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The Effects of Soil Parameters on Efficiency of Essential Oil from *Zingiber zerumbet* (L.) Smith in Thailand

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***Abstract*—**Natural products from herb have been used in different aspects of life as a result of their various biological activities. Generally, plant growth and production of secondary compounds largely depend on environmental conditions. To better understand this correlation, study on biological activity and soil parameter is necessary. This research aims to study the soil parameters which affect the efficiency of the antioxidant activity of essential oils extracted from the *Zingiber zerumbet* in three areas of Thailand, including Min Buri district, Bangkok province; Muang district, Chiang Mai province and Kaeng Sanam Nang district, Nakhon Ratchasima province. The soil samples in each area were collected and analyzed in the laboratory. The essential oil of *Z. zerumbet* in each province was extracted and tested for antioxidant activity by hydrodistillation method and DPPH (2,2-diphenyl-1-picrylhydrazyl radical) assay, respectively. The results showed that, the soil parameters such as pH, nitrogen, potassium and phosphorus elements and exchange of cations of soil specimen from Nakhon Ratchasima province were the highest ($P<0.05$) (6.10 ±0.03, 0.15 ± 0.04 percent of total nitrogen, 16.67 ± 0.46 mg/L, 3.35 ± 0.65 mg/kg and 12.87 ± 0.11 cmol/kg, respectively). In addition, IC50 (Inhibition Concentrtion of antioxidant at 50%) of *Z. zerumbet* essential oil collected from Nakhon Ratchasima showed the highest value ($P<0.05$) (1,400 µg/mL). In conclusion, the soil parameters are once important factor for the efficiency of essential oils extract from *Z. zerumbet*.

***Keywords*—**Antioxidant, essential oil, herb, soil parameter, *Zingiber zerumbet.*

I. Introduction

ZINGIBER zerumbet (L.) Smith is a monocotyledonous plant commonly known as the pinecone or shampoo ginger that is widely cultivated in tropical and subtropical regions around the world [1]-[4] including Thailand. As described in Koga's study [1], *Z. zerumbet* rhizome was used for medical purposes including, inflammation, diarrhea, stomach cramps, bacterial infections, fever, flatulence, allergies and poisoning treatments.

Essential oils are one type of natural products found in plants that have been gaining interest among researchers because of their antioxidant activities [5]-[11]. However, the activity largely depends upon the essential oil content and compositions. Boyle et al. [12] showed that the essential oil content of rosemary plants was affected by growth conditions including growing medium as well as fertilization regime. Other studies also demonstrated a relationship between soil conditions and the compositions of essential oils extracted from *Salvia desoleana* [13], *Flos lonicerae* [14] and *Lavandula angustifolia* [15]. This suggests the importance of growth conditions in essential oil production. *Z. zerumbet* (Fig. 1) has also been known for their benefits in traditional Thai medicine. This may be attributed to essential oils produced in plant rhizhomes. The main interest of the present study is to determine the effects of soil conditions on the production of essential oils by *Z. zerumbet* collected from different areas in Thailand. Additionally, essential oil samples were also examined for their antioxidant activity.

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II. Materials and Methods

A. Plants and Soils

The rhizomes of *Zingiber zerumbet* (Figs. 2-4) and soil samples were collected from three areas of Thailand, including Min Buri district, Bangkok province; Muang district, Chiang Mai province and Kaeng Sanam Nang district, Nakhon Ratchasima province.

B. Soil Preparation and Soil Parameters Analysis

Soil samples from each area were collected from five points over the planting area. Soils were gouged out with a shovel at 15 cm depth in a V shape. Soils obtained from five points of the same area were pooled together in a plastic bag [16]. Then, the soils were analyzed for pH, nitrogen (Kjeldahl method), phosphorus (Molybdenum blue method) and potassium contents (Atomic absorption spectrophotometry (AAS)). The soil cation exchange (CEC) was also determined [17].

C. Blended Z. zerumbet Rhizome Preparation

The rhizomes of *Z. zerumbet* were thoroughly washed, sliced and baked to 60 °C for 3 days. Subsequently, samples were blended thoroughly in a blender and used for extraction of essential oils.

D. Extraction of Z. zerumbet Essential Oils

Seventy-five grams of blended samples were put into a container and added with 300 mL of distilled water. The extraction was performed by hydrodistillation in distilling apparatus for 2 hrs. Essential oils were collected in a brown bottle that was wrapped with aluminum foil and stored at 4 °C for further analysis.

