ANTIMICROBIAL ACTIVITY AND PHYTOCHEMICAL PROFILES OF *WARBURGIA UGANDENSIS* SPRAGUE (CANELLACEAE) EXTRACTS FROM DIFFERENT POPULATIONS ACROSS THE KENYAN RIFT VALLEY

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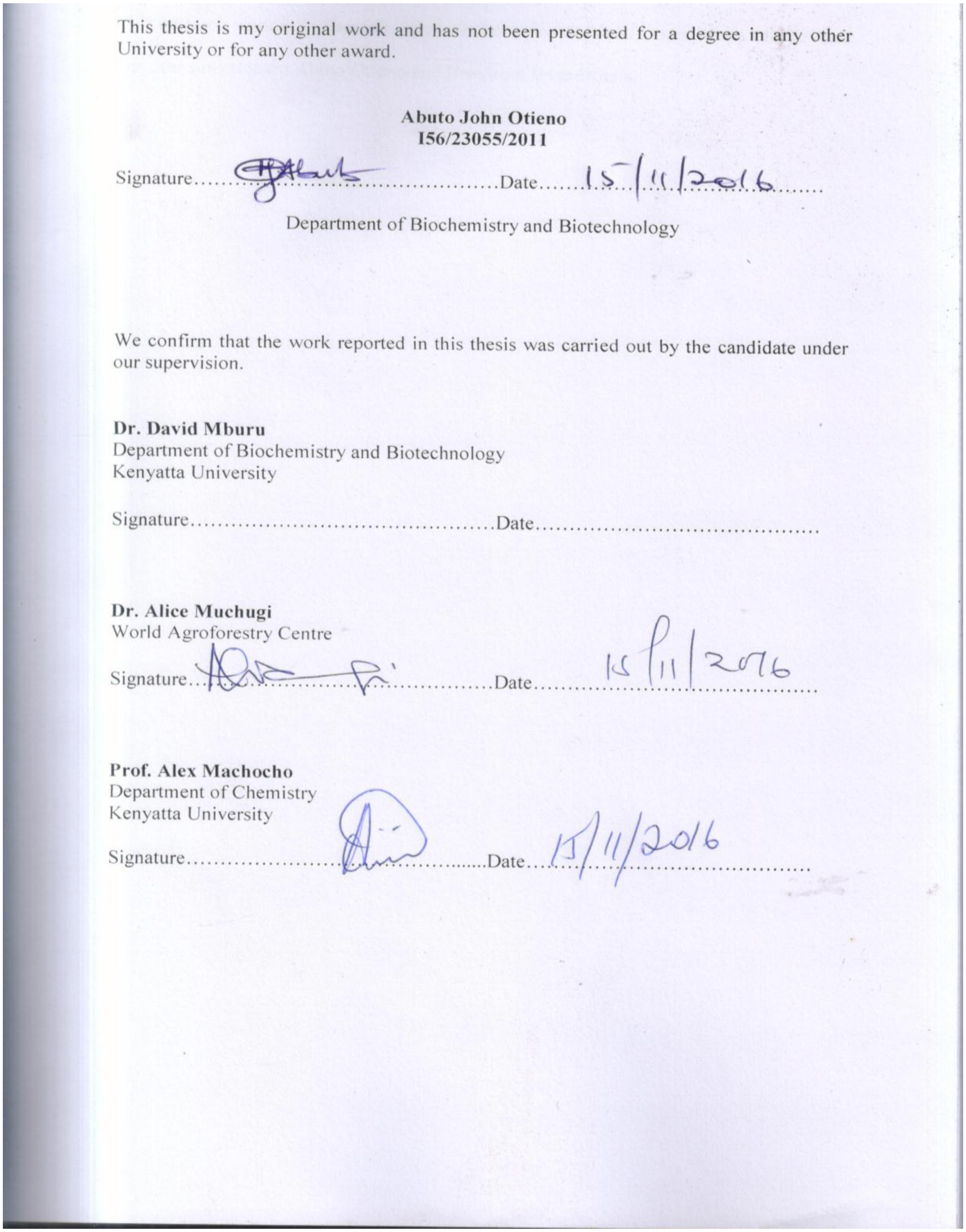
DECLARATION



This thesis is my original work and has not been presented for a degree in any other University or for any other award.

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DEDICATION

This research work is dedicated to my beloved wife and friend Dorca Auma Murono and our dear sons Benard Abuto Otieno and Benjamin Jesse Otieno.

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AR	Analytical Reagent
ATCC	American Type Culture Collection
CFU	Colony Forming Units
CMR	Centre for Microbiology Research
C 30	Chloramphenicol at a dose of 30µg per disk
DBH	Tree Diameter at Breast Height
DCM	Dichloromethane
DMSO	Dimethyl Sulphoxide
FL 25	Fluconazole at a dose of 25µg per disk
GC-MS	Gas Chromatography Mass Spectrometry
GPS	Global Positioning System
HSD	Honest Sigificant Difference
IBM	International Business Machines
ICRAF	International Centre for Research in Agroforestry
ID	Identification
KEBS	Kenya Bureau of Standards
KEMRI	Kenya Medical Research Institute
LV	Leaves
MeOH	Methanol
MHA	Mueller-Hinton Agar
MIC	Minimum Inhibitory Concentration
NIST	National Institute of Standards and Technology
PSMs	Plant Secondary Metabolites
PUFAs	Polyunsaturated Fatty Acids
R.A	Relative Abundance
SB	Stem Barks
SEM	Standard Error of Mean

SPSS	Statistical Package for Social Sciences

ABSTRACT

Warburgia ugandensis Sprague is a highly valued medicinal plant which is over-exploited for its medicinal use among many communities. Encroachment and fragmentation of the species habitat has led to a notable decrease in its population size and distribution to the level that warrant some conservation efforts. Moreover, information on diversity in its antimicrobial activity and phytochemical profiles is lacking. The aim of this study was to evaluate variations in antimicrobial activity and phytochemical profiles of leaf and stem bark extracts of *W. ugandensis* from different populations across the Kenyan Rift using different extraction solvents. The plant materials were collected, washed, dried at room temperature, milled into fine powder and sequentially extracted with dichloromethane (DCM) and methanol (MeOH). The antimicrobial activity tests against *Staphylococcus aureus (*ATCC 25923), *Escherichia coli* (ATCC 25922) and *Candida albicans* (ATCC 90028) were carried out using disk diffusion and ninety six well microtitre plate assays. Antimicrobial activities were qualitatively and quantitatively assessed by the presence or absence of inhibition zones and minimum inhibitory concentration (MIC) values. The MIC values were determined by correlating the minimum diameter of zone of inhibition with the lowest concentration of the extract at which no visible microbial growth was noted. Phytochemical profiles in the extracts were determined using GC-MS system. *Staphylococcus aureus* and *Candida albicans* were susceptible to the plant extracts while *Esherichia coli* was resistant.The stem bark extracts displayed the highest antimicrobial activity compared to the leaf extracts. The DCM extracts exhibited stronger antimicrobial activity compared to MeOH extracts. Preliminary bioassay screening using disk diffusion method showed that DCM stem bark extracts from Kitale and Rumuruti were the most active against *S. aureus* and *C. albicans* with mean zone of inhibition of 19.75mm, respectively. The MIC analyses with ninety six well microtitre plate assay revealed that DCM stem bark extracts from Londiani, Rumuruti, Kitale and Kinale were the most active against *C. albicans* with mean MICs of 0.11 ± 0.03, 0.32 ± 0.10, 0.47 ± 0.12 and 0.56 ± 0.20mg/ml, respectively. The DCM stem bark extracts from Rumuruti and Karura were the most active against *S. aureus* with mean MICs of 1.43 ± 0.28 and 1.47 ± 0.36mg/ml, respectively. This study revealed significant differences in antimicrobial activity among extracts of *W. ugandensis* from different parts and regions (populations) ($p < 0.05$). The plant sites, samples, parts, solvent types and their interactions had significant effects on antibacterial and antifungal activities. Quantitative and qualitative differences were observed in the phytochemical profiles of the Kenyan populations of *W. ugandensis*. Sesquiterpenoids (30.25-56.76%), fatty acid derivatives (9.48-22.50%) and monoterpenoids (0.83-15.97%) were the most dominant classes of compounds. Other classes of compounds identified included diterpenoids, triterpenoids, phytosterols, tocopherols, ketones, aldehydes, carbohydrate derivatives, phenolics, furans, furanones, pyrans, coumarins, benzene derivatives, alkaloids, flavonoids, anthracenes, phenanthracenes and naphthalene derivatives. The observed variation in the antimicrobial activity could be linked to the diversity in the phytochemical profiles of this plant species. This study recommends sustainable utilization of *W. ugandensis* as an antimicrobial agent. There is also need to develop efficient conservation strategies for the Kenyan populations of *W. ugandensis*.

CHAPTER ONE

INTRODUCTION

1.1 Background information

Natural products and secondary metabolites formed from living systems, notably from plant origin, have shown great potential in treating various human diseases and pathogenic infections (Lai *et al.,* 2010). Natural products are an important source of new antimicrobial agents. Drugs obtained from unmodified natural products or semi synthetic drugs obtained from natural sources accounted for 78% of the new drugs approved by the United States Food and Drug administration (US FDA) between 1983 and 1994. This evidence contributes to the support and quantification of the importance of screening natural products (Suffredini *et al.,* 2006). According to the World Health Organization (WHO), 65-80% of the world's population relies on traditional medicine to treat various diseases (Gurinder and Daljit, 2009). To date, many plants have been found to possess beneficial health effects such as antioxidant, anti-mutagenic, anti-inflammatory and antimicrobial properties. Due to the emergence of multiple drug resistant strains of pathogens as a result of indiscriminate use of antibiotics to treat infectious diseases, great interests are being regenerated in herbal medicine (Gurinder and Daljit, 2009).

Phytochemicals, being natural and non-nutritive bioactive compounds are produced by plants as protective agents against external stress and pathogenic attack hence are source for plant defense and survival (Chew *et al.,* 2009). Based on their biosynthetic origin, phytochemicals can be classified as phenolics, alkaloids, flavonoids, terpenes, saponins and tannins among others. According to Ullah *et al.* (2012), medicinal plants produce secondary metabolites that are responsible for their therapeutic properties but the presence of these molecules and conversely, their activities are affected by environmental factors like geographical locations, fertility of cultivars, parts used, season and time of collection. Nikolic and Zlatkovic (2010) noted that chemical profiles of plants and the accumulation levels of special metabolites in plant tissues can be influenced by factors such as temperature, light quality and light intensity. Thus, the yield and composition of secondary metabolites within species vary between plants from different geographical locations and may be influenced by environmental and genetic differences (White, 2006).

Generally, many medicinal plants used by different communities for treating a variety of medical conditions are in existence. One such plant is *Warburgia ugandensis* Sprague, which is a highly valued species within the traditional health systems of the communities where it naturally occurs (Kokwaro, 1976; Beentje, 1994). The species is rated second among the top ten priority species according to utility and sustainable use (Kariuki and Simiyu, 2005). *Warburgia ugandensis* trees are found mainly within natural forests but most of these forests are being degraded by anthropogenic activities. The plant materials used in herbal remedies are nearly exclusively harvested from the wild and this threatens their survival (ICRAF, 1992). Joshi and Joshi (2000) and Tabuti *et al.* (2003) noted that threats to sustainable use of this species in Kenya include high population growth rate, unemployment, poverty, environmental degradation, competing land uses, lack of indigenous knowledge, intensified commercialization of traditional medicine and high demand for medicinal plants in the local and international markets due to low prices.

Although a highly valuable species, *W. ugandensis* is being destroyed due to the high demand for the medicine extracted from the bark, roots, young twigs, leaves and fruit for use by traditional healers (Beentje, 1994). The tree species has a high medicinal value both for humans and livestock, exhibiting broad spectrum antimicrobial activity. The medicinal significance of this species is linked to the presence of drimane sesquiterpenes such as warburganal (Haraguchi, 1998), muzigadial, polygodial (Taniguchi and Kubo, 1993), ugandensidial and mukaadial (Mashimbye *et al.,* 1999). Therefore, to develop sustainable management strategies for conservation and utilization of the tree species, there is need to assess the existence of regional variation in the profiles of its phytochemicals in Kenya.

1.2 Statement of the problem and justification

Warburgia ugandensis is one of the valuable medicinal trees found in Africa. The species is facing threat of destruction due to poor harvesting methods and over-exploitation by traditional medicinal practitioners based on its wide application in treatment and management of various diseases and use as timber. Encroachment and fragmentation of *W. ugandensis* habitat have led to notable decrease in its population size to the level that warrants some conservation efforts. Previous studies have shown significant regional genetic differentiation within and among *W. ugandensis* populations with regard to eastern and western arms of the Kenyan Rift Valley to the level of suggesting speciation (Muchugi *et al.,* 2008; Muchugi *et al.,* 2012). It is not known if such regional differentiation also exists in its antimicrobial activity and phytochemical profiles.

Currently, there is little pharmacological data linking the traditional medicinal uses of the plant with its phytochemical profiles in Kenya. Though widely used in traditional medicine therapy, there is no published documentation showing variation in antimicrobial activity and phytochemical profiles of extracts of *W. ugandensis* from different populations in Kenya. The diversity in abundance of active phytochemicals expressed in the species in Kenya is also not documented. Moreover, there is no scientific data showing how the compounds in this particular species vary.

The knowledge on antimicrobial activity and phytochemical profiles of extracts of *W. ugandensis* from different populations across the Kenyan Rift Valley will help to identify plants showing high bioactivity with regard to the percentage relative abundance of the active compounds expressed in the species. This will assist in designing strategies to identify suitable genotypes of the plant species in the genus *Warburgia.* Some plant parts can be more sustainably harvested than others. Therefore, it is important to assess levels of expression of these active compounds in different parts of *W. ugandensis*. The knowledge gained will ensure the possibility of targeted harvesting, conservation and utilization strategies for the species. Findings from this study will be valuable in providing data that will support the existing information on the use of *W. ugandensis* in traditional medicine therapy.

