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Antibacterial and Antioxidant Activities of Indonesian Ginger (Jahe Emprit) Essential Oil Extracted by Hydrodistillation

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Abstract

The rhizome of ginger is commonly used as a spice, food, beverage as well as medicine. Plant essential oils including from ginger have been widely used for food preservation, pharmaceutical, and alternative medicines. Currently, there is a growing interest of consumer for natural sources such as essential oils for natural antibacterial and antioxidant. Jahe emprit (Zingiber officinale var. Amarum) is one of Indonesian ginger variety used to obtain ginger essential oil. The objective of the current study was to investigate the effect of solvent to feed (SF) ratio in hydrodistillation process on yield, chemicals content, antibacterial and antioxidant activities of ginger essential oils from jahe emprit. SF ratio used in this study is 10:0.7, 10:1.7, 10:2.7. Chemicals content was conducted using GCMS analysis. Antibacterial assay was conducted using the disc diffusion method against Escherichia coli and Staphylococcus aureus. The antioxidant assay was conducted using 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging assay. The results show that the highest essential oil yield was obtained from SF ratio 10:1.7 which gave a yield of 3.7%. GCMS analysis shows that camphene was always the major compound present in those 3 SF ratio, although the amount present differed. Besides, four other major compounds present were varied. The antibacterial assay using 1% concentration showed ginger oil obtained from SF 10:0.7: and 10:2.7 have the same activities for S. aureus, whereas SF ratio 10:1.7 has the lowest activities. However, for E. coli, all SF ratio gave the same results. For antioxidant activities at 1000 ppm concentration, the highest activity was obtained from SF ratio 10:2.7.

1. INTRODUCTION

The rhizome of ginger is commonly used as a spice, food, beverage as well as medicine. Plant essential oils including from ginger have been widely used for food preservation, pharmaceutical and alternative medicines [1,2]. Currently, there is a growing interest of consumer for natural sources such as essential oils for natural antibacterial and antioxidant [3, 4]. Essential oil generally refers to concentrated volatile oils that are hydrophobic, lipophilic and carry distinct scent through various parts of a plant or herbs whereas hydrodistillation is the most frequently used technique for obtaining volatile oils from plant materials [5]. Although there are many other methods such as organic solvent distillation, steam distillation, expression, and maceration [6]. Jahe emprit (Zingiber officinale var. Amarum) [7, 8, 9] is one of Indonesian ginger variety used to obtain ginger essential oil [10, 11]. According to [12], Indonesia is number 6 in Top 10 ginger producer country (Fig. 1).

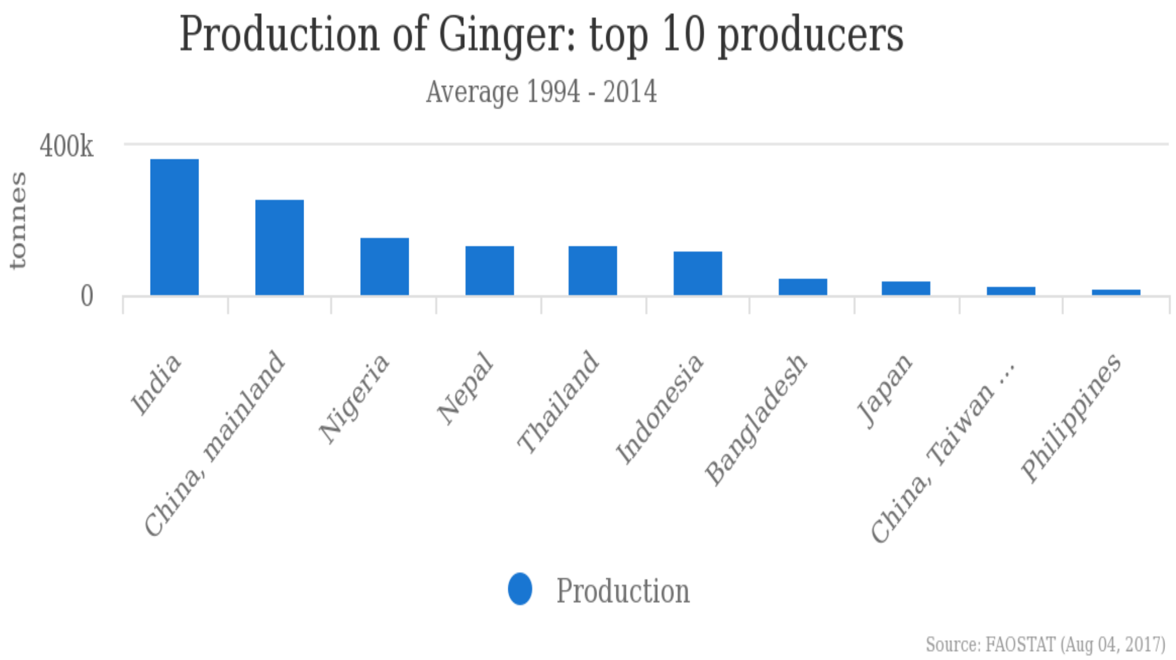

Fig. 1. Top 10 ginger producer countries (Souce: FAO)

