Influence of processing parameters on the yield and 6-gingerol content of *Zingiber officinale* extract

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ABSTRACT

Ginger (Zingiber officinale) belongs to the Zingiberaceae family. The ginger rhizomes contain polyphenol compound (6-gingerol and its derivatives), which have high antioxidant and antimicrobial activities. The aim of this study is to determine the processing parameters for the extraction of ginger essential oil using hydrodistillation method. The processing parameters, including the effect of extraction time, solid to solvent ratio and drying temperature for the extraction of ginger essential oil and 6-gingerol content. The essential oil produced from hydrodistillation extraction method were analyzed for 6-gingerol content by using High Performance Liquid Chromatography (HPLC). The optimum processing parameters obtained were extraction time of 90 minutes, solid-to-solvent ratio of 1:20 and sample drying temperature at 50 °C. The optimum parameter was determined based on its maximum yield and 6-gingerol content from ginger extraction which were 7.02 % (w/w) and 35.3404 mg/L, respectively.

Keywords: *Zingiber Officinale*, hydrodistillation, 6-gingerol, essential oil, processing parameter
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INTRODUCTION

Ginger (*Zingiber officinale*) is a widely used herb and a food - flavouring agent. Its neutraceutical properties have long been an interest to the food processing and pharmaceutical industries. The rhizome of ginger is used as a food ingredient, as well as a traditional medicinal herb to treat many diseases, including gastrointestinal, stomachic, rheumatic disorders and muscular discomfort [1]. The volatile essential oils from ginger extract contribute to the characteristic of flavour, varies from 1.0-3.0%. However the oleoresin, which responsible for the pungent smell of ginger, varies from 4.0-7.5% and also possesses substantial antioxidant activity [2]. Among the representative bioactive compounds in ginger, most of them are known as homologous phenolic ketones and exist as 6, 8, and 10-gingerols with different lengths of their unbranched alkyl chains [3]. According to previous researches the gingerols have prominent cancer preventive effects against gastric and colon cancer *in vitro* [4,5] and skin cancer *in vivo* [6]. Several studies revealed that the 6-gingerol has been found to possess various biological activities and pharmacological effects, including anti-inflammatory, analgesic, antipyretic, chemopreventive, angiogenesis, and antioxidant properties [7-9]. The chemical structure of 6-gingerol as shown in Figure 1.
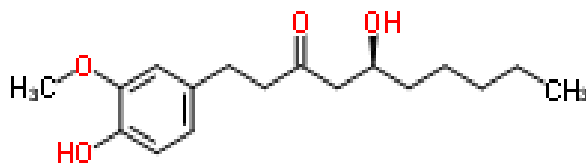
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Figure 1: Chemical structure of 6-gingerol

Previous studies have reported various extraction methods to obtain phytochemicals from ginger, such as high-pressure Soxhlet extraction [10], shaking (warm temperatures) [11], reflux [12] and sonication [13]. However, this study will be carried out to investigate the potential of hydrodistillation for the extraction of essential oils from Ginger (*Zingiber Officinale*) by evaluating the oil yield at various parameter conditions and its quality by using High Performance Liquid Chromatography (HPLC).

EXPERIMENTAL SECTION

Materials
Fresh gingers (*Zingiber Officinale*) were acquired from a local farm in Pahang, Malaysia on May 2014. The standards 6-gingerol for high performance liquid chromatography (HPLC) analysis were obtained from Chromadex Inc. (Irvine, CA, USA).

Optimization of essential oil extraction
In order to optimize the variable parameters of extraction for achieving maximum essential oil yield, the distillation was conducted at three different parameter conditions which were solid to solvent ratio (1:20, 1:30, 1:40, 1:50, 1:60 g/ml), different extraction time (30, 40, 50, 70, 90, 120 minutes) and different drying temperature (40 °C, 50, 60 °C).