1.3 Research questions

(i) Are there variations in antimicrobial activity of different plant parts of *W. ugandensis* extracts from different populations across the Kenyan Rift Valley?

(ii) Are there variations in phytochemical profiles in different plant parts of *W. ugandensis* extracts from different populations across the Kenyan Rift Valley?

1.4 Objectives of the study

1.4.1 General objective

To evaluate variations in antimicrobial activity and phytochemical profiles of the leaf and stem bark extracts of *W. ugandensis* from different populations across the Kenyan Rift Valley.

1.4.2 Specific objectives

(i) To establish differences in antimicrobial activity of different plant part extracts of *W. ugandensis* from different populations across the Kenyan Rift Valley.

(ii) To establish differences in phytochemical profiles in different plant part extracts of *W. ugandensis* from different populations across the Kenyan Rift Valley.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Canellaceae plant family

The Canellaceae are a small family of flowering plants (angiosperms) in the order Canellales (Judd *et al.,* 2008). The order Canellales includes only one other family, the Winteraceae (Steyermark, 1952). The Canellaceae are a tropical plant family of small to medium trees, rarely treelets and shrubs, evergreen and aromatic. Their flowers and fruits are often red (Kubitzki, 1993). The distribution of Canellaceae plant family is disjunct between tropical and sub-tropical America (Neotropic ecozones) and Africa (Afrotropic ecozones) (Hamel and Zamora, 2005). Six genera and sixteen species have been traditionally recognized in this family. There is one genus each in tropical Africa (*Warburgia*) and Madagascar (*Cinnamosma*), two in tropical South America (*Capsicodendron* and *Cinnamodendron*) and two in the Caribbean (*Canella* and *Pleodendron*) (Salazar and Nixon, 2008). The genus *Warburgia* consist of four species all found in Africa but with restricted distribution in east and southern Africa (Orwa *et al.,* 2009). The species include *Warburgia stuhlmannii* Engl., *Warburgia elongata* Verdc., *Warburgia salutaris* (Bertol.f) Chiov. and *Warburgia ugandensis* Sprague synonym *W. breyeri* Pott (ICRAF, 1992).

The Canellaceae plant family has species in both xeric (dry) and wet forests (Steyermark, 1952). Chemical composition of Canellaceae species consist of monoterpenes and drimane-type sesquiterpenes such as cinnafragrins, polygodial, mukaadial, polygonone, isopolygodial, capsicodendrin and cinnamodial (Bastos *et al.,* 1999). They also have alkaloids of the aporphine type, including N-(cinnamoyl)-tryptamines, lignans of the aryltetraline type, as well as cinnamaldehydes and allylphenols. Their leaf mesophylls contain crystals of calcium oxalate and most species are cyanogenetic (Salazar and Nixon, 2008). Canellaceae species are traditionally used for medicinal, aphrodisiac, fishing, ritualistic and aromatic purposes (Bastos *et al.*, 1999).

2.2 Distribution and morphological description of *Warburgia ugandensis*

In Africa, *W. ugandensis* is widely distributed in countries such as Uganda, Kenya, Malawi, Democratic Republic of Congo, Ethiopia, South Africa, Tanzania and Swaziland (Orwa *et al.*, 2009). Different names have been used to describe the species for example, the plant is known as East African green wood, East African greenheart, pepper-bark tree in English and “Mukuzanume” or “Muwiya” in Luganda (ICRAF, 1992). *W. ugandensis* occurs in lowland rainforest and upland dry evergreen forest. The species also relicts in secondary bushland and grassland as well as on termitaria in swamp forest (Orwa *et al.*, 2009).

According to Maundu and Tengnas (2005), the species is widely distributed in lower rain forest and drier highland forest areas at altitudes between 1,000 to 2,000m. It is a spreading evergreen tree growing to a height of 4.5 to 40m with diameter of approximately 70cm. Its bark can either be smooth, scaly, pale green, brown or slash pink. The leaves are short stalked, alternate, simple, dotted with glands and lacking stipules. Berries which are purple when dried contain several heart shaped seeds in a cream green pulp (Orwa *et al.*, 2009). Maundu and Tengnas (2005) also reported that this species is hermaphroditic and flowers at the beginning of the rainy season and fruits much later in the rainy season. In Kenya the species flowers in December and January and seeds in May.

2.3 Propagation of *Warburgia ugandensis*

Natural regeneration of *W. ugandensis* is primarily from seeds which germinate easily in ecological conditions of natural habitats. *Warburgia ugandensis* can be regenerated artificially from stem cuttings (Akwatulira *et al.*, 2011), seedlings and direct sowing (ICRAF, 1992). Timing of the seed collection is important. Fruits that have fallen to the ground rot easily. Ripe fruits can either be harvested directly from the tree or shaken off the branches and collected from the ground (Orwa *et al.*, 2009). Under ideal conditions, the seeds germinate within 15 days (ICRAF, 1992). However, although preliminary studies indicate that *W. ugandensis* has a very high seed germination rate (Mbuya *et al.*, 1994), the seeds of this tree are highly recalcitrant, a fact that has hindered natural regeneration of this species (Omondi *et al.*, 2004). Seed propagation is generally difficult because they are often attacked by fungus and propagation through stem cuttings is also difficult since only a few propagules can be produced (Kowalski and Staden, 2001). Kuria *et al.* (2012) demonstrated that *W. ugandensis* can be regenerated through clonal propagation (tissue culture) as an alternative to seed propagation. The authors indicated that clonal propagation is desirable to obtain a uniform and high quality plantation without genetic variation.

2.4 Medicinal uses of *Warburgia ugandensis*

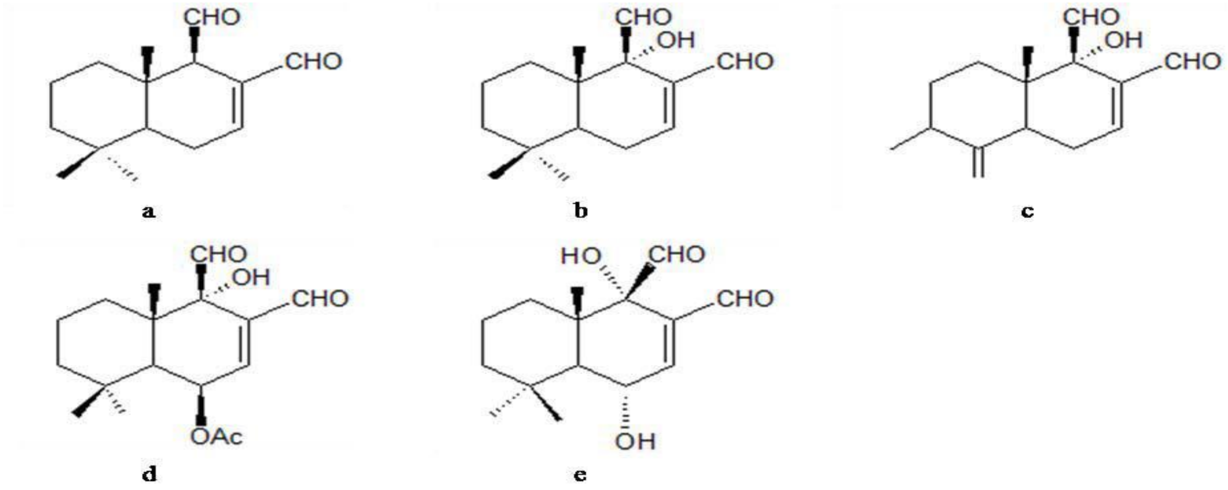
Many ailments such constipation, toothache, stomachache, cough, fever, muscle pains, week joints and general body pains can be managed by chewing and swallowing the juice from dried bark *W. ugandensis* (Kubo *et al.,* 1976). It is also effective in powdered form in treatment of the same diseases (Githinji *et al.,* 2010). Fresh roots are normally boiled and mixed with soup for the prevention of diarrhea. Leaf decoction baths are used as a cure for many skin diseases (Kokwaro, 1976). The inner bark which is reddish, bitter and peppery often has a variety of applications. When dried and ground to a snuff, it provides treatment for common cold and also clears sinuses. It can be chewed or smoke from the burning bark inhaled as remedy for chest complaints. The barks, roots or leaves can be boiled in water and the decoction drunk to treat malaria, but this may cause violent vomiting (Katende *et al.,* 1995; Taniguchi *et al.,* 1978).

2.5 Non medicinal uses of *Warburgia ugandensis*

Besides medicinal uses, *W. ugandensis* is also used as firewood, timber, fodder, tool handles, food seasoning, mulch for soil conservation, ornamental, shade and resin. The wood of *W. ugandensis* is resistant to insect attack and very strong (ICRAF, 1992; Maundu and Tengnas, 2005).

2.6 Pharmacological properties of tree species in the genus *Warburgia*

Several drimane sesquiterpenes have been isolated from the stem barks of *W. ugandensis, W. stuhlmanii* and *W. salutaris* (Kioy *et al*., 1990; Jansen and de Groot, 1991; Frum *et al*., 2005). The tree species in the genus *Warburgia* have high therapeutic value both for humans and livestock which is attributed to the abundance of drimane sesquiterpenes (Haraguchi, 1998). Studies have indicated the presence of muzigadial, ugandensidial, muzigadiolide (Mashimbye *et al.*, 1999), pereniporin B, isopolygodial, polygodial (Taniguchi and Kubo, 1993), mukaadial, warburganal, salutarisolide, cinnamolide, and 11α-hydroxy muzigadiolide in the stem bark (Kioy *et al.*, 1990; Rajab and Ndegwa, 2000) and ugandensolide, warburgin, warburgiadione, cinnamide, drimenol, drimenin (Mohanlall and Odhav, 2009) and deacetyl-ugandensolide in the heart wood (Brooks and Draffan, 1969). In addition, sesquiterpenes such as ugandenial A (Xu *et al.*, 2009), 9α-11α-dihydroxy,6ß-acetyl-cinnamolide, 9α-hydroxycinnamolide (Ssegawa and Kasenene, 2007) and dendocarbins A, L and M (Mang'uro *et al.*, 2003; Wube *et al.*, 2005) have also been identified (Figures 2.1 and 2.2).



a b c

d e

Figure 2.1: Chemical structures of polygodial (a), warburganal (b), muzigadial (c), ugandensidial (d) and mukaadial (e).

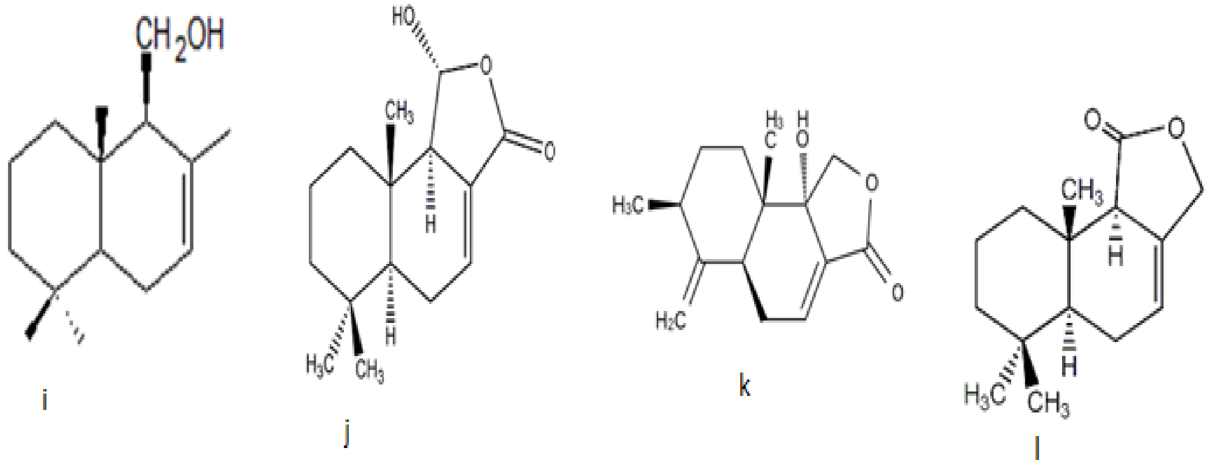


Figure 2.2: Chemical structures of drimenol (i), dendocarbin A (j), salutarisolide (k) and drimenin (l).

The bioactivities of the drimane sesquiterpenoids include skin irritant effects (Kubo and Taniguchi, 1988), antimicrobial, antiulcer, anticancer, insect antifeedant, phytotoxic, cytotoxic, piscicidal and molluscicidal properties (Olila *et al.*, 2001b). The drimane sesquiterpenoids also exhibit activities against mitochondrial oxidative phosphorylation and plant growth regulation (Rajab and Ndegwa, 2000). The sesquiterpene warburganal which has been isolated from *Warburgia* species possesses antifeedant activity against larvae of the African army worms *Spodoptera littoralis* and *Spodoptera exempta*, widely occurring African crop pests (Baulio, 2007).

Table 2.1: Summary of the medicinal uses of tree species in the genus *Warburgia*

Country	**Part used**	**Medicinal use / used to treat**	**References**
South Africa	Stem barks, roots	Aphrodisiac, coughs, colds, sores, inflammation, backache, emetic, influenza, constipation, headache, antioxidant and anti-inflammatory.	Leshwedi *et al.* (2008); Rabe and van Staden (2000).
Uganda	Stem barks, roots and leaves	Stomachache, constipation, coughs, toothache, weak joints and general body pains, malaria and sexually transmitted diseases.	Katende *et al.* (1995).
Kenya	Stem barks and leaves	Sexually transmitted diseases, stomachache, throat and chest infections, loss of appetite, malaria, diarrhea, coughs, internal wounds (ulcers) and antileishmanial.	Kiringe (2006); Were *et al.* (2010); Githinji *et al.* (2010).
Ethiopia	Stem barks	Tuberculosis, malaria, bronchitis, pneumonia, coughs and rabies.	Wube *et al.* (2005); Geyid *et al.* (2004).
Tanzania	Stem barks, roots	HIV related opportunistic infections, malaria, diarrhea, flue and antifungal.	Kayombo *et al.* (2007).
Zimbabwe	Stem barks, roots	Backache, abdominal pains, abortion, diarrhea, headache, indigestion, loss of appetite, aphrodisiac, pneumonia and snake bites.	Mukamuri and Kozanayi (1999).

