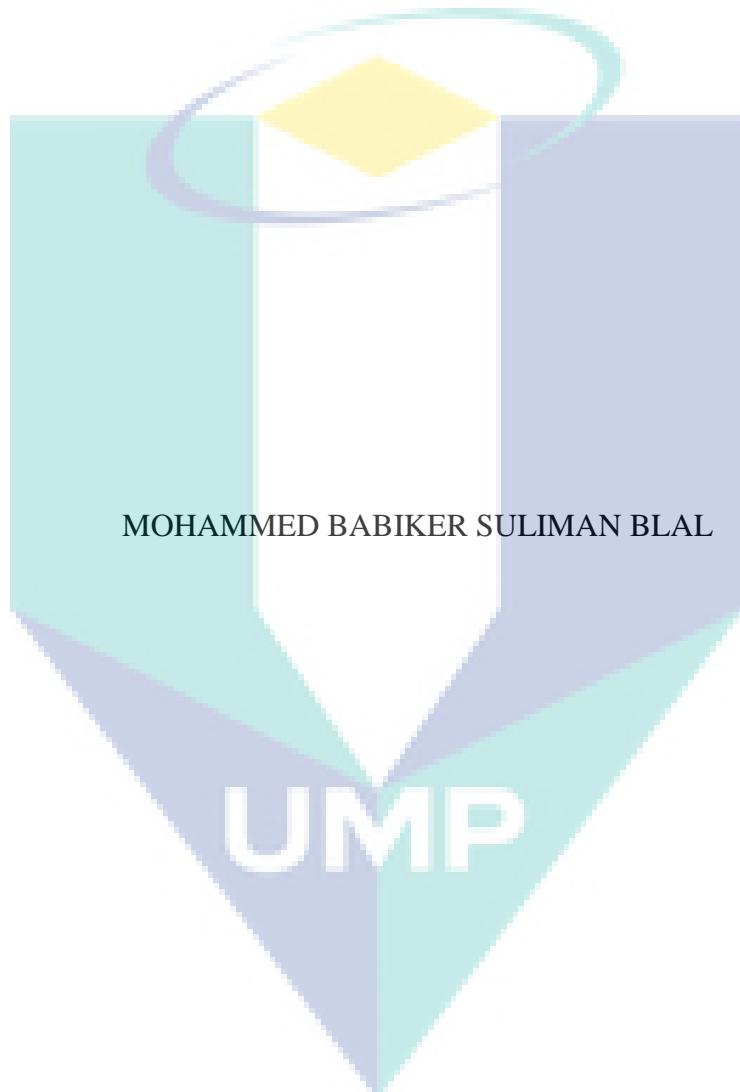


INVESTIGATION OF ANTIMICROBIAL ACTIVITY, BIOASSAY-GUIDED
ISOLATION AND IDENTIFICATION OF ANTIMICROBIAL COMPOUNDS
FROM *SWIETENIA MACROPHYLLA* KING



DOCTOR OF PHILOSOPHY (INDUSTRIAL CHEMISTRY)

UNIVERSITI MALAYSIA PAHANG

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FROM *SWIETENIA MACROPHYLLA* KING