Analysis of sample
The extracted essential oil was recovered using a rotary evaporator, weighed and stored in vials at 4 °C prior to the analysis. The evaporation process was conducted at 100 °C to remove the remaining of solvent in extracts. Extraction yield for essential oils were calculated using the following equation [14]:

$$\text{Yield of essential oil (\%)} = \frac{amount\ of\ essetial\ oil\ (g) obtained}{amount\ of\ raw\ materials\ (g) used} \times 100$$

The extracted essential oil samples were analyzed by using HPLC. 6-gingerol was selected as the quality indicator for this research. The system consists of Waters 600 System Controller, Waters 2996 Ultra- violet (UV) detector and equipped with Waters 717 Autosampler. Waters 2996 UV detector detects chemical compounds that pass through HPLC column and sent the data to the computer for analysis. Column Oven was used to maintain the temperature of column during analysis.

A Phenomenex Luna C18 100A column (250 mm x 4.6 mm, 5 µm particle size, USA) was used as a stationary phase. The chromatographic profiles were obtained using a reversed-phase C-18 column at flow rate of 1.0 mL/min at room temperature and the extract was eluted with a isocratic system of 65% Acetonitrile CH_3CN and 35% Acetic acid. The mobile phase combinations were selected through optimization for better separation of compounds and shorter time. The detection wavelength chosen was 230 nm because the detection of 6-gingerol sensitive at that wavelength. The experiments were done in triplicate. The concentration of 6-gingerol were reported in mg/L (ppm).

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RESULTS AND DISCUSSION

Effect of extraction time on yield
From the graph in Figure 2, the amount of essential oil yield does not increase after 90 minutes. The graph showed that most of the essential oil was collected within 30 to 90 minutes with 1%, 5%, 6%, 6.7% and 7%, respectively. The hydrodistillation method reaches the highest essential oil yield of 7% w/w when the extraction time was 90 minutes.
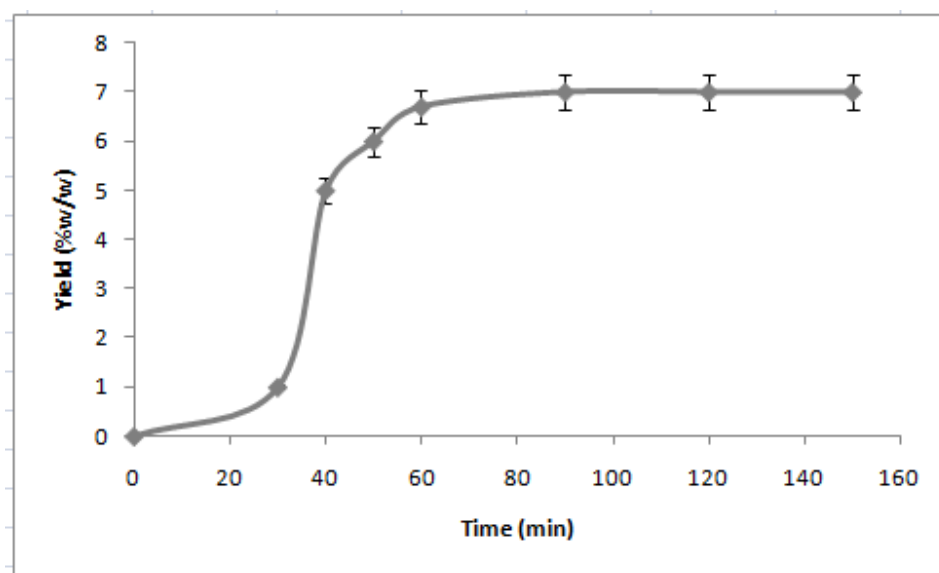

Figure 2: Extraction yield of essential oil at different extraction time at 50 °C and 1:20 g/ml ratio solid to solvent

A similar observation was reported by Aburahman *et al*. 2013 in their study extraction and characterization of essential oil from *Zingiber Officinale* Roscoe and *Cymbopogon citrates* by using the Microwave-Assisted Hydrodistillation [14]. The extraction process increases at the beginning, but gets slow gradually by increasing the extraction time because the cutting material is exhibited to the high temperature, the bioactive compounds in essential oil started to degrade. According to Pin *et al*. 2009, the extraction process of betel leaves was rapid at the beginning, but slowed down as the process approaching equilibrium after 40 minutes [15]. As a result, the less extraction time to finish the extraction process was sufficient based on herb a plant was used in research. Nevertheless, further increases in the extraction time cause over heat supplied to the sample and this lead to the drying up of volatile component in the essential oils [16].