Therefore ginger is one of the important Indonesian plants need to be studied for further development of potential value-added products. Although there are already many studies about ginger, however different varieties of ginger, their growth location and processing methods might affect the yield and chemicals content presents in the oils or other extracts of ginger that will also affect their bioactivities [13, 14]. Compare to other varieties of Indonesian ginger jahe merah and jahe gajah, it was found that jahe emprit gave the highest oil yield (3.9%) [15]. The objective of this research is to study the effect of SF ratio on hydrodistillation process of dried jahe emprit rhizome to yield, chemical content, antibacterial and antioxidant activities of ginger essential oils obtained.

2. EXPERIMENTAL SECTION

2.1. Materials

Fresh rhizomes of Indonesian ginger cultivar Zingiber officinale var. Amarum with local name is jahe emprit were purchased from the local farmer on Wonogiri (Central Java, Indonesia) on 2016. The rhizomes were washed, sliced and sun-dried until they reach the water content of 7-12% [13]. The chemicals are water, methanol (Merck, Germany), 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) (Sigma-Aldrich, USA)., nutrient agar (High Media, USA).

2.2. Hydrodistillation

This process was carried out at standard Clevenger-type apparatus. A 3000 ml flask was used as boiling flask with 1000 ml of water as the solvent. The process was maintained by heating at 300oC for 24 hours [13]. Dried ginger rhizomes weight variation of 70, 170 and 270 g with 1000 ml of water were used to give solvent to feed (SF) ratio of 10:0.7; 10:1.7 and 10:2.7.

2.3. GCMS Analysis

An analysis was performed using an Agilent 15977 A Network GC System was equipped with an Agilent 7890B Series auto-injector, coupled to an Agilent 5977A Mass Selective Detector. The carrier gas used was He with the flow rate of 40 ml/min with DB 1 as the columns (pressure 8.8085 psi) and Electron Impact (EI) as the ionizer. The sample was heated from 70°C up to 250°C with a heating rate of 10°C/min. The detector and injector temperature was 250°C with the initial time of 1 minute [16].

2.4. Antibacterial Assay

Antibacterial assay was conducted using the disc diffusion method against Staphylococcus aureus and Escherichia coli. Before used for assay, each bacterium was grown in nutrient agar and incubated at 37°C for 24 hours. For the antibacterial assay, each bacterium was mixed with 15-20 mL of nutrient agar in the Petri dish. Filter paper disc (6 mm diameter) was placed on the agar surface. DMSO was used to dissolve the samples, and 10µl of each sample at a concentration of 1% was placed on the disc. Streptomycin at the same concentration was used for positive antibacterial control.

The plates were then incubated at 37°C for 24 hours. All plates were observed for zones of growth inhibition, and the diameter of these zones was measured in millimeters. The assays were carried out in duplicate.

2.5. Antioxidant Assay

Antioxidant activity was measured as 1,1-diphenyl-2-picryl-hydrazyl DPPH free radical scavenging assay using the method reported by Yen and Chen (1995) with minor modification. Sample at the concentration of 200 µg/mL was mixed with 1 mL of a methanolic solution containing DPPH radicals at 1 mM. The mixture was shaken vigorously and left to stand for 30 min in the dark, and the absorbance was then measured at 517 nm. The ability to scavenge the DPPH radical was calculated using the following equation: DPPH scavenging effect (%) = $[(A0-A1/ A0)\times 100]$, where A0 was the absorbance of the control reaction and A1 was the absorbance in the presence of the sample. The assays were carried out in duplicate.

3. RESULT AND DISCUSSION

The effect on yield of the ginger extract obtained from different SF ratio is shown in Table 1. The results show that the highest essential oil yield was obtained from SF ratio 10:1.7 which gave a yield of 3.7%. The yield obtained from SF ratio 10:2.7 is lowest indicate there is a specific optimum SF ratio needed to obtained optimum yield. The ginger essential oils obtained from hydrodistillation in this study was higher than reported Mesomo et al. [17] and Supardan et al. [18] that only less than 2% but similar to reported by Djafar et al. [19]. Differences with [17] might be due to different ginger variety and growth location. The amount of water used in current experiments was lower than the one used by reported in [18]. Based on this result, too much amount of water or too much ginger amount lower the oil yield.

