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Effect of Drying and Hydrodistillation Time on the Amount of Ginger Essential Oil

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***Abstract*— The objective of this research is to study the effect of drying and hydrodistillation time on the amount of ginger (*Zingiber officinale* Rosc.) essential oil. For this purpose, a hydrodistillation laboratory-scale extraction unit was employed. The fresh ginger were dried by air drying for 1, 2 and 4 days at ambient temperature. In general, ginger oil obtained in the form of bright yellow liquid with a distinctive aroma of ginger. The experimental results showed that the yields of the ginger essential oils were affected by the drying time of raw material and hydrodistillation times. The obtained essential oil was analyzed by gas chromatography–mass spectrometry and 12 compounds were identified. The major compounds of ginger essential oil were 1,8-cineole, geranial, geraniol, camphene and neral.**

***Keywords*— Essential oil; ginger; hydrodistillation**

I. INTRODUCTION

Ginger, originated in the Indo-Malayan region, is now widely distributed across the tropics of Asia, Africa, America and Australia. Ginger, the rhizome of *Zingiber officinale* Roscoe, is one of the most important and extensively used spices worldwide. In ancient times ginger was used for its flavor but was more valued for its medicinal properties and was therefore a constituent of many pharmaceutical preparations. Fresh ginger is valued both for its aroma and for its pungency. The volatile constituents that impart the characteristic pleasant smell (described as sweet, warm, camphoraceous, or citrus-like) are present in the essential oil of ginger [1].

Essential oils from various plants can be isolated using a number of methods such as hydrodistillation, steam distillation and organic solvent extraction [2]. Hydrodistillation and steam distillation are traditional methods for removal of essential oils from medicinal plants/herbs. These methods have some drawbacks such as losses of volatile compounds and elevated temperatures used can cause partial or full degradation of natural constituents especially monoterpenes which are vulnerable to structural changes under steam distillation conditions. These methods are known to be energy intensive methods due to long extraction times [3]. However, unlike organic solvent extraction method, these methods do not involve solvents, thus avoiding removal of the solvent process. These methods are also safe to operate and environmentally friendly [4] as well as can be employed for small or large industries [5,6].

Conventional processing, which includes washing, drying, and grinding of the ginger rhizomes, is implicated with quantity and quality of ginger essential oil. Drying is one of important postharvest processing of plant materials involving the removal of moisture from the plant tissues, therefore decreasing the weight and preparing the plant material for further process. A proper control of the drying process is important in minimizing the loss of the medicinal compounds of the plant parts as well as maximizing the yield of essential oil product [7]. Some studies have been conducted to provide a reliable basis for further development of drying as postharvest processing of plant materials. Wang et al. [8] reported that the yields of the oils were significantly affected by the drying methods in hydrodistillation of Pineapple Mint (*Mentha rotundifolia variegata*) from China. Higher oil yields by air-drying at 22°C was obtained when compared with oven-drying. Meanwhile, Sourestani et al. [9] studied the influence of drying, storage and distillation times on essential oil yield and composition of anise hyssop (*Agastache foeniculum* (Pursh.) Kuntze). They observed that the plant material dried at room temperature showed the higher essential oil content (2.2%) compared than dried by oven at 40°C (1.6%). The oil content of anise hyssop was also affected by storage time, however, the distillation time did not have a significant effect on the essential oil content of anise hyssop.

The objective of this work was to study the extraction process of ginger essential oil using hydrodistillation. The effects of drying and hydrodistillation time on the amount (yield) of ginger essential oil are presented in this work. The chemical composition of ginger essential oil produced was also analyzed.

II. Experimental Procedure

Samples of ginger were collected from around Banda Aceh, Indonesia. Fresh gingers were washed and dried by air drying for 1, 2 and 4 days at ambient temperature. Finally, the air-dried samples were cut into pieces about 0.5 cm in width before loaded to hydrodistillation still.