E. Antioxidant Test with DPPH Radical Scavenging Activity

The experiment was performed according to [18] with slight modifications. Briefly, essential oils were prepared at the 2,000 μg/mL concentration. 100 mL of the essential oil samples were mixed with 100 mL of 0.025 mM 2,2-Diphenyl-1-picrylhydrazyl radical and left in the dark for 30 min. The mixtures were measured for the absorbance (Abs) at 492 nm using Microplate reader. Each sample was performed in triplicates. Ascorbic acid was used a standard. Percentage of inhibition was calculated as:

$$\% \text{ Inhibition} = \frac{\text{Abs control} - \text{Abs sample}}{\text{Abs control}} \times 100$$

F. Analysis of Chemical Composition of the Oil

The chemical composition was analysed by Gas chromatography-Mass Spectrometry (GC-MS) (Agilent Model GC G1530N, MS G2573A) at the Scientific Instrument Centre, Faculty of Science King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. This was operated using the following conditions: 250 °C injector temperature, 60-180 °C at 2 °C per minute column temperature, then held at 180 °C for 4 min. The detector temperature was set at 300 ^{o}C. Particle mass spectra were recorded using a charged electric impact 70 eV.

Fig. 1 The leaves and inflorescences of *Z. zerumbet*

III. Results and Discussion

A. Soil Parameters

The results of soil parameters analysis from the three areas found that soil samples were moderately acidic. The soil pH ranged from 5.42-6.10 (Table I). The sample from Nakhon Ratchasima displayed the highest nitrogen content (0.15±0.04% of the total nitrogen), potassium (16.67±0.46 mg/L) and phosphorus (3.35±0.65 mg/kg) contents. This was followed by the sample from Bangkok, while the sample from Chiang Mai showed the lowest nutrient contents. These differences were statistically significant ($p<0.05$) (Table I). Moreover, the cation exchange value of the soil from Nakhon Ratchasima was also significantly higher than that of the soils from Bangkok and Chiang Mai ($p<0.05$) (Table I).

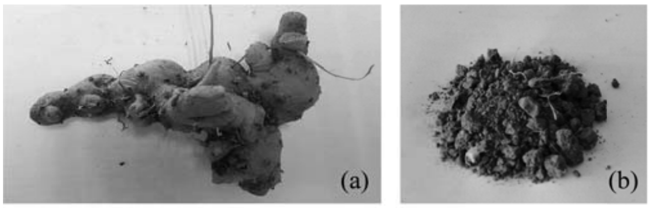

Fig. 2 The samples of Bangkok: (a) rhizome of *Z. zerumbet*, (b) soil sample

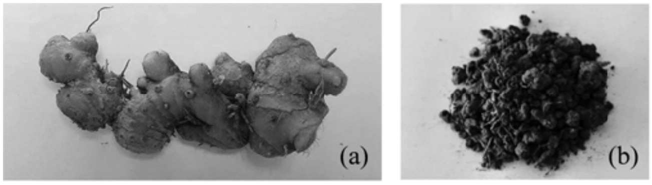

Fig. 3 The samples of Chiang Mai: (a) rhizome of *Z. zerumbet*, (b) soil sample

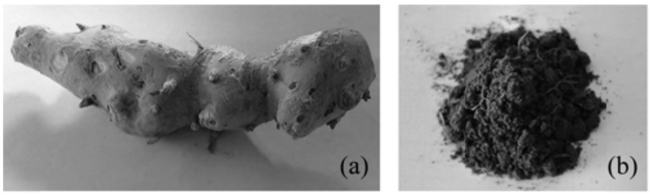

Fig. 4 The samples of Nakhon Ratchasima: (a) rhizome of *Z. zerumbet*, (b) soil sample

B. Antioxidant Efficiency of Essential Oils

The essential oil contents of *Z. zerumbet* from Nakhon Ratchasima, Bangkok and Chiang Mai were 1.41, 1.21 and 0.56%, respectively. The antioxidant activities of essential oils extracted from the rhizome *Z. zerumbet* were tested by DPPH radical scavenging activity at the 492 nm wavelength. The result showed that IC50 values of essential oils extracted from Nakhon Ratchasima, Chiang Mai and Bangkok were 1,400 μg/mL, 1,600 μg/mL and higher than 2,000 μg/mL, respectively. (Fig. 5)

C. The Active Components in Essential Oils

The chemical compositions of the essential oil of *Z. zerumbet* samples were analyzed using GC-MS. Zerumbone and Caryopyllene were found as major compounds in samples from Bangkok (Fig. 6) and Nakhon Ratchasima (Fig. 7). In contrast, Zerumbone, Terpinen-4-ol and Caryopyllene were predominantly found in the sample from Chiang Mai (Fig. 8). The essential oils and extracts of *Z. zerumbet* have been reported for their bioactivities that included anti-inflammatory, antioxidant, antidiabetic, anticancer, antimicrobial, analgesic, antimalarial, antiviral, antialzheimer diseases and dementia activities [1], [19].

