultrasonic waves can increase organosulfur levels of garlic oil from 19,26% (MAE method) to 22,95% (MUAE method).
3. The addition of ultrasonic waves can reduce energy consumption. This is proven from energy consumption, which decreased from 1.87 kWh (MAE method) to 0.64 kWh (MUAE method), which means that it can reduce energy consumption by 65%.

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