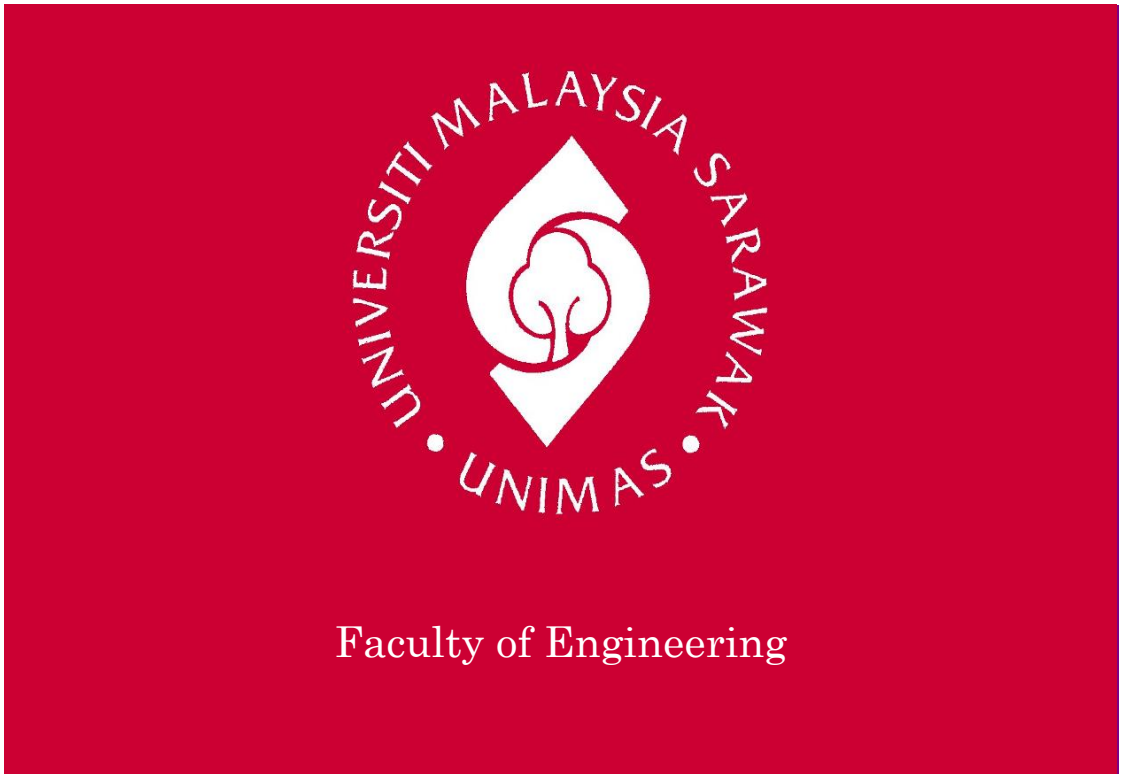

OPTIMIZATION AND KINETIC STUDY OF PLECTRANTHUS AMBOINICUS ESSENTIAL OIL EXTRACTION

SIM SIEW MING

Bachelor of Engineering with Honours

(Chemical Engineering)

2018

UNIVERSITI MALAYSIA SARAWAK

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_____

IR. DR. LIM SOH FONG
(Final Year Project Supervisor)

12th June 2018
Date

OPTIMIZATION AND KINETIC STUDY OF PLECTRANTHUS AMBOINICUS ESSENTIAL OIL EXTRACTION

SIM SIEW MING

A dissertation submitted in partial fulfilment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Chemical Engineering and Energy Sustainability)

Faculty of Engineering
Universiti Malaysia Sarawak

2018

Dedicated to my beloved parents and my family who always bestow me sustainable motivations and encouragements

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ABSTRACT

Plectranthus amboinicus leaves are the famous aromatic and medicinal herbs that widely used for medicinal purposes because they show antimicrobial, anti-inflammatory and antitumor properties. P. amboinicus essential oil plays an important role as naturally originated medicines that can be used as remedy to cure illness and diseases without bring any side effects on the patients. Thus, the aim of this project is to extract essential oil from *P. amboinicus* leaves by using microwave pre-treatment followed by hydrodistillation (HD) extraction method. This method is proven to save heating and extraction duration, cost and energy (Azadmard-damirchi et al., 2010). The *P. amboinicus* essential oil extracted was characterized by using Fourier Transform Infrared Spectrophotometer (FT-IR) and UV-Vis Spectrophotometer. From the FTIR result obtained, at frequency of 3600-3106 cm^{-1}, it shows the presence of phenolic –OH group in the *P. amboinicus* essential oil where thymol and carvacrol as the major phenolic components present in the essential oil. Besides, from Foulin-Ciocalteu method, a total of 2.92 mg/g of phenolic compounds were determined when a water-to-plant ratio of 20 was used. Moreover, a second order kinetic model proposed by Kusuma and Mahfud (2015) was fairly fitted to the experimental data. This means that the performance of hydrodistillation of *P. amboinicus* essential oil can be predicted by using this second order kinetic model. In the condition tested, the yield of *P. amboinicus* essential oil was optimised by using response surface methodology with the central composite design. There were three independent variables - the water-to-plant ratio, microwave pre-heating duration and microwave oven power with the yield of *P. amboinicus* essential oil as responding variable. From ANOVA analysis, the optimal conditions that yielded the highest production of *P. amboinicus* essential oil was microwave power of 260.86 W, microwave pre-heating duration of 3.83 min and water-to-plant ratio of 18.10.