According to Munakata (1975), an antifeedant is a compound that inhibits feeding but does not kill the predator directly, although it may die by starvation. Warburganal interferes with the stimulus transduction process in the chemoreceptor cells of the army worms (Braulio, 2007). Consequently, warburganal contains α,β-unsaturated 1,4-dialdehyde moiety in conformity with several other repellants and antifeedant terpenoids. Their repellency implies a role in the natural defense systems of the host organisms (Kuglerova *et al.*, 2011). Generally, the predator does not even have to chew the plant. For example, aphids have been shown to detect polygodial with sinsilla located on their antennal tips (Mohanlall and Odhav, 2009).

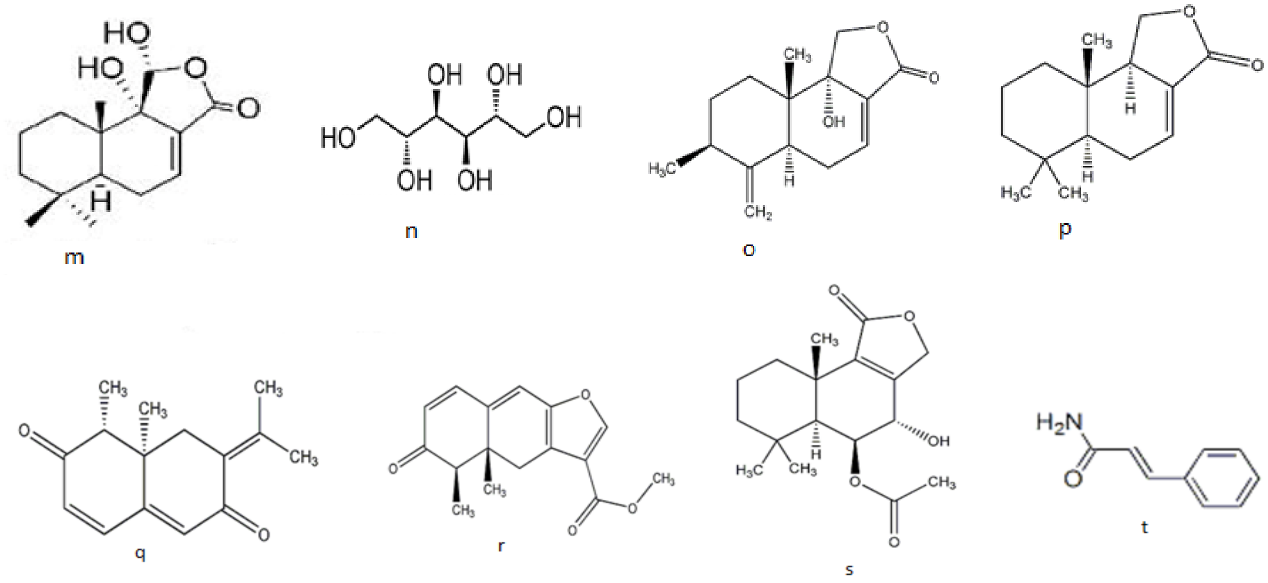


Figure 2.3: Chemical structures of ugandenial A (m), mannitol (n), muzigadiolide (o), cinnamolide (p), warburgiadione (q), warburgin (r), ugandensolide (s) and cinnamide (t).

Ngure *et al.* (2009b) indicated that hexane extracts of *W. ugandensis* had antileishmanial properties against *Leishmania major* and *Leishmania donovani* parasites. The findings of their study scientifically substantiated the claim made by Kenyan traditional healers that *W. ugandensis* stem barks possess antileishmanial effects. In a similar study, Githinji *et al.* (2010) showed that *W. ugandensis* exhibited trypanocidal, antileishmanial and immunodulative activities which are attributed to alkaloid group of metabolites such as tannin and other compounds including mannitol and epipolygodial present in its stem bark extracts. Mechanisms by which these metabolites exert their antimicrobial potentials include substrate deprivation, complexation with the cell wall, membrane disruption, binding to adhesins making them passive, inactivation of the enzymes and metal ion complexation leading to inactivation of such ligands that depend on those ions for functionality (Cowan, 1999).

The three major bioactive components in *Warburgia* species extracts namely warburganal, polygodial and muzigadial have been shown to possess broad spectrum antimicrobial activity against a range of pathogens responsible for community and nosocomial infections (Jansen and de Groot, 1991). Using a two-fold dilution method, Taniguchi *et al*. (1983) demonstrated that warburganal exhibited a broad antimicrobial activity against all yeasts and filamentous fungi tested and that it was highly active against *Sclerotinia libertiana, Candida utilis* and *Saccharomyces cerevisiae*. Ngigi and Ndalut (2005) also reported that muzigadial, a pure compound extracted from leaves of *W. ugandensis* exhibited higher antifungal activity against *Aspergillus niger*, *Fusarium oxysporum* and *Alternaria passiflorae*. Rabe and van Staden (2000) noted that fractionation of the ethyl acetate extracts of the stem barks of *W. salutaris* by chromatographic techniques yielded muzigadial which exhibited antimicrobial activity against Gram-positive bacteria. Muzigadial was found to be the major antibacterial agent in the stem bark extracts of *W. salutaris* with minimum inhibitory concentration values ranging from 12.5 to 100 µg/ml against both *Staphylococcus aureus* and *Bacillus subtilis* while flavonol glycosides such as kaempferol, myricetin and quercetin were detected in the methanolic leaf extracts of *W. ugandensis* (Rabe and van Staden, 2000; Manguro *et al*., 2003).

A study carried out by Ahmed *et al.* (2012) indicated that ethanol, dichloromethane and water extracts at 2.5, 5, 10 and 30% concentrations of *W. salutaris* exhibited antihelmintic effects against *Haemonchus contortus*. Evaluation of *in vitro* molluscidal activity of aqueous extracts of South African dried leaf samples of *W. salutaris* also showed that they were active against *Bulinus africanus* (Clarke and Appleton, 1997). According to Rabe and van Staden (2000), warburganal possessed effective molluscidal, cytotoxic and hemolytic properties while polygodial enhanced the activity of antibiotics actinomycin D and rifampicin. Van Wyk *et al.* (1997) also reported the presence of sugar alcohol mannitol in *Warburgia* species which is used medicinally for dyspepsia, as a diuretic and sweetener for diabetics.

Kuglerova *et al.* (2011), studying antioxidant activity of *W. salutaris*, showed that this species exhibited effective free radical scavenging effect in 2,2-diphenyl-1-picrylhydrazyl (DPPH) test. Machida *et al.* (1999) also observed that polygodial was able to accelerate production of reactive oxygen species (ROS) in the cells of *Saccharomyces cerevisiae*, which further indicated the pro-oxidant effect of *Warburgia* species. Due to its antioxidant properties, Leshwedi *et al.* (2008) similarly noted that extracts of *W. salutaris* exhibited protective effects against crystalline silica induced inflammatory cytokine expression, deoxyribonucleic acid (DNA) strand breakage, activation of nuclear transcription factor kappa B (NF-κB) and lipid peroxidation. Hence, according to Leshwedi *et al.* (2008), *W. salutaris* may be a potential prophylactic and therapeutic agent against fibrogenecity and carcinogenicity caused by crystalline silica induced cellular injury. Consequently, Steenkamp *et al.* (2005) suggested that the antioxidant activity displayed by the extracts of *Warburgia* species could be due to its effective pharmacological activities and abilities in the regulation of immune and inflammatory responses through cytokine mediation and treatment of various inflammatory conditions.

2.7 Effects of geographic and genetic variation on yield and composition of plant secondary metabolites

Plants may produce as much as 100,000 small molecules (Dixon, 2001), which include primary metabolites that are present essentially in all plants resulting from primary metabolic activities (Dixon, 2001). Plants also produce secondary metabolites in small quantities and are specific to certain species and plant parts and their synthesis is dependent on geographical factors (Zhi-linn *et al.,* 2007). These compounds are the result of the secondary metabolic pathways that take place in certain plant species. For plants little effects have been attributed to these potential substances like, defense against microorganisms, insects and herbivores. While some of them give plants their odors and pigments, many of them are responsible for plant flavors but for humans, at instances, they are life saving drugs (Evans, 2002).

The main function of plant secondary metabolites is thought to be the adaptation of the plants to their environment. By interacting with ecosystems, these natural compounds largely contribute to plant fitness, for example, protection of plants from pathogens, by phytoalexin and phytoanticipins or preventing the serious leaf damage from the ultra violet absorbing compounds (Kayani *et al.,* 2007). Thus, environmental factors such as temperature, light, carbon dioxide availability and soil conditions have a prominent effect on the secondary metabolism resulting in extreme variability in the phytochemical contents of wild and cultivated plants and the products derived from them (Nikolic and Zlatkovic, 2010). Temperature regimes are known to be different at different micro sites within a forest. These temperature differences may cause chilling injury in plants, which encompasses imbalances in metabolism, accumulation of toxic substances and increased membrane permeability (Chokoe *et al.*, 2008). According to Nikolic and Zlatkovic (2010), soils have been known to have varying physical, chemical and biological properties, which can vary considerably over distances of as little as 10 metres, resulting in differences in the growth of trees and plants in general.

Consequently, the yield and composition of secondary metabolites within a species may vary between plants from different geographical locations and may be influenced by environmental and genetic differences. A number of studies have investigated these phytochemical variations and revealed differences within or between populations as shown in the following examples for *Melaleuca alternifolia* (Australian tea tree) (Homer *et al.*, 2000), *Echinacea* species (purple coneflower), *Aloe ferox* (Binns *et al.*, 2002) and *Paeonia lactiflora* (paeony) (Wills and Stuart, 1999), all important medicinal plants. In view of the studies by Homer *et al.* (2000) and many other investigations, it is evident that there are countless examples of the occurrence of geographic variations in the yield and composition of secondary metabolites, determining, for several species, the existence of distinct chemotypes or chemical races (Figueiredo *et al.*, 2008).

Homer *et al.* (2000) used the chemical variation of three bioactive markers, terpinolene, 1,8-cineole and terpinen-4-ol in leaf oil extracts to classify *Melaleuca alternifolia* plants into three geographically distinct regions. In addition, the authors' study on 615 individual plants at 41 sites identified six chemotypes within the distribution range of *M.*

alternifolia. In their paper, Homer *et al.* (2000) used the term chemotype to classify plants of distinct chemical composition. Most of the chemotypes were found throughout the distribution range in south-eastern Australia. However, the authors found a definite correspondence between location and oil chemotype. This observed variation was accredited to genetic rather than environmental differences between the locations. Although the above authors ascribe the differences in chemical composition to genetic variation, comparison with the works of Binns *et al.* (2002) and Wills and Stuart (1999) suggests that genetic and environmental effects may depend on the plant species and compounds under investigation.

Elsewhere, a similar study by Pateira *et al.* (1999) concerning several populations of *Crithmum maritimum* grown on the mainland of Portugal reported two distinct chemotypes. They also indicated variations in the essential oils of *Zingiber officinale* and *Myristica fragrans* (nutmeg tree) within the distribution range in Australia, India and Sri Lanka. According to Figueiredo *et al.* (2008), the different phytochemical compositions of a species found from different origins reflect the different environmental conditions of each particular location and culture conditions (different solar exposition, different altitudes and different soil types among other conditions). In addition, Figueiredo *et al.* (2008) noted that these conditions interplay together, therefore the differences in phytochemical composition found from different geographical origins are also due to genetic differences. Consequently, the occurrence of different secondary metabolites of a species from different geographical origins may also be determined by the processing of the plant material and extraction techniques (Figueiredo *et al.*, 2008).

According to Sawyer (1994), geographical variation may have some effects on the level of medicinal active compounds of plants of the same species. Intraspecific variation of chemical compounds is common in many plants species, and often shows defined geographical patterns, that may reflect environmental differences within the range of a species. Therefore, chemical races are often described and have provided taxonomists with powerful tool in the search for relationships where geographically distinct profiles in the occurrence of secondary metabolites are described (Bohm, 2009). Previous study on bioactive constituents in *Prunus africana* (African cherry) with respect to geographical variation throughout Africa and association with environmental and genetic parameters indicated pronounced variation in the concentration of selected bark constituents among the populations studied. This pronounced spatio-genetic pattern showed that *Prunus africana* exhibit interspecific diversity within and among populations in the concentrations of chemical constituents in the bark (Kadu *et al.,* 2012).

Similarly, a study by Gachie *et al.* (2012) on variation in yield and composition of crude bark extracts of *Prunus africana* also revealed that *P. africana* trees from different provenances of Kenya differ in their crude bark mean yields, chemical composition and specific compounds. Differences between geographically and genetically isolated *P. africana* populations have also been shown from DNA fingerprinting of leaf chloroplasts' DNA (Barker *et al.,* 1994). The differences were also observed between western and central Kenyan populations of *P. africana* by Muchugi *et al.* (2006). These differences could be due to the geographical and genetical isolation among the populations (Muchugi *et al.,* 2006). Elsewhere, correlation between the metabolic contents and DNA fingerprints among geographically distinct plant populations have been reported for phenolic acids in *Fructus xanthii* and for volatile constituents in *Ocimum gratissimum* and *Tanacetum vulgare* (Han *et al.,* 2008).