MOHAMMED BABIKER SULIMAN BLAL

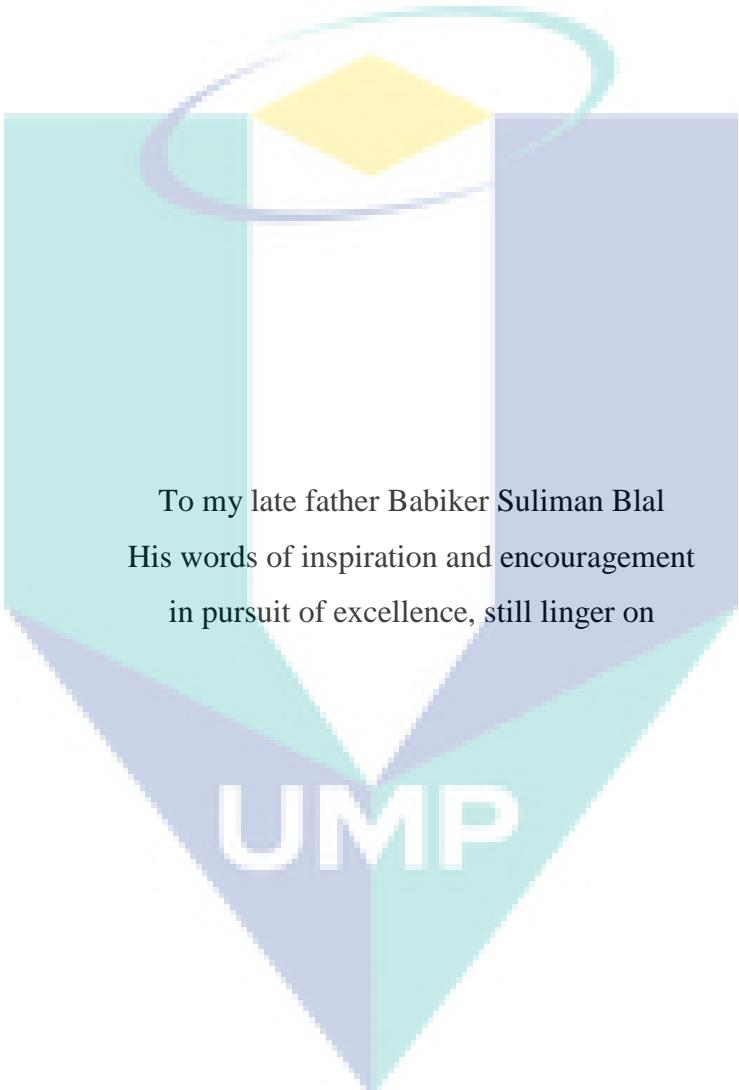
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Doctor of Philosophy in Industrial Chemistry

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Faculty of Industrial Sciences and Technology
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JULY 2016

DEDICATION



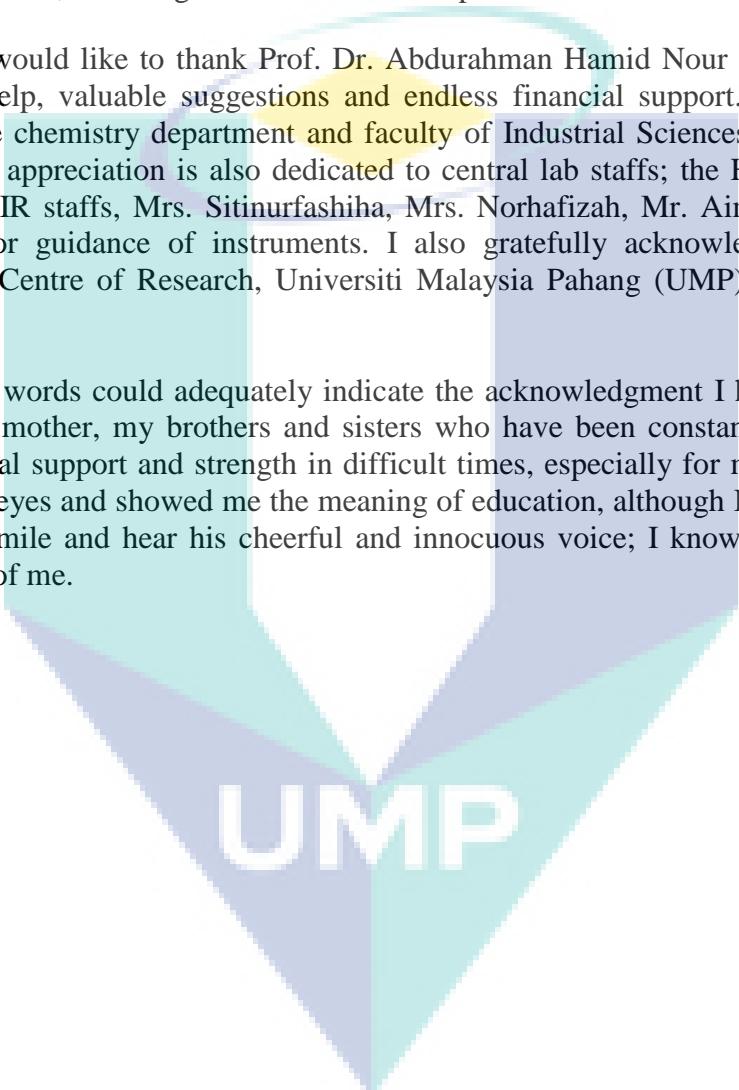
To my late father Babiker Suliman Blal
His words of inspiration and encouragement
in pursuit of excellence, still linger on