ABSTRAK

Daun *Plectranthus amboinicus* adalah herba aromatik dan ubat-ubatan yang terkenal yang digunakan secara meluas untuk tujuan perubatan kerana ia menunjukkan sifat antimikroba, anti-radang dan antitumor. Minyak pati *P. amboinicus* memainkan peranan penting sebagai ubat-ubatan semula jadi yang boleh digunakan sebagai ubat untuk menyembuhkan penyakit tanpa membawa apa-apa kesan sampingan kepada pesakit. Oleh itu, matlamat projek ini adalah untuk mengekstrak minyak pati dari daun *P. amboinicus* dengan menggunakan pra-rawatan microwave diikuti dengan kaedah pengekstrakan hidrodistilasi (HD). Kaedah ini terbukti dapat menjimatkan masa pemanasan dan pengekstrakan, kos dan tenaga. Minyak pati *P. amboinicus* yang diekstrak dicirikan dengan menggunakan Spectrophotometer Inframerah Transformasi (FT-IR) dan Spektrofotometer UV-Vis. Dari hasil FTIR yang diperolehi, pada kekerapan 3600-3106 cm^{-1}, ia menunjukkan kehadiran kumpulan fenolik -OH dalam minyak pati *P. amboinicus* di mana thymol dan carvacrol adalah komponen fenolik utama yang terbukti hadir dalam minyak pati. Selain itu, dari kaedah Foulin- Ciocalteu, jumlah kandungan fenikol yang terdapat dalam minyak pati adalah tertinggi iaitu 2.917mg/g untuk nisbah air ke tumbuhan sebanyak 20. Selain itu, model kinetik kedua yang dicadangkan oleh Kusuma dan Mahfud (2015) paling sesuai untuk data eksperimen. Ini bermakna prestasi hidrodistilasi minyak pati *P. amboinicus* boleh diramalkan dengan menggunakan model kinetik urutan kedua ini. Selain itu, hasil minyak penting *P. amboinicus* dioptimumkan dengan menggunakan kaedah permukaan respon dengan reka bentuk komposit pusat. Terdapat tiga pembolehubah bebas - nisbah air ke tumbuhan, tempoh pra pemanasan gelombang mikro dan kuasa ketuhar gelombang mikro dengan hasil minyak pati *P. amboinicus* sebagai pemboleh ubah yang bertindak balas. Dari analisis ANOVA, keadaan optimum yang menghasilkan pengeluaran minyak pati *P. amboinicus* tertinggi ialah kuasa gelombang mikro 260.86W, tempoh pemanasan microwave 3.83 minit dan nisbah air kepada tanaman 18.10.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
FT-IR	-	Fourier Transfer Infrared Spectroscopy
HD	-	Hydrodistillation
IR	-	Infrared
MAHD	-	Microwave-Assisted Hydrodistillation
RMSE	-	Root-Mean-Square Error
RSM	-	Response Surface Methodology
SD	-	Steam Distillation
SFE	-	Supercritical Fluid Extraction
TPC	-	Total Phenolic Content

LIST OF NOMENCLATURES

%	-	Percent
°C	-	Degree Celcius
cm	-	Centimeter
cm^{-1}	-	Per centimeter
g	-	Gram
g/L	-	Gram per litre
kV	-	kiloVolt
m	-	Meter
mg GAE/ g	-	Milligram of Gallic Acid per gram of dry weight of extract
min	-	Minute
L	-	Litre
mL	-	Millilitre
mL/min	-	Millilitre per minute
mg/mL	-	Milligram per millilitre
mm	-	Millimeter
nm	-	Nanometer
µm	-	Micrometer
ppm	-	Parts per Million
s	-	Second
W	-	Watt

CHAPTER 1

INTRODUCTION

1.1 Background of Study

People nowadays concerns about living a healthy lifestyle. They prefer to consume natural products especially food, medicines and pharmaceutical products rather than that produced by synthetic chemicals because the natural product will not bring harmful effect to human health. Hence, natural essential oil that is usually found in plants such as rosemary, lavender, lemongrass and mint can replace synthetic chemical compounds in manufacturing healthy food and medicines. In addition, they are rich in nutrients and are commonly used as traditional medicines.