In their study on chemotypic and genetic diversity in *Epimedium sagittatum* from different geographical regions of China, Chen *et al.* (2015) noted that different geographical plant populations within a single species can exhibit variation in the production of secondary metabolites. Chen *et al.* (2015) further indicated that genetic and environmental variations both contribute to differences among populations; however, the relative significance of these factors is not clear. Plant secondary metabolite production is a quantitative trait influenced by both biotic and abiotic environmental factors and is known to display extensive geographic variation (Dinchev *et al.,* 2008; Chen *et al.,* 2013). Extensive genetic diversity among intraspecific populations of *Epimedium sagittatum* from different regions of China was shown by using a retrotransposon-based molecular marker system. The results thereof would assist in the development of strategies for conservation, utilization and domestication of *E. sagittatum* (Chen *et al.,* 2015).

In spite of the fact that the environment plays a key role in determining plant phenotype, plant secondary metabolite production is a genetically encoded quantitative trait. For instance, the variation in ginsenoside composition within American ginseng (*Panax quinquefolius* L.) is linked to genotypic variation (Schlag and McIntosh, 2013). In determination of quantitative and qualitative differentiation in glucosinolates, Kliebenstein *et al*. (2001) noted that the active plant secondary metabolites of Brassicaceae plant family were primarily genetically controlled in *Arabidopsis*. According to Kulheim *et al.* (2011), genetic diversity in *Eucalyptus globulus* could possibly explain most of the variation in the concentration of herbivory-deterrent plant secondary metabolites. Shedding light on the genetic basis of plant secondary metabolites is crucial to systems-wide understanding of their interactions with environment (Suhre and Greger, 2012).

Hamilton *et al.* (2001) indicated that the relative importance of genotype and environment on plant secondary metabolites accumulation is as variable as the compounds produced. In several studies, the accumulation of plant secondary metabolites is mainly genetically controlled (Kulheim *et al.,* 2011). For instance, there is a great genetic influence on the observed chemical assay of *Anemopsis californica* (Medina-Holguín *et al.,* 2007), *Lippia graveolens* (Martínez-Natarén *et al.,* 2014), *Panax quinquefolius* (Lim *et al.,* 2005), *Pinus ponderosa* (Gerson *et al.,* 2009), *Cremanthodium lineare* (Saito *et al.,* 2013), *Scrophularia ningpoensis* (Yang *et al.,* 2011), *Eucalyptus globulus* (Kulheim *et al.*, 2011) and *Ligularia vellerea* (Tori *et al.,* 2008). However, the association between the chemical and genetic diversity in these studies did not eliminate the environmental influences on plant secondary metabolite production.

A study on the impact of geographical locations on *Mentha spicata* antibacterial activities revealed variation in the content of rosmarinic acid in the leaf tissues due to environmental and physiological conditions; therefore, any geographical change that commonly results in an alteration in the environment will affect the presumed medicinal activity of the plant (Fletcher *et al.*, 2010). Badoni *et al*. (2009) accredited variation in phytochemicals to geographical location, seasons and soil fertility which can ultimately impact on the quantity of secondary metabolites in plant species thereby affecting the presumed antimicrobial activities related to medicinal plants. Cowan (1999) indicated that plants growing in the environment are exposed to a wide range of abiotic stress such as osmotic stress, salinity and temperature variations. These factors consequently affect their growth and metabolic processes necessary for the synthesis of a wide range of secondary metabolites such as terpenoids, alkaloids, flavonoids, fatty acids, phytosterols, tannins, polyphenols and other compounds which may have remarkable antimicrobial properties (Cowan, 1999).

Research findings have shown that in plants from which useful natural products are extracted, spatio-chemical differences among populations have been only occasionally described and studies linking a spatial pattern in chemical concentrations with genetic differences among natural populations are even more limited (Prida *et al.*, 2007). One of the most cited examples of spatio-chemical diversity in secondary metabolites, including its genetic background, is the variation of cyanogenesis in *Trifolium repens* throughout Europe (Hayden and Parker, 2002). To confirm these research findings, Crag and Newman (2007) indicated that chemical diversity in nature is based on biological and geographical diversity, explaining why researchers travel around the world obtaining samples to analyze and evaluate in drug discovery and bioassays. Additionally, living plants contain a much greater diversity of bioactive compounds than any chemical library made by humans and therefore biochemical profiles of plants harvested at different times and locations may vary greatly (White, 2006).

In one of their studies on management of medicinal plants in Nyanza, Ochieng'-Obado and Odera (1995) recommended that there should be studies to ascertain possible variations in medicinal plant active compounds in different geographical regions in order to prevent genetic erosion by planning their conservation. Kadu *et al*. (2012) in their study on bioactive constituents in *Prunus africana* also indicated that regardless of whether the concentrations of certain bark constituents in *P. africana* are linked to genetic parameters, knowledge about their regional variation is essential in order to optimize the sustainable conservation and use of this vulnerable tree species.

2.8 Gas Chromatography Mass Spectrometry (GC-MS) analysis

Phytochemical analyses of extracts were performed by GC-MS, a techinique which enables seaparation, identification and quantification of complex mixtures of chemicals. The method is fundamental for the analysis of relatively low molecular weight compounds (Hites, 1992). To use GC-MS, the organic compounds must be sufficiently volatile, thermally stable and in solution for injection into the gas chromatograph (Svendsen and Verpoorte, 1983). Gas chromatography and mass spectrometry are, in many ways, highly compatible techniques. In both methods, the sample to be analysed is in the vapor phase, and both methods deal with about the same amount of sample, typically less than one nanogram (Kintz *et al.,* 1991). The samples are normally analysed as organic solutions thus materials of interest need to be solvent extracted, for example in hexane or dichloromethane and the extract subjected to various 'wet chemical' techniques before GC-MS analysis is done (Svendsen and Verpoorte, 1983).

The sample solution is injected into the GC inlet where it is vaporized and swept onto a chromatographic column by the carrier gas. The sample moves through the column and the compounds comprising the mixture of interest are separated by virtue of their relative interaction with the coating of the column (stationary phase) and the carrier gas (mobile phase) (Sasidharan *et al.*, 2011). Different substances in the sample travel through the column at different speeds and so become separated from each other. The separated substances are eluted from the column successively. As they exit, they are detected by a flow-through device (detector) (He, 2000). The time taken by a substance to travel through the column is known as its retention time. A detector provides a graph where each substance is represented by a peak. The number of peaks reveals the number of compounds present in the sample while the position of each peak shows the retention time for each compound (Hites, 1992).

A mass spectrometer is able to identify substances very quickly, accurately and in very small amounts. If a GC machine is connected to a mass spectrometer, this combination allows the separated substances leaving the column of the GC machine to be detected. It also provides the relative formula mass of the substances separated by GC. Molecular ion peak is the peak furthest to the right in a mass spectrum while its relative mass is the relative formula mass of the substance being analysed (Hajslova and Cajka, 2007).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Sample collection

Leaves and stem barks were collected randomly from five ecological populations of *W. ugandensis* across the Kenyan Rift Valley in the following forests; Kinale (along the Kikuyu escarpment), Londiani (along the Mau escarpment), Rumuruti (within the Rift Valley), Kitale and Karura (west and east of the Kenyan arm of the Rift Valley), respectively (Figure 3.1). The samples collected were taxonomically identified, authenticated and their voucher specimen deposited at the ICRAF herberium in Nairobi. Ecological and geographical details of these regions are summarized in table 3.1. Leaves and stem barks were harvested from four trees per population; labeled T1, T2, T3, and T4. The Geographical Positioning System (GPS) readings of the locations were recorded as shown in table 3.2. Debarking was done using a sharp edged machete at Diameter at Breast Height (DBH) (Table 3.2).

Table 3.1: Ecological and geographical details of regions where samples were collected

Region	***Soil type**	**#Temp. (^oC)**	**# Rainfall (mm)**	**#Altitude (m)**
Kinale	Andosols; highly fertile, very deep, well drained, dark red soils.	14-16	800-1400	2150-2450
Rumuruti	Phaeozems; well drained, less weathered red brown sandy clay loam luvisols.	16-18	800-1100	1850-2150
Londiani	Nitosols; deep well drained, highly leached, acid red soil with a high clay content.	14-16	1000-1600	2150-2450
Karura	Trachyte; fine grained and weather to red / brown soils or plastic clays.	18-20	800-1400	1500-1850
Kitale	Humic ferralsols; sandy clay loam, well drained, very deep red to dark-red soils.	16-18	800-1400	1850-2150

Source: *Jaetzold *et al.* (2006); #Teel (1984).

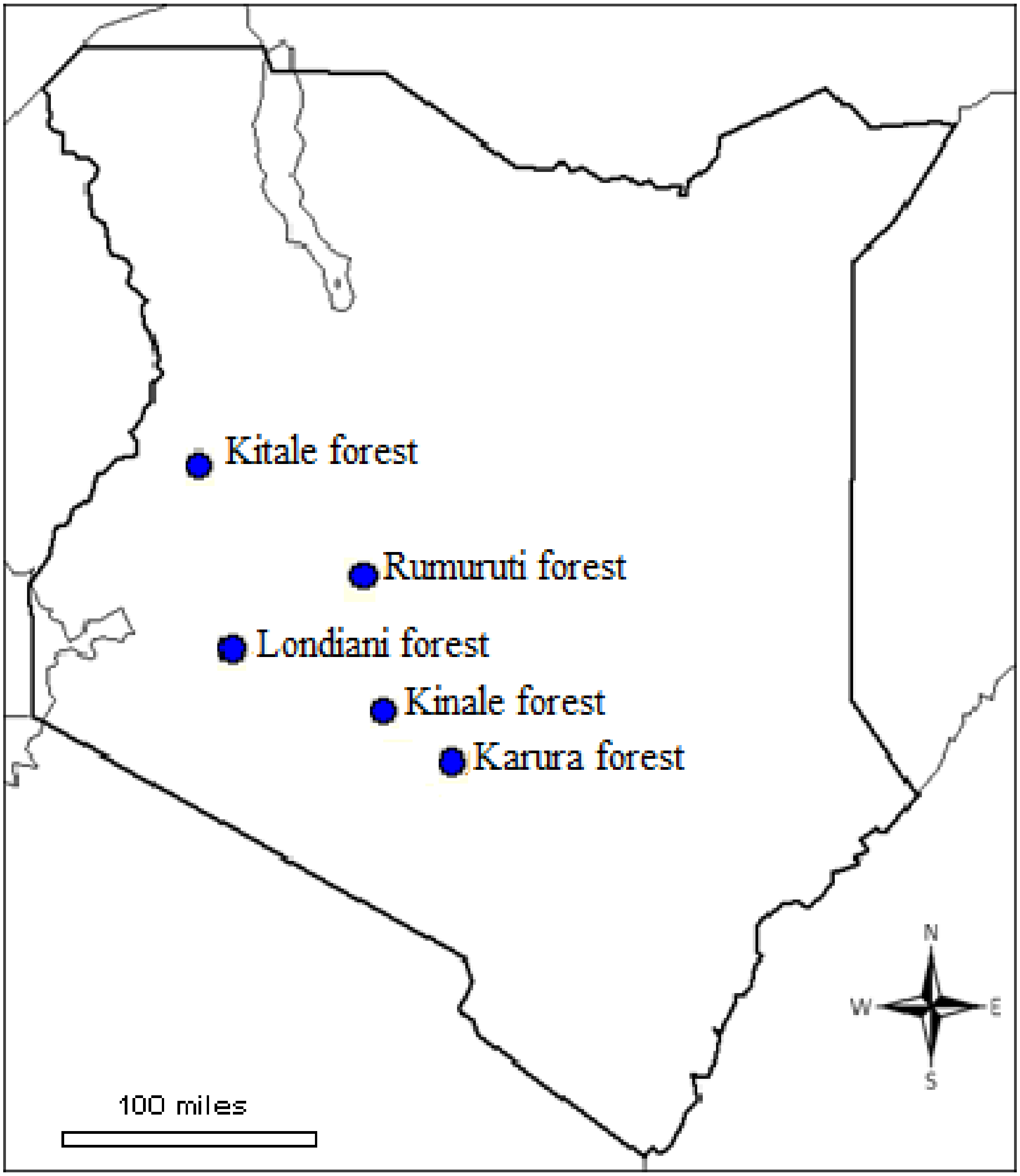


Figure 3.1: Map showing forests where samples of *W. ugandensis* were collected in Kenya.

Table 3.2: GPS, altitude (elevation), and DBH readings of the regions where samples were collected in Kenya

Sample	Eastings	Southings	Elevation (m)	DBH (cm)
Karura Forest				
T1	036^{o} 50.578’	01^{o} 14.752’	1649	30.30
T2	036^{o} 50. 585’	01^{o} 14.755’	1651	14.80
T3	036^{o} 50.587’	01^{o} 14.746’	1671	21.10
T4	036^{o} 50.639’	01^{o} 14.699’	1646	43.40
Londiani Forest				
T1	035^{o} 34.201’	00^{o} 14.193’	2335	8.50
T2	035^{o} 34.152’	00^{o} 14.169’	2304	5.00
T3	035^{o} 34. 021’	00^{o} 14.163’	2261	7.50
T4	035^{o} 34.013’	00^{o} 14.160’	2255	7.00
Kitale Forest				
T1	#Latitude:01°00' N		#1850-2150	49.00
T2	#Longitude: 35°25’E			31.60
T3	#Latitude: 1° 0' 27.01’’ N			14.70
T4	#Longitude: 35° 1’ 15.69’’ E			22.00
Kinale Forest				
T1	#Latitude: 0°56’S		#2150-2450	65.90
T2	#Longitude: 36°40’E			24.60
T3	#Latitude: 0°56.7’S			60.70
T4	#Longitude: 36°35.7’E			17.20
Rumuruti Forest				
T1	#Latitude: 00°07’ N		#1850-2150	15.00
T2	#Longitude: 36°25’E			21.00
T3	#Latitude: 0° 10' 26.904’’N			45.00
T4	#Longitude: 36° 26’ 22.308’’E			42.00

Source: #Teel (1984).