The experiments were performed in a hydrodistillation laboratory-scale unit. The hydrodistillation still contains a grid which keeps the plant material of ginger pieces in a fixed position. The water is boiled in a boiler, then, the steam produced come to still through below the charge and passes through the plant material. The still is packed evenly and not too tightly so that steam can extract from the complete charge efficiently. In each experiment the hydrodistillation was loaded with approximately 20 kg of the sample. To investigate the effect of hydrodistillation time on the amaount of essential oil, samples of the plant were subject to distillation until 300 min. The oil layer and hydro layer were separated by funnel. Then, the oil layer was dried over anhydrous sodium sulphate, weighed, stored in sealed vial in the dark and ready for analyses. The yield of ginger essential oil was defined as the amount of essential oil obtained by feeding dry raw material into the hydrodistillation still.

The chemical composition of ginger essential oil was analyzed by a gas chromatograph coupled with a mass spectrometer detector, GC-MS (Shimadzu, Japan, Model QP 5090A), using a capillary column DB5 (30 m, 0.25 mm, 25 μm). Helium was used as carrier gas. The sample components were identified by matching their mass spectra with those from the library database.

III. Results and Discussion

Figure 1 shows the effect of hydrodistillation time on the yield of the essential oil for various drying time of raw material. There was a marked correlation between the hydrodistillation time and the yield of essential oil. As expected, the yield of ginger essential oil increased with increasing hydrodistillation time. A similar trend result has been observed for various drying time. This means that an increase in the hydrodistillation time contributes to a longer contact between steam and plant material for providing larger mass transfer. Longer hydrodistillation times were therefore beneficial to increase the yield of essential oil of ginger. The yield of essential oil was found to increase from 0 to 0.055, 0.021 to 0.083 and 0 to 0.057 for 1, 2 and 4 days of drying time, respectively, when the hydrodistillation time increased from 30 to 240 min

As can be seen in Fig. 1, the yield of the essential oil no longer increased with further increase in hydrodistillation time after 240 min. It is suggested that when the material was extracted for 240 min, the essential oil contained in materials had been dropped to a minimum value. Enujiugha and Akanbi [10] reported a similar result trends for African bean oil seeds. Meanwhile, Boskabady et al. [11] working with finely ground *C. cyminum* found that there was significant increase in oil yield when the extraction time was increased from 2 to 7 h, but yield was either unchanged or decreased slightly when the time was continuously increased.

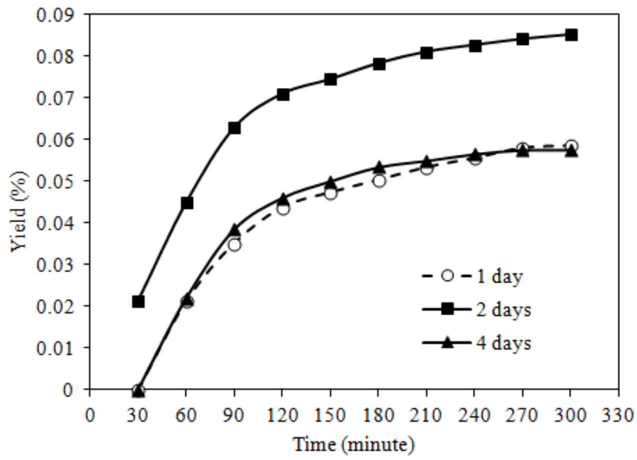

Fig. 1. Effect of hydrodistillation time for various drying time

Fig. 1 also shows the effect of drying time of material on the yield of the essential oil. In general, the drying of plant material caused either an increase or a decrease in the essential oil yield [9]. In our experiments, the yield increased with increasing drying time from 1 to 2 days, however, the yield decreased with further increasing drying time to 4 days. This suggests that longer drying time will not be appropriate for an efficient extraction of ginger essential oil, since a part of volatile compounds in essential oil will disappear from the material during the drying process. During drying of raw material, heat-sensitive active ingredients in the plant materials wll be lost. Thus, a proper control of the drying process is important in minimizing the loss of volatile compounds of the plant parts [7]. In addition, it must be considered that the extended drying times promote the growth of bacteria and molds. There was no significant difference of essential oil yield for 1 and 4 days of drying time. It could be concluded that drying of ginger rhizoma by air drying in 2 days at ambient temperature is more suitable and recommended for obtaining higher ginger essential oil content.