Table 1. Ginger essential oil yield obtained from various SF ratio of hydrodistillation process

SF ratio	Dried Ginger Weight (g)	Volume (mL)	Yield (%)
10:0.7	70	2.300	3.286
10:1.7	170	6.350	3.735
10:2.7	270	5.900	2.185

Table 2 shows the overall results of GCMS analysis and Fig. 2 shows the five major compounds of ginger oils obtained from hydrodistillation with three different SF ratios. GCMS analysis shows that camphene was always the major compound present in those 3 SF ratios, although the amount present differed. Besides, four other major compounds present were varied. Camphene, sulcatone and eucalyptol content from SF ration 10:2.7 significantly higher than others might due to highest solid material used and these compounds more easily released during hydrodistillation. The chemicals content obtained in this study was similar to other published results although the highest major compound present was varied, in this study camphene whereas other reported curcumene [17, 18]; zingiberene [20]; 1,8 cineol [21]. These suggest that chemical component obtained might also depend on the varieties or source of ginger material used as also observed by [13, 14].

The antibacterial activity against E. coli and S. aureus of the ginger oils was measured as the diameter of the inhibition zone present after the incubation period, the results are shown in Table 3. The antibacterial assay using 1% concentration showed ginger oil obtained from SF 10:0.7 and 10:2.7 have the same activities for S. aureus, whereas SF ratio 10:2.7 has the lowest activities. However, for E. coli, all SF ratio gave the same results. Results obtained in this study is in agreement with results reported by [17, 20, 22] although the variety of ginger they used was differed and they are grown in other countries. This suggests that similar compounds present such as citral, borneol, and eucalyptol which were major compounds found in the current study might be responsible with the antibacterial activity.

Table 2. GCMS analysis of ginger essential oil constituent obtained from various SF ratio of hydrodistillation process

No	RT	Compound	Area (%)		
			10:0.7	10:1.7	10:2.7
		Monoterpenes			
1	4.633	*Pinene*	2.68	2.96	5.01
2	4.948	*Camphene*	13.94	15.34	24.41
3	5.818	*Myrcene*	1.66	1.81	-
		Oxygenated Monoterpenes			
4	6.952	*Eucalyptol*	7.11	7.01	12.04
5	9.032	*Linalool*	1.77	1.61	2.61
6	11.149	*Borneol*	4.42	4.16	5.57
7	13.153	*Citronellol*	1.18	1.07	1.12
8	13.770	*Geraniol*	2.75	2.71	2.41
9	14.161	*Citral*	5.56	5.40	2.49
10	5.705	*Sulcatone*	1.14	1.50	13.93
11	11.729	*Rose Furan Oxide*	1.19	1.05	0.23
		Sesquiterpenes			
12	17.816	*Curcumene*	8.06	9.54	5.64
13	17.992	*Zingiberene*	5.33	7.94	3.69
14	18.118	*Farnesene*	1.78	-	1.28
15	18.169	*Bisabolene*	2.57	3.12	1.92
16	18.383	*Sesquiphellandrene*	4.13	5.03	2.19
17	19.240	*trans-Sesquisabinene hydrate*	1.34	1.09	0.20
18	20.425	*Isoitalicene*	2.03	1.53	0.13
		Oxygenated Sesquiterpenes			
19	18.736	*Elemol*	1.08	0.91	0.22
20	19.530	*Zingiberenol*	3.08	2.50	0.46
		Total number of compounds	20	19	19
		Total peak area	72.8	76.28	85.55