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First and foremost, I would like to express my deepest gratitude to Allah for providing me all types of infinite blessings and patience to finalize this project. Meanwhile, I take pride to convey my heartfelt respect and most sincere appreciation in acknowledging my supervisor Dr. Azhari Hamid Nour, for his kind guidance, precious understanding and constant encouragement throughout my research work. I am also heartily appreciative and grateful to my co-supervisor Prof. Dr. Mashitah Mohd Yusoff for her high expectation, encouragement and mentorship.

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ABSTRACT

The plant genus *Swietenia* of which *Swietenia macrophylla* (Family: Meliaceae) belongs to, is a large *mahogany* tree growing in the rainforest of Malaysia and widely used in traditional medicine to treat various diseases. In this study, the physicochemical properties of the lipid, phytochemical and antimicrobial activity of extracts and fractions from *Swietenia macrophylla* were investigated. Then the compounds from the most active fraction were isolated and identified. The Minimum Inhibitory Concentrations (MIC) of these compounds were also identified. The dried plant parts (seeds, leaves, stems and roots) were subjected to maceration and later the most active crude extract (seeds extract) was fractionated into different classes according to the polarity with various solvents. The seed oil was extracted by solvent semi-continuous extraction method (Soxhlet) with hexane for six hours. The volatile compounds were identified in the extracts by GC-MS analysis, and the physicochemical properties of the seed oil were determined according to the standard methods. In the antimicrobial test, all the crude, fractions, seed oil and isolated compounds were investigated against nine microorganisms (all were lab strains) by using agar diffusion method. The microbes were: six bacteria, namely; *Staphylococcus aureus*, *Bacillus subtilis*, *Enterococcus faecalis*, *Salmonella typhi*, *Pseudomonas aeruginosa*, and *Escherichia coli*; and three funguses namely; *Candida albicans*, *Aspergillus flavus* and *Aspergillus niger*. The isolation and purification of active compounds has been carried out using chromatographic techniques (analytical HPLC and preparative-LC), and the structure elucidation of the isolated compounds based on spectroscopic techniques including, MS, IR and NMR. The GC-MS results showed three, five, eight, and ten compounds in the roots, stems, leaves, and seeds, respectively. The predominant compound existed in the all extracts was palmitic acid, with relative abundances of 2.03% (roots), 5.79% (seeds), 6.40% (stems), and 14.15% (leaves). The major compound in each part as: 1-tetradecene (18.08%); phytol (19.68%); linoleic acid (39.76%) and stearic acid (52.0%) for the stems, leaves, seeds and roots respectively. The physicochemical properties of the seeds oil were refractive index (1.46), specific gravity (0.954), viscosity (412.7), iodine value (71.5 mL/g), saponification value (211.75. mg KOH/g) and peroxide value (3.25%) are an attribute of the oil to be used for industrial purposes, such as in manufacturing of paint, varnish, and ink industries. The antimicrobial activity among the extracts was extremely broad against all tested organisms. Overall, among the crude extracts, the seeds extract showed more potent as antimicrobial activity than other parts against most tested microbes, whereas within fractionated seed fractions; fraction 3 (ethyl acetate fraction) is more potent. Compounds isolation and structural elucidation of the most bioactive fraction yielded four limonoids, namely swietenolide (**1**), proceranolide (**2**), 3-*O*-tigloyl-6-*O*-acetylswietenolide (**3**) and swietenine acetate (**4**). Among the isolated limonoids, swietenolide (**1**) showed highest activity against all of the tested organisms. The MIC values of the compounds ranged from 4 to 256 µg/mL. Conclusively, these results suggested that limonoids present in *S. macrophylla* were associated with antimicrobial activity. This provides the scientific evidence for the possible use of limonoids derived from *S. macrophylla* as a source of herbal antimicrobial agent(s).