3.2 Sample preparation

The leaves were thoroughly washed with water while the stem barks were first pretreated by cleaning with a hard brush and then washed with water to remove dirt and soil particles before being chopped into small pieces. All samples were rinsed with sterile distilled water. The samples were then dried on laboratory tables at room temperature for 2-3 weeks until completely dry. The dried plant samples were ground into fine powder using an electrical mill. The powder were kept in air tight (zip locked) polythene bags and stored at 4^oC in readiness for further analyses.

3.3 Solvent extraction

A 200g measure of the plant powder was transferred into 1L conical flasks. Sequential extraction was done with organic solvents (AR, Sigma Aldrich) of increasing polarity, which included dichloromethane (DCM) and methanol (MeOH). An 800ml aliquot of DCM was added into the conical flasks and the flasks placed on a shaker and soaked for 48 hours. The samples were filtered using Buchner funnel and Whatman filter paper (No.1) under vacuum. The filtrates were further soaked in 800ml of DCM for 24 hours until they remained clear. The filtrates were concentrated at reduced pressure using a rotary evaporator (Eyela-Tokyo Rikakikai Company Ltd) at 35^oC and 45^oC for DCM and MeOH extracts, respectively at the Chemistry Research Laboratory of Kenyatta University. The extracts were then transferred into sterile, labeled and pre-weighed vials, which were air dried and the weight of dry extracts taken. The extracts were tightly capped and stored at 4^oC. This procedure was repeated sequentially using MeOH for the same plant samples.

3.4 Antimicrobial activity

3.4.1 Test strains and standard drugs

The antimicrobial activity tests were carried out at the Centre for Microbiology Research (CMR) of Kenya Medical Research Institute (KEMRI) in Nairobi. Microorginisms used during the bioassays tests were *Staphylococcus aureus* (ATCC 25923), *Escherichia coli*

(ATCC 25922) and *Candida albicans* (ATCC 90028). The positive controls (standard drugs) used for antibacterial and antifungal bioassays were chloramphenical (Biomeriuex) at a dose of 30µg per disk and fluconazole (Pfizer) at a dose of 25µg per disk (Pfizer), respectively. Dimethyl sulphoxide (DMSO) was used as a negative control.

3.4.2 Preparation of extracts for antimicrobial activity

The extracts for bioassay analysis were prepared by transferring 1g of extract into pre-labeled sterile universal bottles and 1ml of 99.9% pure dimethyl sulphoxide (DMSO) (Sigma-Aldrich) added, and the mixture was consequently agitated using mechanical vortex mixer. The concentration of extracts after dissolving in DMSO was 1:1 (1g/ml; 1g of extract in 1ml of DMSO). This procedure was repeated for all the extracts.

3.4.3 Media and plates preparation

Mueller-Hinton Agar (MHA) (Oxoid, UK) was used to perform susceptibility tests. This was prepared by suspending 19g of the agar in 500ml of distilled water. The medium was boiled to dissolve in a warm water bath with continuous shaking. It was sterilized by autoclaving at 121^{o}C for 15 minutes. The sterilized agar was allowed to cool to 50^{o}C in a water bath. The freshly prepared and cooled agar was then poured into pre-labeled sterile petri dishes (90mm in diameter) on a level, horizontal surface to give uniform depth of 4mm corresponding to approximately 25ml of the medium per plate. The agar plates were allowed to set at room temperature. The plates were labeled by indicating the laboratory ID numbers corresponding to the extracts. The agar plates were stored at 4^{o}C.

3.4.4 Preparation of the McFarland standard for bacterial suspension turbidity

The 0.5 McFarland turbidity standards were prepared according to the method described by Chapin and Lauderdale, (2003). A 0.18mol/L Sulphuric acid (1% v/v H_2SO_4) and 0.048mol/L aqueous Barium Chloride (1.175% w/v $BaCI_2.2H_2O$) solutions were prepared. Slowly, with constant agitation, a 9.9ml aliquot of 0.18mol/L Sulphuric acid solution (1% v/v H_2SO_4) was added to 0.05ml of 0.048mol/L aqueous Barium Chloride (1.175% w/v $BaCI_2.2H_2O$) solution in a sterile tube, and the contents sealed and stored in the dark at room temperature.

3.4.5 Preparation of inocula suspensions

Test microorganisms were obtained from the stock culture maintained at the CMR-KEMRI laboratory. The inocula suspensions were prepared by direct colony method. The microbes were grown in Mueller-Hinton Agar (MHA). Three to five (3-5) colonies of each test organism were picked with a sterile wire loop and suspended in 15ml of sterile 0.85% normal saline (NaCl) in universal bottles and then mixed by mechanical vortex mixer. Thereafter, the inocula suspensions were standardized with 0.5 McFarland turbidity standards, which corresponded to approximately $1.5x10^8$ CFU/ml. The turbidity of inocula suspensions were visually compared to McFarland standard by placing the tubes in front of ‘Wickerham’ card (a white card with black lines printed on it). Suspensions of similar turbidity to the 0.5 McFarland blurred the black lines to about the same extent. This process was carried out in sterile conditions.

3.4.6 Calculation of concentrations of the extracts

Before the two fold-serial dilutions, 1g (1000mg) of extract was mixed with 1ml of DMSO to give a starting concentration of 1g/ml (section 3.4.2). During the dilution process, 0.1ml of 1g/ml of extract was added to 0.1ml of DMSO in the first well of the microtitre plate to give a volume of 0.2ml (0.1ml of DMSO + 0.1ml of extract) in the first well. Since the original concentration of the extract was 1g/ml, thus 0.1ml (volume of crude extract) corresponded to 1g/ml. To calculate the concentration of the extract after dilution in the first well with a volume of 0.2ml, the following formula was used:

$C_1V_1 = C_2V_2$

Where C_1 = Initial Concentration

V_1 = Initial Volume

C_2 = Final Concentration

V_2 = Final Concentration

Thus, the final concentration of the extract (C_2) was calculated as follows:

$$C_2 = \frac{1\text{g/ml} \times 0.1\text{ml}}{0.2\text{ml}}$$

$$C_2 = 0.5\text{g/ml}$$

Since 1g is equal to 1000mg thus 0.5g/ml is equivalent to 500mg/ml. From the calculation, 1:1 dilution factor represented 0.5g/ml (500mg/ml) of the extract concentration during the initial dilution. To determine the concentrations of the extract in the successive dilutions, the initial concentration (0.5g/ml) was reduced by a factor of two.

3.4.7 Bioassay screening of the plant extracts

Preliminary screening for antimicrobial activity of DCM and MeOH leaf and stem bark extracts of *W. ugandensis* was carried out using disk diffusion method. The bacterial and fungal suspensions were inoculated onto the entire surface of MHA plates with sterile cotton-tipped swab to form an even lawn. This process was carried out separately for each test organism. Sterile paper disks (6mm in diameter) were impregnated with 20µl of crude extract and then placed on the surface of each MHA plate corresponding to the sample ID numbers using sterile forceps. Chloramphenical at a dose of 30µg per disk and fluconazole at a dose of 25µg per disk were used as standard drugs for antibacterial and antifungal assays, respectively. Dimethyl sulphoxide was used as a negative control. After inoculation and application of the disks, the plates were left at room temperature for about 10 minutes to allow the extracts to diffuse from the disks to the medium. Thereafter, the plates were incubated at 37^{o}C for 24 hours for the bacterial strains and 24-72 hours at 37^{o}C for the fungal strain. The inhibition zones were measured to the nearest millimeter (mm) using a metric ruler and then the diameters were recorded as the zones of inhibition.

3.4.8 Minimum inhibitory concentration (MIC) analysis

Prior to MIC assays, the extracts were diluted by two-fold serial dilution. Using a micropipette, 100µl of DMSO (diluent) was dispensed to all the wells across the rows of

96 well microtitre plates. One hundred microlitres (100µl) of 1g/ml of the extract was transferred to the first well and mixed by using micropipette to draw up the mixture and expel it back to the well until it was homogenous. This yielded a 1:1 concentration in the first well containing the sample (crude extract) and DMSO. Then, 100µl of the contents of the first well was transferred to the second well in the row already containing 100µl of DMSO. Dilution and mixing was repeated for all the wells while reducing the concentration by half across the rows of 96 microtitre plates. Then, 100µl of the contents of the last well was withdrawn and discarded, leaving all the wells with uniform volume of 100µl. This process was repeated for all the samples.

Series of two-fold serial dilutions of the extracts were prepared in concentrations of 1:1, 1:2, 1:4, 1:16, 1:32, 1:64, 1:128, 1:256, 1:512, 1:1024, 1:2048, 1:4096, 1:8192, 1:16384 and 32768 for *S. aureus* and *C. albicans*, respectively. Sterile paper disks impregnated with 20µl of crude extracts were prepared. These were then placed on the surface of each MHA plate corresponding to the sample ID numbers by use of sterile forceps. The plates were then incubated for 24 hours at 37^{o}C for *S. aureus* and 24-72 hours at 37^{o}C for *C. albicans,* respectively. Zones of inhibition were measured to the nearest milimeters (mm) using a metric ruler and recorded. Then, MIC values were determined by correlating the minimum diameter of zone of inhibition with the lowest concentration of the crude extracts at which no visible microbial growth was observed.

3.4.9 Preparation of samples for GC-MS analysis

Five hundred milligrams (0.5g) of DCM and MeOH (leaf and stem bark) extracts of *W. ugandensis* were weighed and put into 50ml conical flasks. Then, 10ml of DCM and 10ml of MeOH were added into each conical flask containing DCM extracts and MeOH extracts, respectively. The extracts were left to dissolve for 24 hours with constant shaking. The extracts were filtered using membrane filters (Sartorius NY 0.45µm, 47mm) and the filtrates transferred into sterile and well labeled 1.5ml GC glass vials (Amber) prior to GC-MS analyses.

3.5 Gas Chromatography Mass Spectrometry (GC-MS) analysis

The profiles of compounds in the extracts were determined using gas chromatography interfaced with mass spectrometer (GC/MS/MS) triple quad system (Agilent Technologies 7890A fitted with Agilent 7693 auto-sampler, a National Institute of Standards and Technology (NIST) library and installed with Mass Hunter Workstation Software for qualitative analysis version B.05.00 build 5.0.519.0, service pack I © Agilent technologies 2012). The instrument was equipped with Helium gas (99.9999% purity) which was used as a carrier gas, Nitrogen gas which was used as a collision gas and a HP5MSUI column (30m length x 0.25mm internal diameter x 0.25µm film thickness). An electron ionization system with ionizing energy of 70eV was used. Helium flow rate was 1 ml/min and an injection volume of 1µL without splitting (splitless injection). Injector temperature was at 250^0C. Ion source temperature was 280^0C. Oven temperature was programmed from 110^0C with an increase of 10^0C to 200^0C then 5^0C to 280^0C. Total GC running time was 36 minutes. The compounds were identified from chromatograms based on their elution time. The chromatograms of the eluted compounds were deconvoluted and their mass spectra matched with those of the NIST 11 database. The NIST 11 database is a fully evaluated collection of electron ionization (EI) mass spectra for various compounds and it contains MS/MS spectra and GC data of over 243, 893 spectra of 212, 861 unique compounds with identifications, almost all with chemical structures (NIST, 2011). The percentage relative abundance (% R.A) of each compound in the plant extract was calculated by comparing its relative peak area to the total peak areas as shown by the formula below.

$$\text{\% relative abundance} = \frac{\text{Peak area of the compound}}{\text{Total sum of all peak areas}} \times 100$$

3.6 Data management and statistical analysis

Descriptive statistics for preliminary bioassay screening of the extracts and minimum inhibitory concentrations were presented in tables and bar graphs. The tests were carried out in triplicate and the mean values of the triplicate tests were recorded. All the values were expressed as Mean ± Standard Error of Mean (x ± SEM). One way ANOVA was used to compare mean MICs of DCM and MeOH extracts from different plant parts and different regions against *S. aureus* and *C. albicans*. Student t-test was used to compare differences in mean MICs of the extracts against *S. aureus* and *C. albicans*. Two way ANOVA was used to analyze the interactions of sites, samples, plant parts and solvent (extract) types on either antibacterial (*S. aureus*) or antifungal (*C. albicans*) activity. Tukey’s HSD test (post-hoc analysis) was used to determine significant differences between mean MICs of different plant part extracts and regions tested against *S. aureus* and *C. albicans* ($p \leq 0.05$). International Business Machine Statistical Package for Social Sciences (IBM-SPSS) version 20 was used for all statistical analyses.

CHAPTER FOUR

RESULTS

4.1 Preliminary bioassay screening of extracts of *W. ugandensis*

The bioassay screening results showed that *S. aureus* and *C. albicans* were susceptible to the plant extracts while *E. coli* was resistant. Due to the lack of antimicrobial activity, no further extracts were tested against *E. coli*. Chloramphenical and fluconazole (positive controls) gave zones of inhibition of 20mm, respectively while dimethyl sulphoxide (DMSO) (negative control) showed no zone of inhibition (6mm, disk diameter). Preliminary bioassay results revealed the stem bark extracts were the most active compared to the leaf extracts regardless of the solvents used for extraction as shown in figures 4.1-4.4. The pattern of inhibition of the extracts against the test microorganisms also varied with the solvent used for extraction and the part of the plant being investigated as well as the regions (sites) where the samples were collected.