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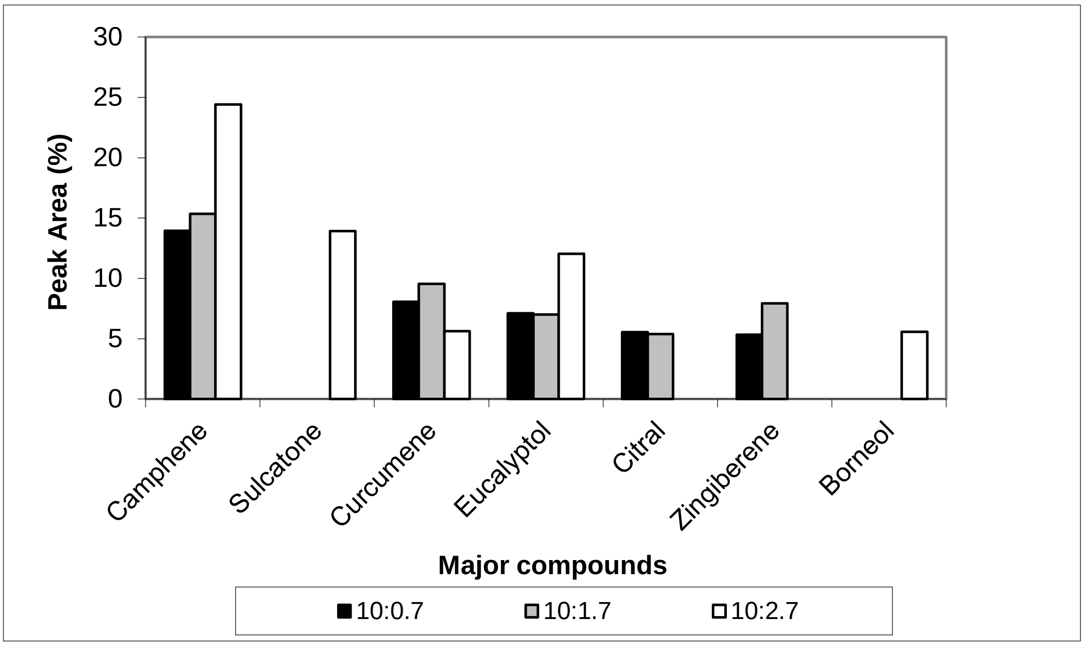

Fig. 2. Five major compounds of ginger essential oils obtained from various SF ratio of hydrodistillation process

Table 3. Antibacterial activity of ginger essential oils obtained from various SF ratio of hydrodistillation process at 1% concentration

SF Ratio	Inhibition zone diameter (mm)	
	Tested Bacteria	
	E. coli	*S. aureus*
Streptomycin	29	22
10:0.7	7	8
10:1.7	7	7
10:2.7	7	8

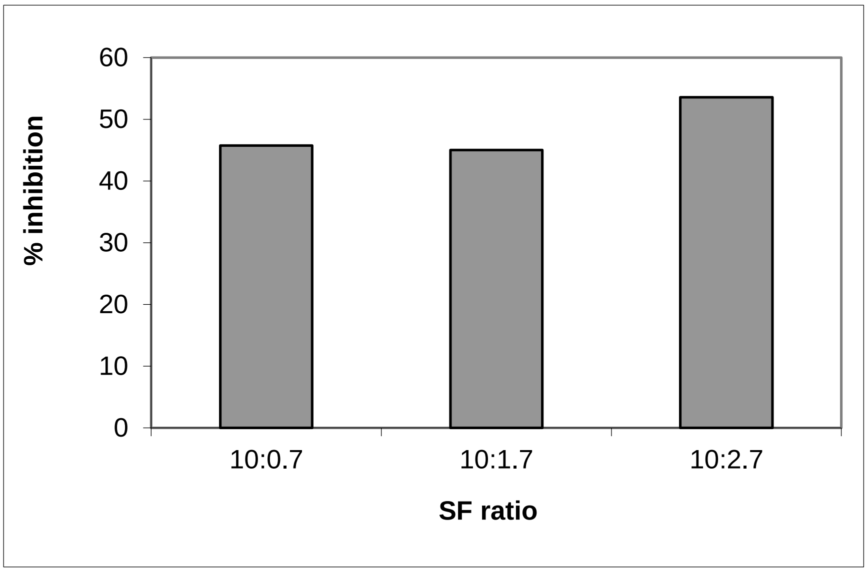

Fig. 3. Antioxidant activities of ginger essential oils obtained from various SF ratio of hydrodistillation process at 1000 ppm concentration.

Results of antioxidant activities of ginger essential oils shown in Fig. 3. The results show that at 1000 ppm concentration, the highest activity was obtained from SF ratio10:2.7. The results was similar to reported study by Bellik [22], that study also found that ginger essential oil has lower antioxidant activity compare to ginger oleoresin.

4. CONCLUSION

Different SF ratio in hydrodistillation process to obtained ginger essential oils from jahe emprit affect yield, chemicals content, antibacterial and antioxidant activities. Highest oil yield was obtained from SF 10:1.7 however highest total peak area of chemical contents, antibacterial and antioxidant were obtained from SF 10:2.7. Camphene always the highest chemical compound in all SF ratios tested.

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