ABSTRAK

Kumpulan tumbuhan *Swietenia* yang berasal dari *Swietenia macrophylla* (Keluarga: Meliaceae) ialah sebuah pokok *mahogany* besar yang tumbuh dalam hutan Malaysia dan digunakan secara meluas dalam perubatan tradisional bagi merawat pelbagai penyakit. Dalam kajian ini, sifat fizikokimia lipid, fitokimia dan aktiviti antimikrobial ekstrak dan pecahan dari *Swietenia macrophylla* telah disiasat. Kemudian sebatian daripada pecahan yang paling aktif telah diasingkan dan dikenal pasti. Kepekatan Perencatan Minimum (MIC) sebatian ini juga telah dikenal pasti. Kemudian sebatian daripada bahagian yang paling aktif telah diasingkan dan dikenal pasti. Bahagian tumbuhan yang dikeringkan (benih, dedaun, tangkai dan akar) adalah tertakluk kepada pemaseratan dan kemudiannya, esktrak mentah yang paling aktif (ekstrak biji) dipecahkan kepada kelas berlainan mengikut keikutuban dengan pelbagai bahan pelarut. Minyak dari benih diekstrak menggunakan kaedah pengekstrakan pelarut separaselanjar (Soxhlet) dengan heksana selama enam jam. Sebatian meruap dalam ekstrak dikenalpasti melalui analisa GC-MS dan sifat fizikokimia minyak benih ini ditentukan mengikut kaedah umum. Dalam ujian antimikrobial, segala bahan mentah, pecahan, minyak benih dan sebatian terasing telah dikaji terhadap sembilan mikroorganisma (segalanya adalah strain makmal) dengan menggunakan kaedah resapan. Mikrob terlibat adalah enam bakteria, iaitu: *Staphylococcus aureus*, *Bacillus subtilis*, *Enterococcus faecalis*, *Salmonella typhi*, *Pseudomonas aeruginosa*, dan *Escherichia coli*; serta tiga kulat, iaitu: *Candida albicans*, *Aspergillus flavus*, dan *Aspergillus niger*. Pengasingan dan pemurnian sebatian aktif telah dijalankan menggunakan teknik kromatografi (analisa dan sediaan HPLC) dan struktur penjelasan sebatian terasing berdasarkan teknik spektroskopik adalah termasuk MS, IR dan NMR. Keputusan GC-MS menunjukkan tiga, lima, lapan dan sepuluh dalam akar, tangkai, dedaun dan benih. Sebatian pradominan yang wujud dalam kesemua ekstrak adalah asid palmitic, dengan limpahan relatifnya adalah 2.03% (akar), 5.79% (benih), 6.4% (tangkai), dan 14.15% (dedaun). Sebatian utama dalam setiap bahagian adalah 1-tetradecene (18.08%); fitol (19.68%) asid linoleik (39.76%) dan steric asid (52.0%) bagi tangkai, dedaun, benih dan tangkai. Ciri-ciri fizikokimia minyak benih adalah indeks biasan (1.46), graviti tentu (0.954), kelikatan (412.7), nilai iodin (71.5 mL/g), nilai saponifikasi (211.75. mg KOH/g) dan nilai peroksida (3.25%) yang merupakan ciri-ciri minyak yang digunakan dalam industri seperti penghasilan cat, varnis dan industri dakwat. Aktiviti mikrobial antara sebatian adalah berkesan terhadap setiap organisme yang diuji. Secara keseluruhannya antara ekstrak mentah, ekstrak benih adalah lebih berkesan untuk aktiviti mikrobial berbanding bahagian lain yang diuji terhadap mikrob yang kerap diuji sementara di antara pecahan benih; pecahan 3 (pecahan etil asetat) adalah lebih sesuai. Pengasingan sebatian dan penjelasan struktur pecahan bioaktif yang paling banyak menghasilkan empat limonoid iaitu swietenolide (**1**), proceranolide (**2**), 3-*O*-tigloyl-6-*O*-acetylswietenolide (**3**) dan swietenine acetate (**4**). Antara limonoid yang terasing, swietenolide (**1**) menunjukkan aktiviti tertinggi terhadap semua organisme yang diuji. Nilai MIC dalam sebatian adalah di paras 4 hingga 256 $\mu\text{g}/\text{mL}$. Secara kesimpulannya, keputusan ini mencadangkan bahawa limonoid yang wujud dalam *S. macrophylla* berhubungkait dengan aktiviti mikrobial. Ini memberikan bukti saintifik untuk kebarangkalian penggunaan limonoid yang berhasil dari *S. macrophylla* sebagai sumber ejen antimikrobial herba yang selamat.