4.1.1 Bioassays for dichloromethane extracts of *W. ugandensis*

The dichloromethane (DCM) stem bark extracts from Kitale, Karura and Kinale were the most active against *S. aureus* with mean zones of inhibition of 19.75, 18.25 and 18mm, respectively. These were followed by DCM stem bark extracts from Rumuruti and Londiani with mean zones of inhibition of 12.5 and 10.25mm against *S. aureus*, respectively. Similarly, DCM stem bark extracts from Rumuruti and Kinale were the most active against *C. albicans* with mean zones of inhibition of 19.75 and 16.25mm, respectively. These were followed by DCM stem bark extracts from Kitale and Londiani with mean zones of inhibition of 13 and 9mm against *C. albicans*, respectively (Figure

4.1). Moderate antimicrobial activities were observed in the DCM leaf extracts of *W. ugandensis*. For instance, DCM leaf extracts from Karura and Kitale exhibited activity with mean zones of inhibition of 12.5 and 11mm against *S. aureus*, respectively. Consequently, DCM leaf extracts from Kitale and Rumuruti showed activity with mean zones of inhibition of 13.5 and 11.5mm against *C. albicans*, respectively (Figure 4.2).

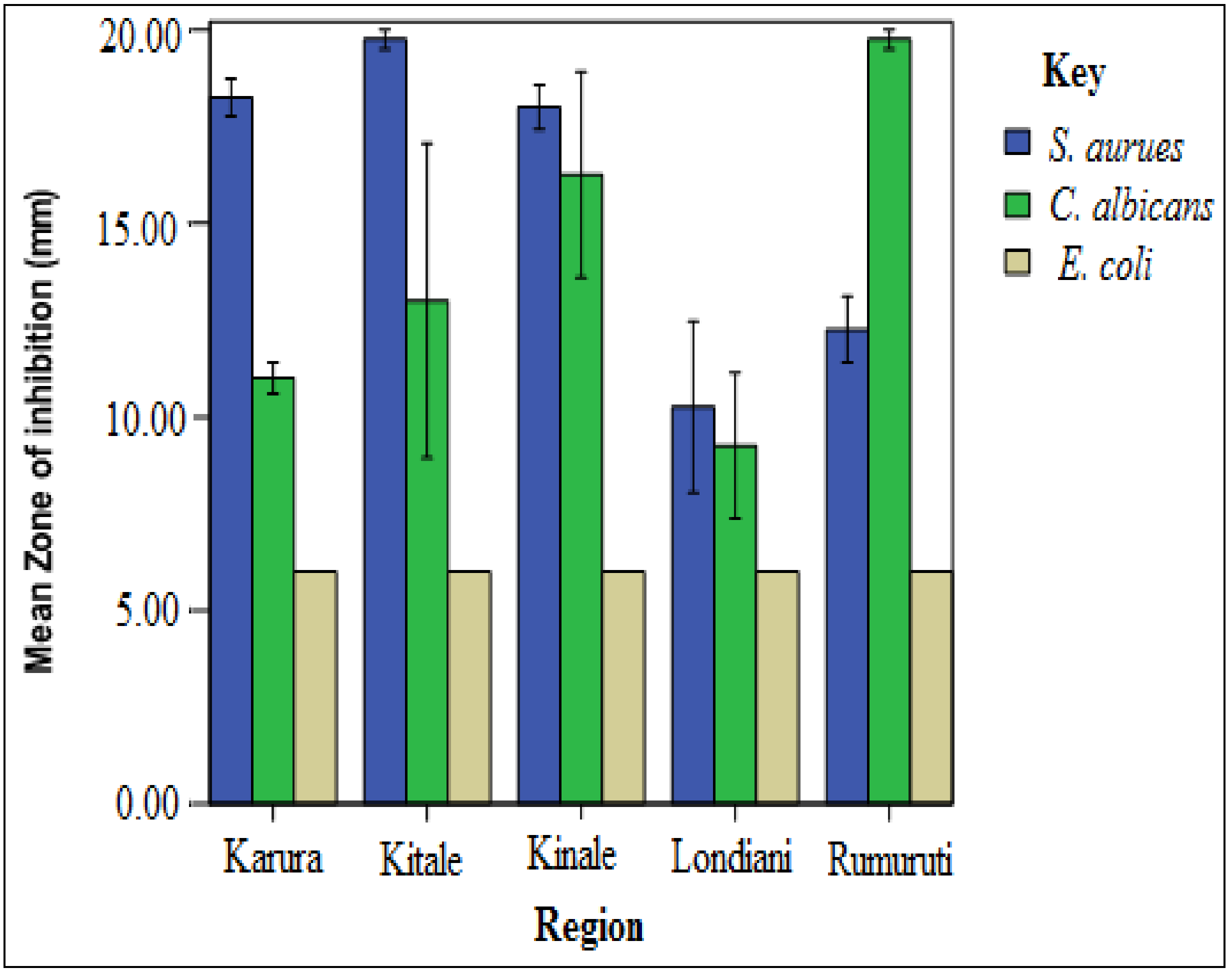


Figure 4.1: Comparison of mean zones of inhibition effects of DCM stem bark extracts of *W. ugandensis*.

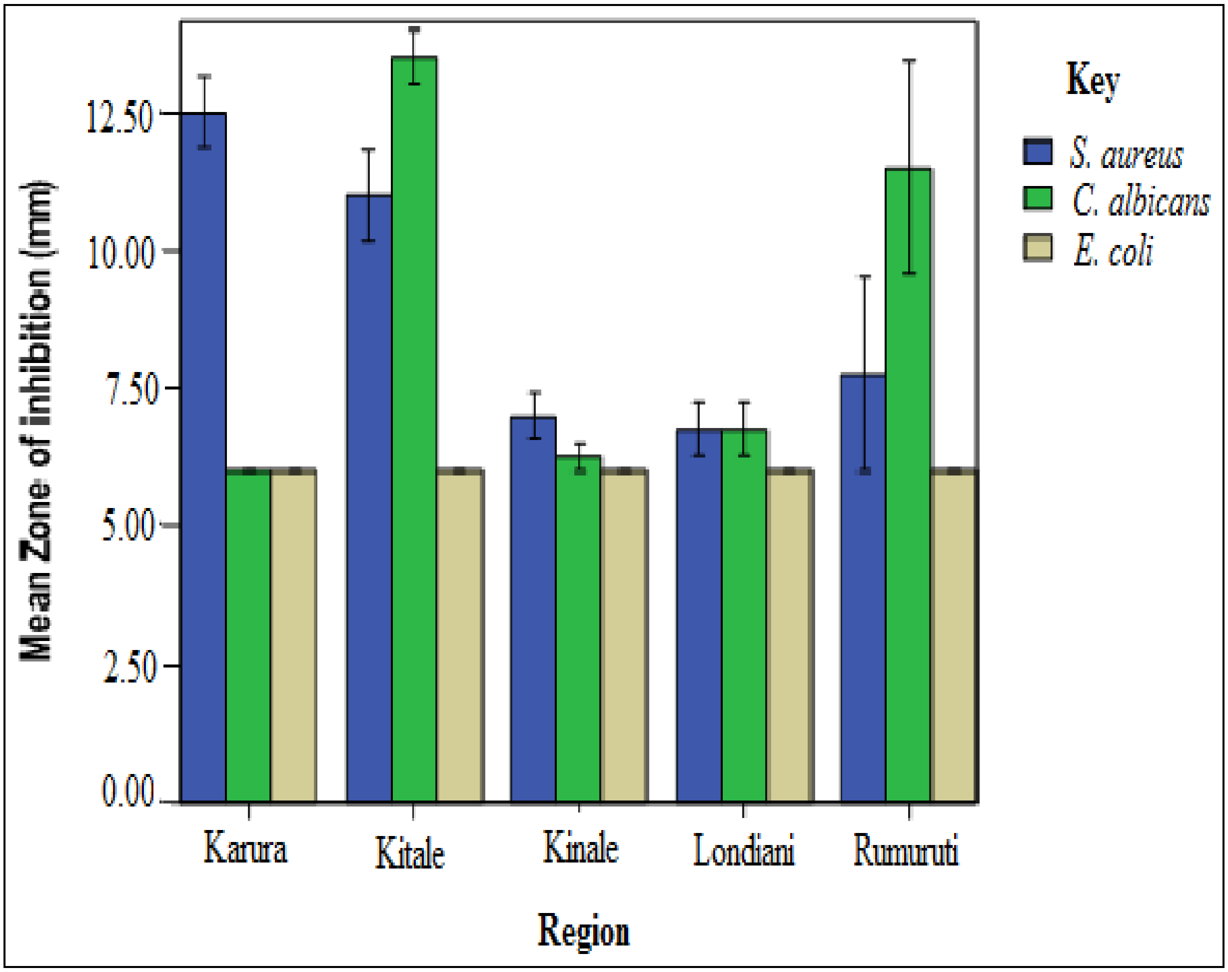


Figure 4.2: Comparison of mean zones of inhibition effects of DCM leaf extracts of *W. ugandensis*.

4.1.2 Bioassays for methanol extracts of *W. ugandensis*

Analyses of methanolic (MeOH) leaf and stem bark extracts revealed that MeOH stem bark extracts from Kitale and Karura were the most active with mean zones of inhibition of 20 and 17.75mm against *S. aureus,* respectively. These were followed by MeOH stem bark extracts from Rumuruti and Kinale with mean zones of inhibition of 13 and 12mm against *S. aureus,* respectively. On the other hand, moderate antifungal activities were observed in MeOH stem bark extracts from Rumuruti, Londiani and Kinale with mean zones of 11.75, 11.25 and 9mm against *C. albicans,* respectively (Figure 4.3). Evaluation of MeOH leaf extracts also revealed moderate antibacterial and antifungal activities against *S. aureus* and *C. albicans*, respectively. For example, MeOH leaf extracts from Kitale and Kinale exhibited activity with mean zones of inhibition of 9 and 7.5mm against *S. aureus,* respectively. Similarly, MeOH leaf extracts from Rumuruti and Kinale exhibited activity with mean zone of inhibition of 7mm against *C. albicans,* respectively (Figure 4.4).

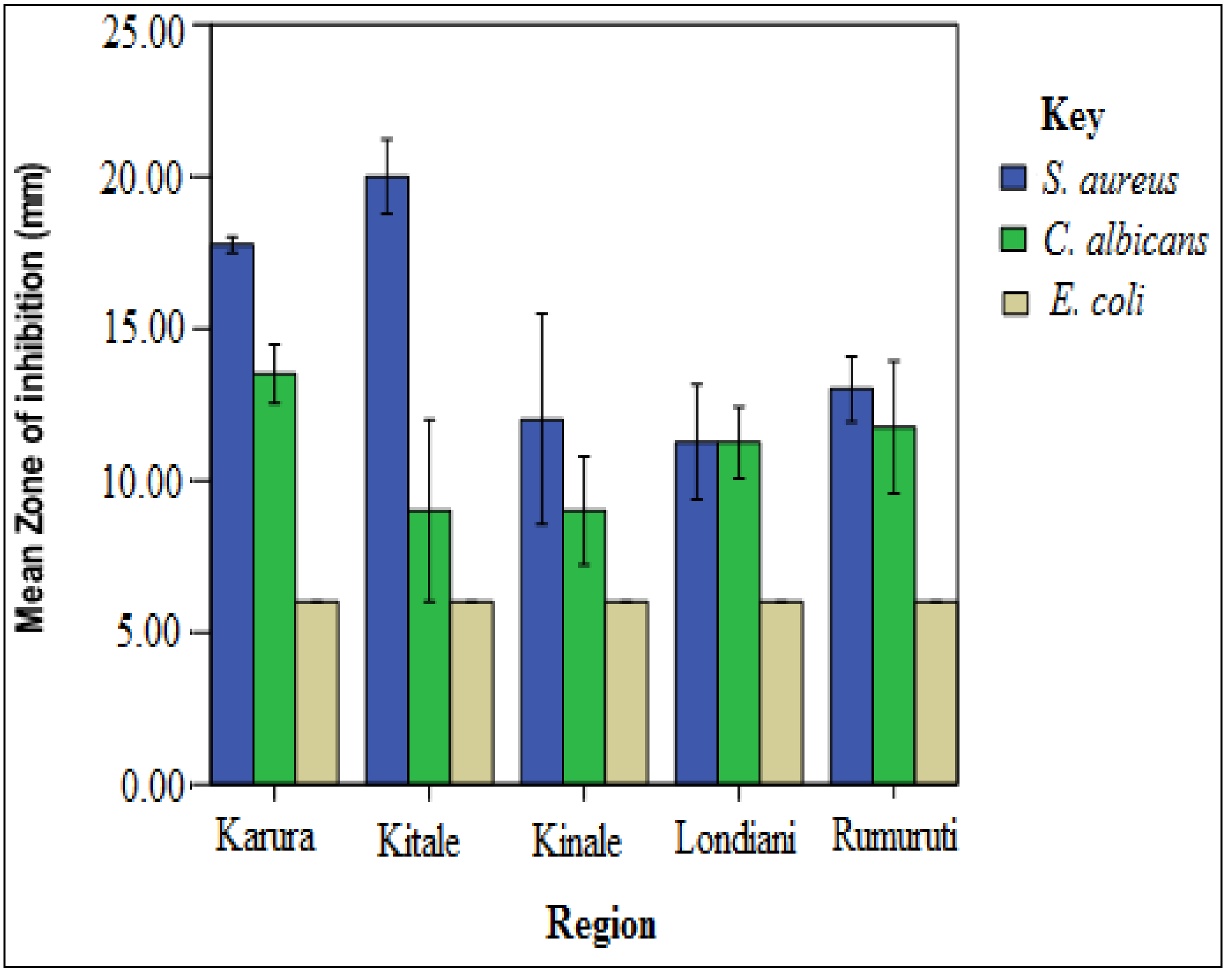


Figure 4.3: Comparison of mean zones of inhibition effects of MeOH stem bark extracts of *W. ugandensis.*