Plectranthus amboinicus (Mexican mint) which is a well-known aromatic perennial herb is used as medicines for centuries to cure asthma, coughs and diseases that caused by bacteria and virus (Ng, Wahida, & Chong, 2014). Apart from that, *P. amboinicus* is found to be very useful in medical fields where it exhibits anti-tumorigenic, anti-inflammatory, antimicrobial and antiviral properties against herpes virus-1 (Costa, Pereira, Rodrigues, & Lima, 2010). It also can be used to treat digestive, urinary, skin and respiratory problems such as bronchitis. This shows the importance of *P. amboinicus* essential oil towards human being in medicinal and pharmaceutical fields.

Hence, this research mainly studies the optimisation and mathematical kinetic modelling of the extraction of essential oil from *Plectranthus amboinicus* leaves by using hydrodistillation method aided by microwave pre-treatment.

1.2 Problem Statement

According to Fernandes et al. (2013), *P. amboinicus* is one of the most well-known medicinal herbs that have been used for centuries because it exhibits anti-microbial, balsamic and anti-inflammatory properties. The essential oil of *P. amboinicus* shows good inhibition activities on both acute and chronic inflammatory processes and also not induce any side effects during the treatment process (Manjamalai, Alexander, & Grace, 2012). Besides, this medicinal plant also contributes in medicinal fields where it possesses bronchodilator, anti-bacterial, antiviral, anti-fungal and anti-tuberculous properties. Apart from that, based on the study from Senthilkumar & Venkatesalu (2010), the essential oil from *P. amboinicus* was proven can be used to reduce the population of malarial vector mosquito A. stephensi. This finding benefits the countries of Africa and Asia that suffer from malaria disease which is known as a killer disease within those countries because *P. amboinicus* essential oil is a natural and inexpensive mosquito larvicidal agent that can be used to control the spread of malaria vector mosquito among people (Senthilkumar & Venkatesalu, 2010). Since the usage of modern medicines and drugs in the treatment of chronic diseases might lead to various and severe side effects on the patient, thus the application of naturally originated medicines are more favourable recently (Ng et al., 2014). Hence, the essential oil from *P. amboinicus* plays an important role as the remedy to cure illness and diseases nowadays.

The *P. amboinicus* essential oil extraction is most commonly performed using hydrodistillation method. This method is a conventional method that is quite time-consuming for full extraction process; energy consuming and also costly to conduct since the overall heating durations typically takes two to three hours (Manjamalai et al., 2012). Apart from that, even though Soxhlet method can also be used for *P. amboinicus* essential oil extraction, however, this method involved solvents such as ethanol, n-hexane or diethyl ether in the extraction process and the extraction time is too long which is four to six hours (Ng et al., 2014). Therefore, in this study, the microwave pre-treatment of the leaves is suggested before the hydrodistillation process. With the aid of microwave oven during pre-heating process, the extraction process will be sped up. This is because the glands that contain essential oil will break during the microwave pre-heating process and this will directly shorten the extraction time since the time for the release of essential oil from the gland will be greatly decreased. Thus, this method will

directly save both energy and cost in extracting the *P. amboinicus* essential oil. Besides, to the best of author's study, there are no optimization and kinetic study on *Plectranthus amboinicus* essential oil extraction. Hence, this project is important to study the extraction of *P. amboinicus* essential oil by microwave aided hydrodistillation despite optimizing and study the kinetics of essential oil extraction.

1.3 Research Objectives

The main aim of this research is to extract essential oil from *Plectranthus Amboinicus* leaves with the following objectives:

i. To extract *P. amboinicus* essential oil by using microwave pre-treatment and hydrodistillation (HD) extraction method;
ii. To characterize the *P. amboinicus* essential oil by using analytical instruments and methods;
iii. To study the kinetics of the extraction of *P. amboinicus* essential oil by hydrodistillation method; and
iv. To optimize the yield of *P. amboinicus* essential oil by using response surface methodology (RSM).

1.4 Scope of Study

This study focused on the extraction of the *P. amboinicus* essential oil by hydrodistillation method aided by microwave pre-treatment. Since hydrodistillation method involves no chemical solvent but only distilled water, thus the factors that may influence the extraction yield of essential oil from *P. amboinicus* leaves are the water-to-plant ratio, microwave pre-heating time and microwave power. These three variables are the important operating parameters that need to be investigated in optimizing the yield of *P. amboinicus* essential oil. Besides, the functional groups that present in the *P. amboinicus* essential oil is identified by using FT-IR and the total phenolic content that present in the essential oil is identified by using UV-Vis spectrophotometer. Also, the kinetic studies and kinetic modelling of the *P. amboinicus* essential oil are also being performed.