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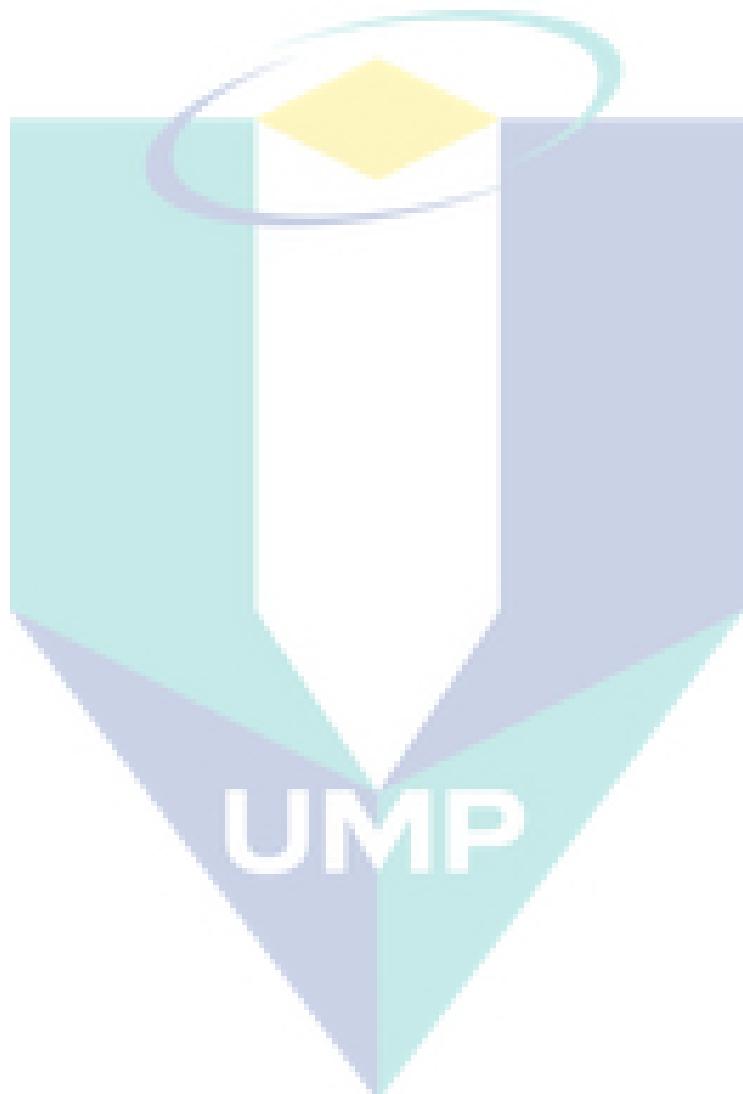
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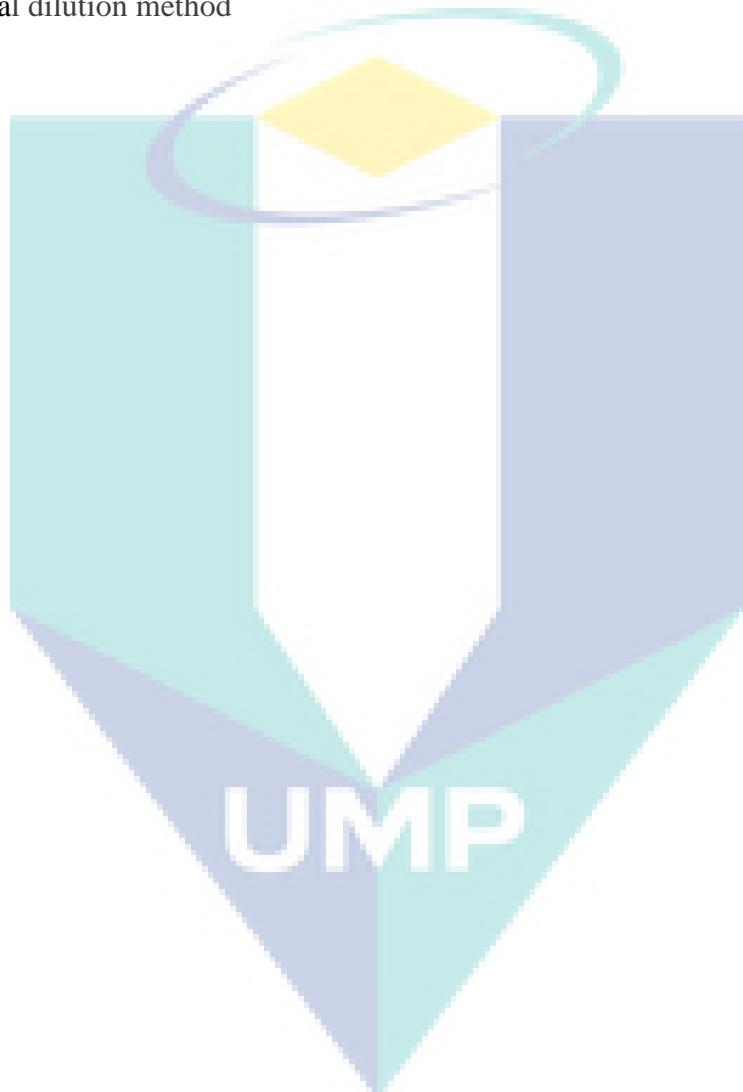
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LIST OF SYMBOLS

