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A preliminary investigation of *China Ginger* and *Kuching Local Ginger* species: Oil extracts and synthesis towards potential greener insect repellent

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ABSTRACT

Ginger essential oil (*Zingiber officinale*) is the volatile oil extracted from ginger rhizome. Compared to chemical synthetic repellent, green insect (in particular mosquito) repellent would be favoured by the public as it is environmentally friendly and does not cause harm to the human's health. The focus of this study is on the comparison study between *China Ginger* and *Kuching Local Ginger* essential oil aim towards utilization as the greener mosquito repellent. In this study, the ginger essential oils are extracted greener method i.e. via hydro distillation process for 7 h. The percentage oil yield for China and *Kuching Local Ginger* are 0.158 wt% and 0.264 wt%, respectively. The extracted ginger essential oils are further subject to Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography- Mass spectrometry (GC-MS) analysis. Based on the FTIR spectrum graph generated, both types of ginger essential oils essentially having the similar function groups including phenolic compounds, alcohol primer, alkena methyl group, aromatic compound, carbonyl compound, carboxylic acid, hydroxyl group. From the GC-MS results it revealed that the most abundant chemical constituents presented in both *China Gniger* and *Kuching Local Ginger* essential are: α-Zingiberene (7.88% and 7.03%), α-Curcumene (6.04% and 6.49%), α-Citral or Genarial (3.81% and 7.86%), β-Bisabolene (3.06% and 4.62%), β-Sesquiphellandrene (5.83% and 5.95%), β-Sesquisabinene (0.07% and 0.51%), β-Selinenol (3.97% and 2.26%), Zingiberenol (5.16% and 1.64%), [6]-Shogaol (0.33% and 0.23%), trans-Sesquisabinene hydrate (1.72% and 2.87%), trans-Geranylgeraniol (3.51% and 2.81%), Camphene (1.17% and 0.56%), Eucalyptol (2.68% and 1.81%), Citronellol (1.76% and 1.55%), Neral (2.82% and 6.03%), and Geraniol (1.62% and 2.29%) respectively. *Kuching Local Ginger* essential oil is found marginally superior insect repellent characteristics due to its higher monoterpene compounds in the essential oil.

1. Introduction

One of the most efficient ways to eliminate the mosquitoes from the residential houses is using the chemical-based mosquito repellent. Most insect repellents operate by creating a vapour barrier around the treated surface, preventing arthropod and insects from coming into contact with the surface Nerio et al. (2010). When making commercial mosquito repellents, non-biodegradable synthetic compounds like N-diethyl-3-methylbenzamide ($C_{12}H_{17}NO$), allethrin, N ($C_{19}H_{26}O_3$), and dimethyl phthalate ($C_{10}H_{10}O_4$) are usually used. These chemicals have the potential to pollute the environment and causes health hazards when used on a large scale (Khater, 2012). Many researchers e.g. Pavela and Benelli (2016) reported that inhaling the repellent chemicals substantially would result in allergic reactions and serious respiratory problems. These toxic compounds may potentially cause cancer if inhaled in prolonged periods of time, and can even can be lethal if inhaled in large

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quantities. Besides, based on the survey reported by Rediff (2015), ~ 11.8% of people who used chemical-based mosquito repellents reported a variety of health problems, including breathing difficulties, headaches, discomfort in the eyes, bronchial irritation, coughing, colds, running noses, skin infections, and asthma. With growing public safety concerns, there is an increasing interest in the usage of natural products derived from plants because natural derivatives are more ecologically friendly, biodegradable and affordable by many.

The use of insecticides based on plant extracts is currently highly promising from the alternatives of protection against insects. Many plant extracts that contain substances with insecticidal effects also include a large group of the so-called essential oils (EOs) (Senthil-Nathan, 2020).

Although EOs make up just a small proportion of a plant's total composition, they contribute to the unique features that make aromatic plants useful in the food as well as their wide applications in the industrial fragrance as well as in the pharmaceutical sectors. Essential oils are comprised of a complex and varied composition that includes a large number of elements, including hydrocarbons and oxygenated molecules. The odor of these compounds is essentially a consequence of the mixture of the smells of each of the compounds individually. Trace constituents are especially essential since they contribute to the oil's distinctive natural scent. As a result, it is critical that the natural proportions of the constituents are preserved throughout the extraction of essential oils from plants (Aziz et al., 2018).

EOs possess a large number of chemicals which have adulticidal activity being reported from plants notably in the Lamiaceae, Miliaceae, Rutaceae, and Zingeberaceae (Chellappandian et al., 2018).