Effect of ratio solid to solvent on yield
The effect of different ratio solid of solvent on essential oil yield at fix time 90 minutes of extraction and 50 °C of drying temperature was presented in Figure 3.

The mass of raw material that were used for the experiment was constant 10 g. Figure 3, showed that the highest essential oil yield obtained at ratio 1:20 and followed by 1:30, 1:40, 1:50 and 1: 60 (g/ml) were 7%, 5%, 4.6%, 3% and 2.8%, respectively. Therefore, it could be concluded that the essential oil of ginger is increased when the amount of water as solvent was reduced. Silva *et al*. 2007 also reported that increasing of ratio solid to solvent above 1:20 (g/ml) could limit the extraction yield as excessive solvent used of phenolic from *Inga edulis* [17]. This implies that the extraction yield is limited by the total available solute when excessive solvent is used. The use of excessive solvent would also lead to the increases of energy consumption during extraction process [18]
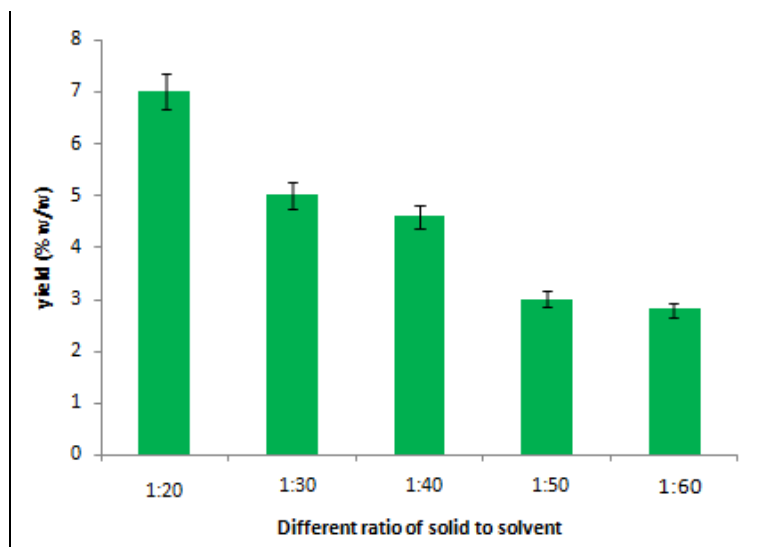
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Figure 3: Variation of extraction yield of essential oil at different ratio solid to solvent with fix time of extraction 90 minutes and 50 °C of drying temperature

Effect of drying temperature on yield
The yield of essential oils was 4.7% (40 °C), 6.8% (50 °C), and 5.6% (60°C) as shown in the Figure 4. As it is clearly seen from the Figure 4 the essential yield will decrease when the temperature increases. High temperature of drying will denature the bioactive compounds on the ginger.
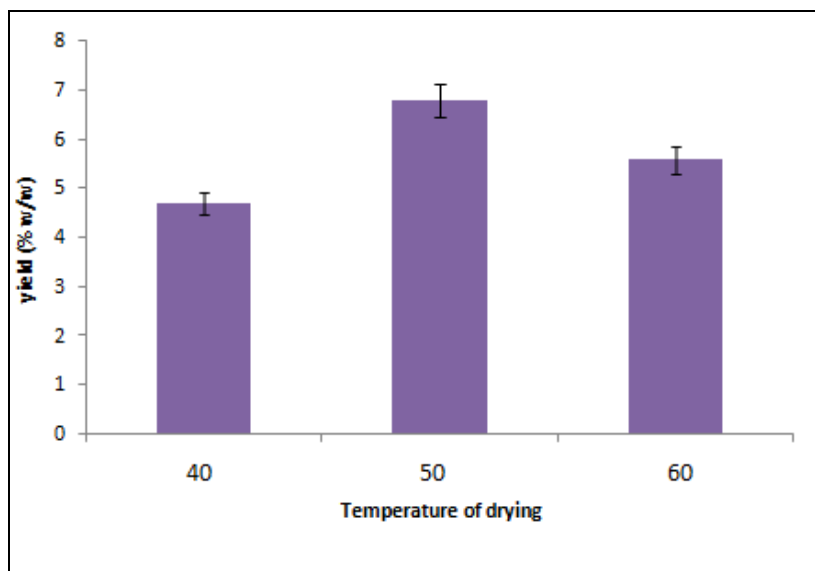