The highest antioxidant activity was observed in essential oils of *Z. zerumbet* from Nakhon Ratchasima. Interestingly, the soil parameters that were examined in the present study also indicated that the soil sample from Nakhon Ratchasima was more fertile than the samples from Bangkok and Chiang Mai. This suggested that soil parameters could potentially influence the antioxidant activity of essential oils that were extracted from plants. This was consistent with a previous report which showed that utilization of different growing medium and fertilization regime affected the production of the essential oil content in rosemary [12].

TABLE I
SOIL PARAMETERS FROM THREE AREAS

Soil samples	Soil parameters				
	pH	nitrogen (%)	potassium (mg/L)	phosphorus (mg/kg)	CEC (cmol/kg)
Bangkok	5.88±0.03^{a}	0.15±0.01^{a}	15.35±0.50^{b}	3.10±0.31^{c}	12.78±1.05^{b}
Chiang Mai	5.42±0.05^{c}	0.14±0.05^{b}	14.45±2.90^{c}	3.27±0.15^{b}	12.14±0.35^{c}
Nakhon Ratchasima	6.10±0.03^{a}	0.15±0.04^{a}	16.67±0.46^{a}	3.35±0.65^{a}	12.87±0.11^{a}

Remark: Each value is the mean ± S.D. of three replicates. Different letters in the same row are significantly different ($p<0.05$)