%	Percentage
=	Equals
° C	Degree Celsius
° C/min	Degree Celsius per minute
µg	Micro gram
µg/mL	Micrograms per milliliter
cm	Centimeter
cm ⁻¹	Reciprocal centimeter
eV	Electron volt
g	Gram
w/w	Weight per weight
g/L	Gram per liter
g/mol	Gram/mol
GHz	Gigahertz
h	Hour
Hz	Hertz
L	Liter
m	Meter
m/z	Mass-to-charge ratio
Meq/kg	Milliequivalents per kilogram
mg	Milligram
mg/g	Milligram per gram
mg/kg	Milligram per kilogram
mg/ml	Milligram per milliliter

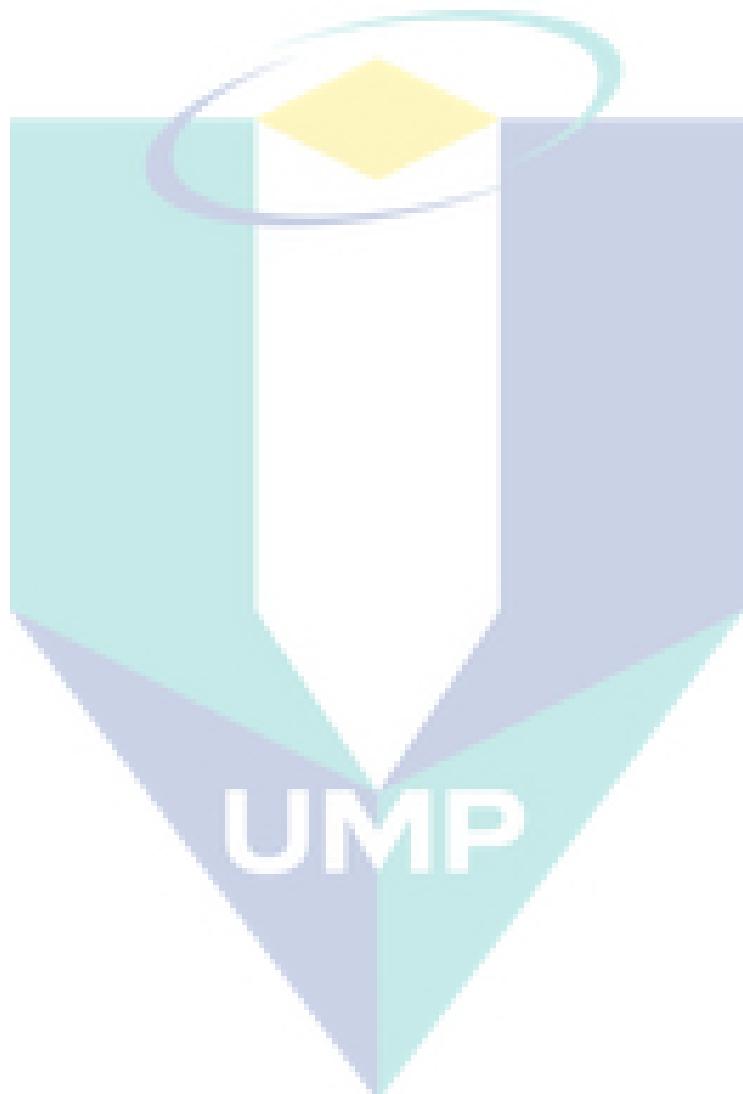
min	Minutes
mL	Milliliter
mL/min	Milliliter per minute
N	Normality
s	Seconds
V	Volt
v/v	Volume per volume
w/v	Mass per volume ratio
w/w	Weight per weight
Wt%	Weight percentage
δ	Chemical shifts
λ_{\max}	Lamda maximum