The dried plant materials containing the active ingredients are then subsequently cut into a smaller size prior to hydrodistillation. High surface area achieved by grinding the plant material into smaller size form has been shown to increase the extraction of phytochemical yield. Gião et al. [12] observed that finer particulate materials yield higher extraction of the active ingredients. A similar result trend was reported by Langa et al. [13] in supercritical fluid extraction of Spanish sage essential oil.

The curves presented in Fig. 1 are typical for the hydrodistillation of essential oils from aromatic plant materials. It can be observed that there are two steps of ginger oil hydrodistillation, i.e. fast and slow oil hydrodistillation. In the fast oil hydrodistillation step, the essential oil is evaporated from the surface of the plant material. The essential oil was rapidly liberated from the surfaces of the plant materials during the fast oil hydrodistillation step. As consequence, the ginger essential oil yield increased rapidly. In the slow oil hydrodistillation step, the rate of essential oil distillation slowed until a nearly constant oil yield was reached with the progress of the hydrodistillation process. In this second step, diffusion of the essential oil from the undestroyed reservoirs in the internal part of the plant materials towards their surfaces was followed by the essential oil distillation. Since the essential oil diffusion was slow, consequently, the rate of essential oil distillation slowed.

In general, ginger essential oil obtained in the form of bright yellow liquid with a distinctive aroma of ginger. From GC-MS analyses, monoterpenoids, sesquiterpenoids and aldehydes were three major classes of compounds found in the ginger essential oils. As presented in Table 1, 12 different compounds identified from the ginger essential oil quantized as percent area, included 4 monoterpenoids (41.75%), 1 sesquiterpenoid (2.73%), 2 aldehydes (24.44%), 3 alcohols (19%), 1 ester (8.81%), and 1 miscellaneous compound (3.27%). Five major components detected in the essential oils with composition more than 10% were 1,8-cineole (23.88%), geranial (14.19%), geraniol (11.96%), camphene (11.52%) and neral (10.25%). Yu et al. [14] reported the composition of ginger essential oil, i.e. β-phellandrene (22.84%), zingiberene (15.48%), camphene (7.30%), β-sesquiphellandrene (5.54%) and geranial (5.25%). These composition variations were the results of plant species, production conditions, harvesting time and climate. In addition, drying process may cause chemical rearrangements and oxidation of compounds in the essential oil. These lead to the appearance and disappearance of some compounds in the essential oil. However, the change in the concentration of the essential oil during drying and storage depends on various factors such as the type of compound, the plant species, the drying time and temperature and the storage conditions [9].

Based on their composition, the ginger essential might be useful for variation purposes. Compound of 1,8-cineole is one of valuable compound applied in various products such as flavoring and fragrance, medicinal, insecticide and repellent. Neral and geranial are widely used as a powerful lemon-fragrance chemical. Camphene shows a terpeney-camphoraceous taste whereas sabinene exhibits a warm, oily-peppery, woody-herbaceous and spicy taste with slightly pungent mouthfeel. Geraniol is. has a sweet, rose-like odour and occurs naturally in essential oils. Meanwhile, zingiberene as important component of ginger oil was about 2.73%. It has a warm, woody-spicy and very tenacious odour whereas a-farnesene shows a very mild, sweet and warm odour [15].

TABLE I
COMPOSITION OF GINGER ESSENTIAL OIL

Component	%
α-pinene	3,31
Camphene	11,52
β-myrcene	3,04
1,8 Cineole	23,88
Linalool L	3,62
Neral	10,25
Borneol	3,42
Zingiberene	2,73
Geranial	14,19
Geranyl acetate	8,81
Benzene	3,27
Geraniol	11,96

IV. CONCLUSIONS

The objectives of this research are to study the effect of drying and hydrodistillation time on the amount of ginger essential oil. The results indicate that the extraction variables have a remarkable effect on the yield of ginger essential oil obtained by hydrodistillation. A proper control of the drying and hydrodistillation time is important in minimizing the loss of the volatile compounds of the plant parts as well as maximizing the yield of essential oil product The GC-MS analyses of the essential oils led to identification of 12 compounds, with monoterpenoids, aldehydes and alcohols as three major classes.

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