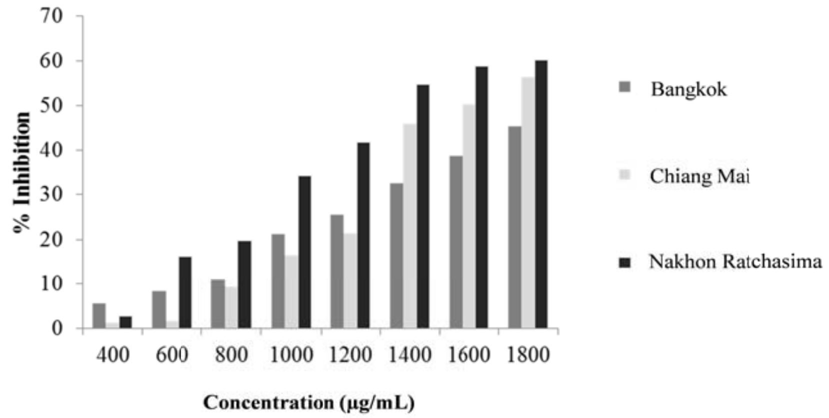

Fig. 5 Inhibition of antioxidant activity of essential oil from all three areas

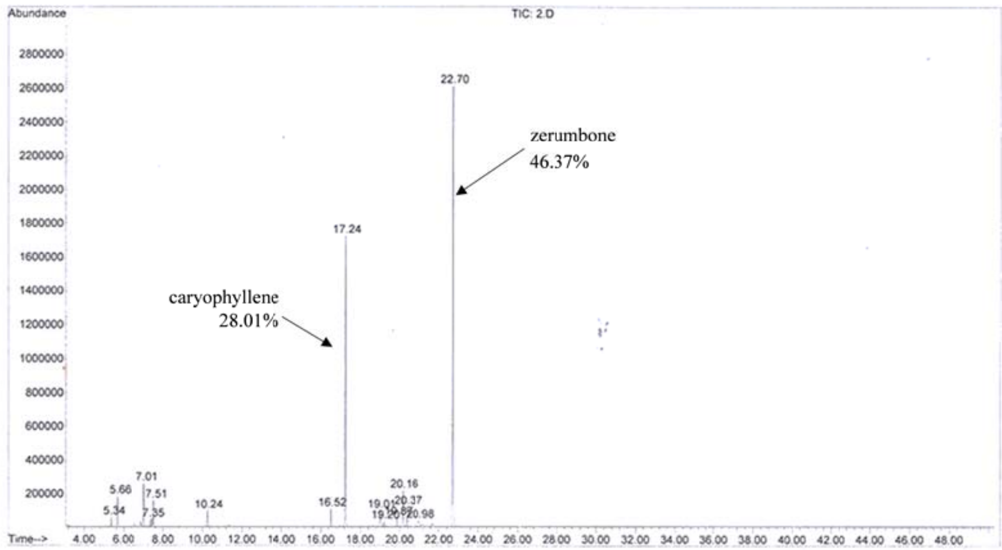

Fig. 6 GC-MS Chromatogram of essential oil from Bangkok

IV. CONCLUSION

The results obtained from this study showed a positive correlation between soil parameters and the antioxidant activity of plant essential oils. This was demonstrated by the high antioxidant activity observed in essential oils extracted from *Z. zerumbet* that was collected from Nakhon Ratchasima where soil parameters were more suitable for plant growth than those of Bangkok and Chiang Mai. More detailed study is needed to establish optimum conditions to increase essential oil production in *Z. zerumbet*.

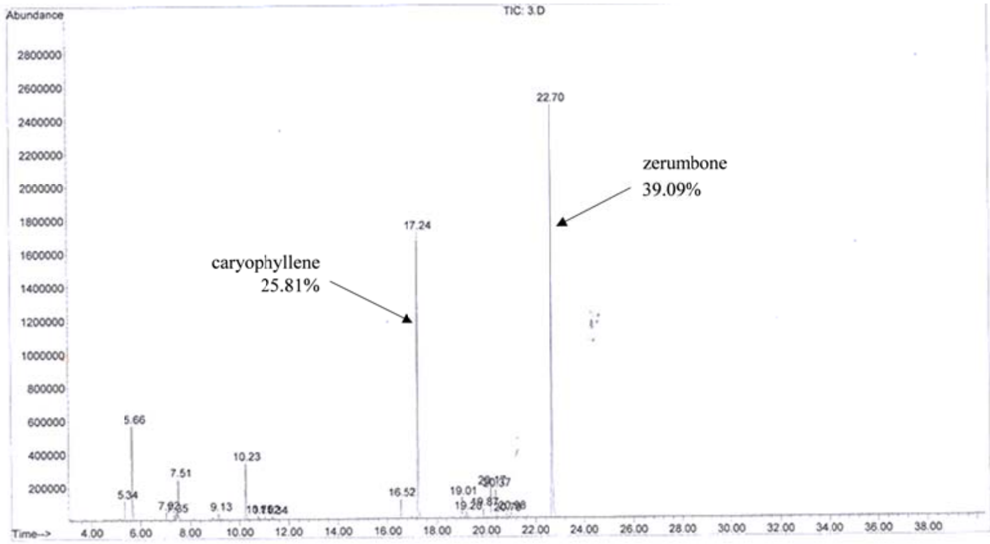

Fig. 7 GC-MS Chromatogram of essential oil from Nakhon Ratchasima

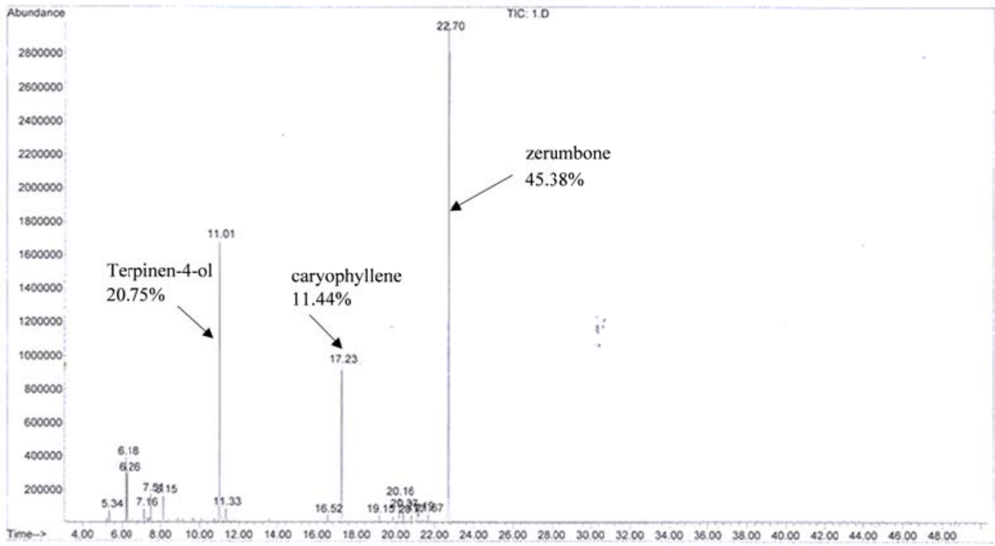

Fig. 8 GC-MS Chromatogram of essential oil from Chiang Mai

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