LIST OF ABBREVIATIONS

SF	Seed fraction
¹³ C-NMR	Carbon nuclear magnetic resonance
1D-NMR	One dimensional carbon nuclear magnetic resonance
¹ H-NMR	Proton nuclear magnetic resonance
2D-NMR	Two dimensional carbon nuclear magnetic resonance
ANOVA	One way analysis of variance
br	Broad resonance
br s	Broad singlet
C	Carbon
COSY	Correlated spectroscopy
d	Doublet
DAD	Diode array detector
dd	Doublet of doublets
DEPT	Distortionless enhancement by polarization transfer
DMSO	Dimethyl sulfoxide
dt	Doublet of triplets
<i>E. coli</i>	<i>Escherichia coli</i>
EI-MS	Electron ionization-mass spectrometry
et al.	And others
FFA	Free fatty acid
FID	Flame ionization detector
FTIR	Fourier transformed infrared Spectrometer
GC	Gas chromatography
GC-MS	Gas chromatography-mass spectrometry

H	Hydrogen
HETCOR	Hetronuclear correlation spectroscopy
HMBC	Hetronuclear multiple bond correlation
HMQC	Hetronuclear multiple quantum correlation
HPLC	High performance liquid chromatography
IR	Infrared
LC-MS	Liquid chromatography-mass spectrometry
m	Multiplet
MS	Mass spectrometry
NA	Nutrient agar
NMR	Nuclear magnetic resonance
<i>P. aeruginosa</i>	<i>Pseudomonas aeruginosa</i>
q	Quartet
s	Singlet
<i>S. aureus</i>	<i>Staphylococcus aureus</i>
<i>B. subtilis</i>	<i>Bacillus subtilis</i>
<i>S. macrophylla</i>	<i>Swietenia macrophylla</i>
<i>E. faecalis</i>	<i>Enterococcus faecalis</i>
<i>A. flavus</i>	<i>Aspergillus flavus</i>
<i>S. typhi</i>	<i>Salmonella typhi</i>
Soxhelt	Solvent semi-continuous extraction
SPSS	Statistical package for the social sciences
t	Triplet
TLC	Thin layer chromatography
USA	United States of America

USDA	United State Department of Agriculture
UV	Ultraviolet spectrometry
API	American Petroleum Institute



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CHAPTER 1

INTRODUCTION

1.1 Introduction

The aim of presenting this chapter is to present the motivation and problem statement, objectives and scopes of the research together with the significance and contribution of the research. All these aspects will be the foundation to further discover the research.

1.2 Research Background and Problem Statement

Nowadays, diseases transmitted by microbes such as fungi and bacteria are one of the health problems in many countries worldwide. *Gram-positive* bacteria such *Staphylococcus aureus* causes several serious problems such as food poisoning, post-operative, endocarditis, osteomyelitis and wound infections (Benayache et al., 2001). *Gram-negative* bacteria such as *Pseudomonas aeruginosa* is mainly responsible for urinary tract infections, ventilator-associated pneumonia, surgical site infection, respiratory infections, ocular infections and burn sepsis (Brooks et al., 2007). In the past 60 years, effective antibiotic agents to treat most of the infections and diseases caused by bacteria are commercially available (Brooks et al., 2007). However, the indiscriminate use of available antimicrobial drugs, the wide and long use of antimicrobial drugs, the specific nature of the relationship of bacteria to antimicrobial drugs and environment factor led some bacteria to develop resistance to commercially available antimicrobial agents.

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