Figure 4: Variation of yield essential oil with different drying temperature at constant ratio solid to solvent 1:20 g/ml and time 2 h

Based on the previous studies of researchers was reported that by increasing the drying temperature could reduce the functional properties and bioactivity of food. Garau *et al*. 2006, reported that the functional properties including water retention capacity and fat absorption capacity of orange's skin dried at 50 °C were higher than samples dried at 60 °C. These findings showed that the quality of the essential oil could be degradation under high temperature drying above 50 °C [19]. The critical drying temperature varies dependent on the extracts and required bioactivity. According to Vega-Galvez. (2008), reduction observed in the retention of ascorbic acid in red bell pepper when the drying temperature rose from 50 to 80 °C [20].

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Identification of 6-gingerol in essential oil from optimum condition
From the optimum condition of parameter which are 90 minute extraction time, 1:20 (g/ml) ratio solid to solvent and 50 °C drying temperature the essential oil was identified contain the 6-gingerol by using the HPLC. The chromatograms of essential oil from ginger extract as shown in Figure 5. Based on the HPLC analysis, the results indicated that the selected compound in essential oil extracts was 6-gingerol by comparison with external standard and the retention time of 6-gingerol is 6.923. The concentration of 6- gingerol under optimum condition is 35.3404 mg/L.
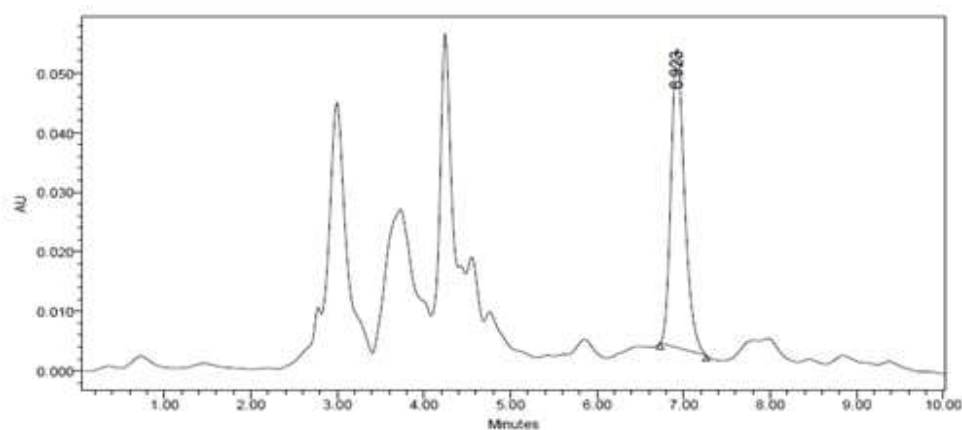

Figure 5: The chromatograms of essential oil from ginger extract at optimum condition

CONCLUSION

This research was conducted to investigate the performance of hydrodistillation method in the extraction of essential oil from Ginger (*Zingiber Officinale*) based on essential oil yield. The optimum condition for this study was obtained under 90 minute extraction time, 1:20 (g/ml) ratio solid to solvent and 50 °C drying temperature. Then, the concentration of 6-gingerol was 35.3404 mg/L have been analyzed.

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