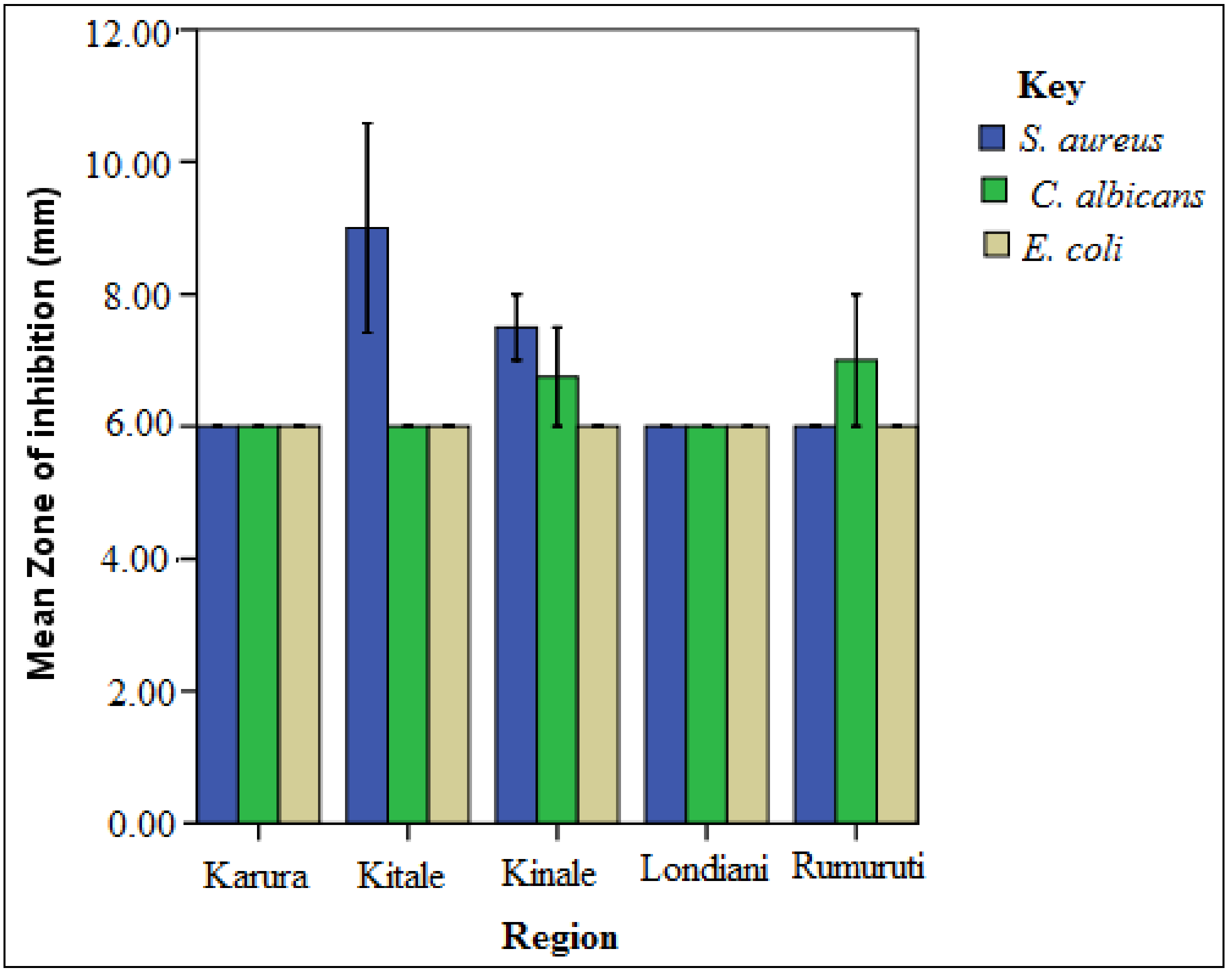


Figure 4.4: Comparison of mean zones of inhibition effects of MeOH leaf extracts of *W. ugandensis.*

4.2 Minimum inhibitory concentration of DCM extracts of *W. ugandensis*

The MIC analyses of DCM extracts showed that DCM stem bark extracts from Kitale, Kinale and Karura were the most active against *S. aureus* with mean MICs of 1.10 ± 0.16, 1.18 ± 0.29 and 1.53 ± 0.28mg/ml, respectively. On the basis of antifungal activity, DCM stem bark extracts from Londiani, Rumuruti, Kitale and Kinale exhibited the highest antifungal activity against *C. albicans* with mean MICs of 0.11 ± 0.03, 0.32 ±

0.10, 0.47 ± 0.12 and 0.56 ± 0.20mg/ml, respectively. Statistical analysis showed significant difference in mean MIC of DCM stem bark extracts from Kitale, Londiani and Rumuruti tested against *S. aureus* and *C. albicans* ($p < 0.05$, $\alpha = 0.05$, t-test). On the contrary, there was no statistical significant difference in mean MIC of DCM stem bark extracts from Karura and Kinale tested against *S. aureus* and *C. albicans* ($p < 0.05$, $\alpha = 0.05$, t-test). One way ANOVA analysis revealed no statistical significant difference in mean MICs of DCM stem bark extracts from the five populations tested against *S. aureus* ($p = 0.159$, $\alpha = 0.05$). On the other hand, there was statistical significant difference in mean MICs of DCM stem bark extracts from the five populations tested against *C. albicans* ($p < 0.001$, $\alpha = 0.05$, one way ANOVA) (Table 4.1).

Comparative analysis of mean MICs of DCM leaf extracts showed that DCM leaf extracts from Kitale and Rumuruti were the most active against *C. albicans* with mean MICs of 1.36 ± 0.30 and 1.44 ± 0.38mg/ml, respectively. These were followed by DCM leaf extracts from Kinale with mean MIC of 3.58 ± 2.13mg/ml against *C. albicans*. Meanwhile, for antibacterial activity, DCM leaf extracts from Kitale, Kinale, Karura and Londiani were active against *S. aureus* with mean MICs of 3.99 ± 0.73, 5.64 ± 1.57, 6.27 ± 1.43 and 6.51 ± 2.12mg/ml, respectively. There was statistical significant difference in mean MICs of DCM leaf extracts from Kitale tested against *S. aureus* and *C. albicans* ($p = 0.05$, $\alpha = 0.05$, t-test). In Kinale, there was no significant difference in MIC of DCM leaf extracts tested against *S. aureus* and *C. albicans* ($p = 0.509$, $\alpha = 0.05$, t-test). One way ANOVA analysis revealed no statistical significant difference in MICs of DCM leaf extracts from the five populations tested against *S. aureus* and *C. albicans* ($p > 0.05$, $\alpha =$

0.05). The DCM stem bark extracts from Londiani, Rumuruti, Kitale and Kinale were the most potent extracts in this study with mean MIC values less than 1mg/ml (Aligianis *et al.*, 2001; Katere and Eloff, 2008) (Table 4.1).

Table 4.1: Comparison of mean MICs of DCM stem bark and leaf extracts of *W. ugandensis*

	Dichloromethane stem bark extracts			**Dichloromethane leaf extracts**		
	Mean MIC (mg/ml)			**Mean MIC (mg/ml)**		
Region	***S. aureus***	***C. albicans***	***p*-value**	***S. aureus***	***C. albicans***	***p*-value**
Karura	1.53± 0.28	2.85 ± 0.78^b	0.131	6.27 ± 1.43	NA	
Kinale	1.18 ± 0.29	**0.56 ± 0.20**^{a}	0.094	5.64 ± 1.57	3.58 ± 2.13	0.509
Kitale	1.10 ± 0.16	**0.47 ± 0.12**^{a}	0.020	3.99 ± 0.73	1.36 ± 0.30	0.005
Londiani	2.12 ± 0.80	**0.11 ± 0.03**^{a}	0.036	6.51 ± 2.12	NA	
Rumuruti	3.13 ± 1.17	**0.32 ± 0.10**^{a}	0.036	NA	1.44 ± 0.38	
***p*-value**	0.159	<0.001		0.541	0.051	

Results were expressed as Mean ± Standard Error of Mean of three determinations per extract. Means followed by the same small letter (s) within the same column are not significantly different from one another at $p < 0.05$ by one way ANOVA and Tukey's HSD post hoc test. Values in bold (MIC < 1mg/ml) are considered noteworthy antimicrobial activity. NA stands for not active.

4.3 Minimum inhibitory concentration of MeOH extracts of *W. ugandensis*

Evaluation of MeOH stem bark and leaf extracts showed that Karura, Londiani, Kitale and Kinale were active against *S. aureus* with mean MICs of 1.43 ± 0.28, 1.47 ± 0.36, 2.24 ± 0.38 and 2.27 ± 0.53mg/ml, respectively. Analysis on the basis of antifungal activity revealed that MeOH stem bark extracts from Rumuruti, Karura, Londiani, Kitale and Kinale were active against *C. albicans* with mean MICs of 0.85 ± 0.23, 1.63 ± 0.59, 2.30 ± 0.64, 2.93 ± 0.98 and 4.72 ± 1.54mg/ml, respectively. There was no statistical significant difference in mean MICs of MeOH stem bark extracts from Karura, Kinale, Kitale, Londiani and Rumuruti tested against *S. aureus* and *C. albicans* ($p > 0.05$, $\alpha =$

0.05, t-test). One way ANOVA test showed no significant difference in mean MICs of MeOH stem bark extracts from the five populations tested against *S. aureus* (p = 0.110, α = 0.05). On the contrary, there was statistical significant difference in mean MICs of MeOH stem bark extracts from the five populations tested against *C. albicans* (p = 0.039, α = 0.05) (Table 4.2).

Analysis of MeOH leaf extracts revealed that extracts from Kinale and Kitale were active against *S. aureus* with mean MICs of 4.76 ± 1.26 and 7.60 ± 1.67mg/ml, respectively. Similarly, MeOH leaf extracts from Rumuruti and Kinale were active against *C. albicans* with mean MICs of 1.79 ± 1.07 and 4.56 ± 1.72mg/ml, respectively. Statistically, there was no significant difference in mean MIC of MeOH leaf extracts from Kinale tested against *S. aureus* and *C. albicans* (p = 0.941, α = 0.05, t-test). One way ANOVA revealed no statistical significant differrence in mean MICs of MeOH leaf extracst from the five populations tested against *S. aureus* and *C. albicans* ($p > 0.05$, α = 0.05). Methanolic leaf of *W. ugandensis* exhibited weak antimicrobial activity except for extracts from Rumuruti which exhibited noteworthy antifungal activity against *C. albicans* with mean MIC value of less than 1mg/ml (Aligianis *et al.,* 2001; Katere and Eloff, 2008) (Table 4.2).

Table 4.2: Comparison of mean MICs of MeOH stem bark and leaf extracts of *W. ugandensis*

Region	**Methanol stem bark extracts**			**Methanol leaf extracts**		
	Mean MIC (mg/ml)			**Mean MIC (mg/ml)**		
	S. aureus	***C. albicans***	***P*-value**	***S. aureus***	***C. albicans***	***P*-value**
Karura	1.47 ± 0.36	1.63 ± 0.59^{ab}	0.817	NA	NA	
Kinale	2.77 ± 0.53	4.72 ± 1.54^{b}	0.336	4.76 ± 1.26	4.56 ± 1.72	0.941
Kitale	2.24 ± 0.38	2.93 ± 0.98^{ab}	0.452	7.60 ± 1.67	NA	
Londiani	1.57 ± 0.37	2.30 ± 0.64^{ab}	0.382	NA	NA	
Rumuruti	1.43 ± 0.28	**0.85 ± 0.23^{a}**	0.154	NA	1.79 ± 1.07	
***P*-value**	0.110	0.039		0.184	0.240	

Results were expressed as Mean ± Standard Error of Mean of three determinations per extract. Means followed by the same small letter (s) within the same column are not significantly different from one another at $p < 0.05$ by one way ANOVA and Tukey's HSD post hoc test. Values in bold (MIC < 1mg/ml) are considered noteworthy antimicrobial activity. NA stands for not active.

4.4 Interactions of plant sites, samples, parts and solvent types on antibacterial and antifungal activities

This study also sought to establish if sites, samples, plant parts, solvent types (extracts) and their interactions had any statistically significant effect on antibacterial (*S. aureus*) and antifungal (*C. albicans*) activities (dependent variables. A two way ANOVA for the interactions between site versus sample, site versus plant part, site versus solvent type, sample versus plant part, sample versus solvent type and plant part versus solvent type on either antibacterial or antifungal activity was determined. There was a statistically significant interaction between the effect of site versus sample on the antibacterial activity (*S. aureus*) (F (12, 112) = 2.657, $p < 0.05$) (Table 4.3). This is confirmed in the profile plot for the interaction between site and sample (Figure 4.5). Non-significant interactions for site versus plant part, site versus solvent type, sample versus plant part, sample versus solvent type and plant part versus solvent type ($p > 0.05$) were observed in the study finding (Table 4.3) and interaction profile plots (Figures 4.6, 4.7, 4.8 and 4.9, respectively).

Other significant interactions were also observed following three way ANOVA for site versus sample versus plant part on antibacterial activity (f (6, 112) = 3.542, p <0.05). Other interactions for site versus sample versus solvent type, site versus plant part versus solvent type, and sample versus plant part versus solvent type were statistically insignificant ($p > 0.05$) (Table 4.3). There was also significant difference in the mean antibacterial (*S. aureus*) effects between the different plant parts of *W. ugandensis*; leaves and stem back extracts for the ($p < 0.001$) (Table 4.3). On the contrary, there was non-significant difference in mean antibacterial effect for the different sites (Karura, Kinale, Kitale, Londiani and Rumuruti) (Table 4.3 and 4.4, respectively), samples (T1, T2, T3 and T4, respectively) (Table 4.3 and 4.7, respectively) and solvent types (DCM and MeOH) (Table 4.3) ($p > 0.05$). All the subsets were homogeneous for both the sites and samples, respectively (Table 4.5 and 4.6, respectively).