Over the recent years, several EOs have been employed in environmentally friendly and commercial repellents formulations (Tisgratog et al., 2016). For instance, AlSalhi et al. (2020) reported that the *Kaempferia galangal* rhizome essential oil (EO) and its major chemical constituents are promising larvicidal agents highly potential use as effective and eco-friendly mosquitocidal formulations. Narayanankutty et al. (2021) investigated the use of Mango ginger (*Curcuma amada Roxb.*) rhizome essential oils as source of environmental friendly insecticides and antibacterial agents using a variety of extraction methods. The results of their study have shown that the microwave-assisted extraction (MAE), ultrasound-assisted extraction (UAE), steam distillation (CSD), and hydrodistillation (CHD) were all having high larvicidal activity against *Aedes, Culex*, and *Armigeres* species. The present study only focus on the CHD method. According to a previous study published by Madreseh-Ghahfarokhi et al. (2018), *Culex theileri* Theobald, 1903 is a wide-distributed species of mosquitoes in different parts of world. It is a large distinct mosquito species through which the repellent activity of ginger essential oil has been studied extensively. It was deduced that different type of the ginger essential oils used produce different insect repellent performance.

Hence, the intention of the present research is to investigate the chemical compositions for two different type of ginger essential oil which are extracted from *China Ginger* and *Kuching Local Ginger* – via greener hydro distillation method, thereafter estimate its potential in terms of insect (mosquito) repellent activity.

2. Methodology

This section discusses on the sample preparation of gingers, extraction of gingers using hydro distillation method, separation of condensate and characterization of ginger essential oils using Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography-Mass spectrometry (GC-MS) analysis.

2.1. Sample Preparation of Gingers

Both *China Ginger* and *Kuching Local Ginger* was purchased from local supermarket in Farley Supermarket, Kuching, Sarawak. The sample ginger rhizomes were sorted to separate the healthy gingers from the damaged, dried, and rotten ones. Then, the sorted healthy ginger rhizomes were brushed and washed by using clean water to remove the soil, dirt or impurity substances attached on the surface of gingers. The cleaned ginger rhizomes were then air-dried in a tray/colander to remove of the excess water from the surface at room temperature. The ginger rhizomes were further cut or chopped into pieces with thickness of ± 0.1 cm using the knife without peeling the skins of the gingers. Finally, the cut ginger rhizomes were stored in an airtight high-density polyethylene bag for further experiment work.

2.2. Extraction of Gingers Using Hydro Distillation Extraction

Both of the *China Ginger* and *Kuching Local Ginger*s had been extracted using same hydro distillation method under same operating parameters. The preparation method of the hydro distillation followed the procedure described by (Mehani et al., 2016; Narayanankutty, 2021). The round bottom flask was first measured of its weight. Then, the cut pieces of ginger rhizomes were inserted into the round bottom flask until 7/10 filled. The weight of the round bottom flask with ginger rhizomes was weighted to get the net weight of the ginger sample. The round bottom flask was further put on the heating mantle and jointed to the condenser. A beaker was put at the end of the condenser to collect the condensate. The cooling water/tap water was flowed through the condenser using the rubber tubing once the heating mantle was switched on to heat the mixture in the round bottom flask. Then, the process was conducted for 7 h of distillation. Finally, the collected condensate extraction is stored for separation process. The overall set up hydro distillation apparatus was shown in Fig. 1.

2.3. Separation of condensate

The collected condensate was first poured into separatory funnel. N-hexane was added into the separatory funnel to dissolve all the oil that was presented in the condensate. Two layers was formed in the separatory funnel and the upper layer was collected in the beaker while the bottom layer was discarded. The collected mixture of n-hexane and ginger essential oil (upper layer) was heated on the hot magnetic plate to evaporate the n-hexane. The separation process can be stopped when the temperature exceeded 75 °C. The remain residues in the beaker was the ginger essential oil. Then it was weighted and calculated for the percentage of the essential oil yield using the following formula in Eq. (1).

$$Percentage \quad of \quad essential \quad oil \quad yield = \frac{Mass \quad of \quad the \quad essential \quad oil}{Mass \quad of \quad the \quad ginger \quad sample} \times 100\% \tag{1}$$

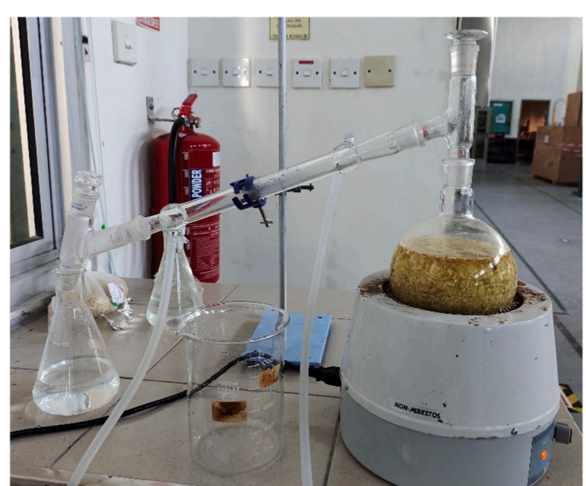

Fig. 1. Hydro distillation extraction apparatus set up.