Table 4.3: Two way ANOVA for tests of between-subjects effects on antibacterial activity

Dependent variable: antibacterial activity (*S. aureus*)
Tukey's HSD test

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	1267.373[a]	55	23.043	3.154	0.000
Intercept	1817.369	1	1817.369	248.717	0.000
Site	31.421	4	7.855	1.075	0.372
Sample	42.169	3	14.056	1.924	0.130
Plant Part	**460.426**	**1**	**460.426**	**63.012**	**0.000**
Solvent Type	2.672	1	2.672	0.366	0.547
Site * Sample	**232.964**	**12**	**19.414**	**2.657**	**0.004**
Site * Plant Part	26.962	3	8.987	1.230	0.302
Site * Solvent Type	48.175	4	12.044	1.648	0.167
Sample * Plant Part	26.868	3	8.956	1.226	0.304
Sample * Solvent Type	30.380	3	10.127	1.386	0.251
Plant Part * Solvent Type	0.000	1	0.000	0.000	0.995
Site * Sample * Plant Part	**155.280**	**6**	**25.880**	**3.542**	**0.003**
Site * Sample * Solvent Type	28.802	8	3.600	0.493	0.859
Site * Plant Part * Solvent Type	6.803	1	6.803	0.931	0.337
Sample * Plant Part * Solvent Type	5.960	2	2.980	0.408	0.666
Site * Sample * Plant Part * Solvent Type	0.123	1	0.123	0.017	0.897
Error	818.381	112	7.307		
Total	3772.512	168			
Corrected Total	2085.755	167			

R Squared = 0.608 (Adjusted R Squared = 0.415)
Interactions (in bold) are significant at $p < 0.05$.

Table 4.4: Multiple comparisons on effects of sites on antibacterial activity

Dependent variable: antibacterial activity (*S. aureus*)
Tukey's HSD test

(I) Site	(J) Site	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Karura	Kinale	-0.4703	0.62476	0.943	-2.2026	1.2620
	Kitale	-0.3864	0.60444	0.968	-2.0624	1.2895
	Londiani	0.0742	0.71234	1.000	-1.9010	2.0493
	Rumuruti	0.8408	0.71234	0.763	-1.1343	2.8160
Kinale	Karura	0.4703	0.62476	0.943	-1.2620	2.2026
	Kitale	0.0838	0.59138	1.000	-1.5559	1.7236
	Londiani	0.5444	0.70130	0.937	-1.4001	2.4889
	Rumuruti	1.3111	0.70130	0.340	-.6334	3.2556
Kitale	Karura	0.3864	0.60444	0.968	-1.2895	2.0624
	Kinale	-0.0838	0.59138	1.000	-1.7236	1.5559
	Londiani	0.4606	0.68325	0.962	-1.4339	2.3551
	Rumuruti	1.2273	0.68325	0.381	-.6672	3.1217
Londiani	Karura	-0.0742	0.71234	1.000	-2.0493	1.9010
	Kinale	-0.5444	0.70130	0.937	-2.4889	1.4001
	Kitale	-0.4606	0.68325	0.962	-2.3551	1.4339
	Rumuruti	0.7667	0.78033	0.863	-1.3970	2.9303
Rumuruti	Karura	-0.8408	0.71234	0.763	-2.8160	1.1343
	Kinale	-1.3111	0.70130	0.340	-3.2556	0.6334
	Kitale	-1.2273	0.68325	0.381	-3.1217	0.6672
	Londiani	-0.7667	0.78033	0.863	-2.9303	1.39706

Based on observed means
The error term is Mean Square (Error) = 7.307.

Table 4.5: Homogeneous subsets for sites on antibacterial activity

Tukey's HSD test

Site	**N**	**Subset**
		1
Rumuruti	24	2.2458
Londiani	24	3.0125
Karura	36	3.0867
Kitale	45	3.4731
Kinale	39	3.5569
Sig.		0.311

Means for groups in homogeneous subsets are displayed based on observed means.
The error term is Mean Square (Error) = 7.307.

a. Uses harmonic mean sample size = 31.452.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha (α) = 0.05.

Table 4.6: Homogeneous subsets for samples on antibacterial activity

Tukey's HSD test

Sample	**N**	**Subset**
		1
T3	42	2.8771
T4	39	2.9564
T1	45	3.3098
T2	42	3.5060
Sig.		0.712

Means for groups in homogeneous subsets are displayed based on observed means.
The error term is Mean Square (Error) = 7.307.

a. Uses harmonic mean sample size = 41.893.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha (α) = 0.05.

Table 4.7: Multiple comparisons on effects of samples on antibacterial activity

Dependent variable: antibacterial activity (*S. aureus*)
Tukey's HSD test

(I) Sample	**(J) Sample**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
T1	T2	-0.1962	0.57996	0.987	-1.7087	1.3164
	T3	0.4326	0.57996	0.878	-1.0799	1.9452
	T4	0.3534	0.59138	0.933	-1.1890	1.8957
T2	T1	0.1962	0.57996	0.987	-1.3164	1.7087
	T3	0.6288	0.58987	0.711	-0.9096	2.1672
	T4	0.5495	0.60111	0.797	-1.0182	2.1173
T3	T1	-0.4326	0.57996	0.878	-1.9452	1.0799
	T2	-0.6288	0.58987	0.711	-2.1672	0.9096
	T4	-0.0793	0.60111	0.999	-1.6470	1.4884
T4	T1	-0.3534	0.59138	0.933	-1.8957	1.1890
	T2	-0.5495	0.60111	0.797	-2.1173	1.0182
	T3	0.0793	0.60111	0.999	-1.4884	1.6470

Based on observed means
The error term is Mean Square (Error) = 7.307.

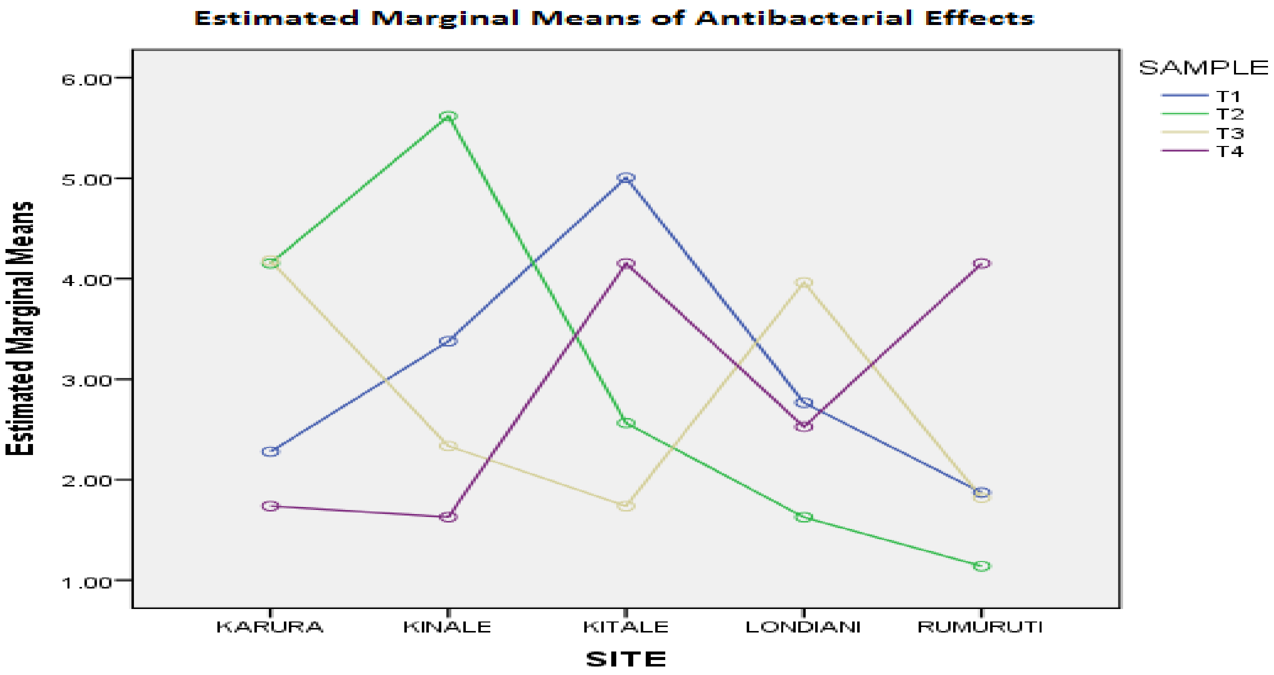


Figure 4.5: Profile plot for the interactions between sites and samples on antibacterial effects.

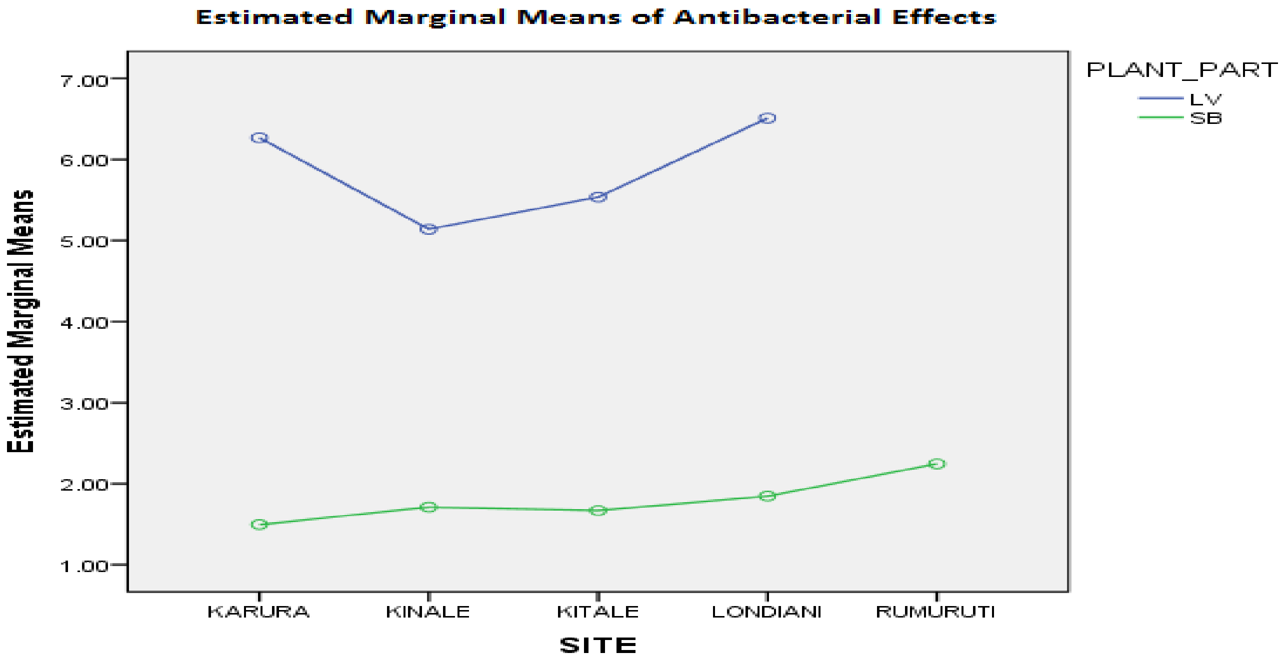


Figure 4.6: Profile plot for the interactions between sites and plant parts on antibacterial effects.

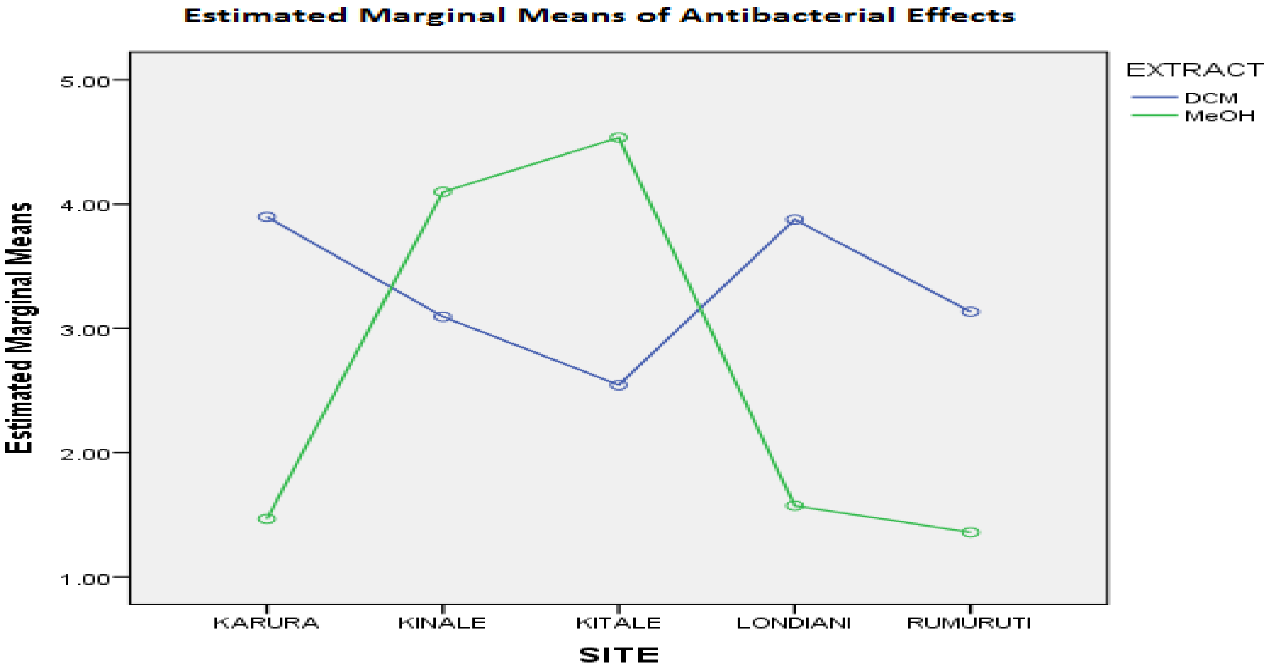


Figure 4.7: Profile plot for the interactions between sites and solvent (extract) types on antibacterial effects.

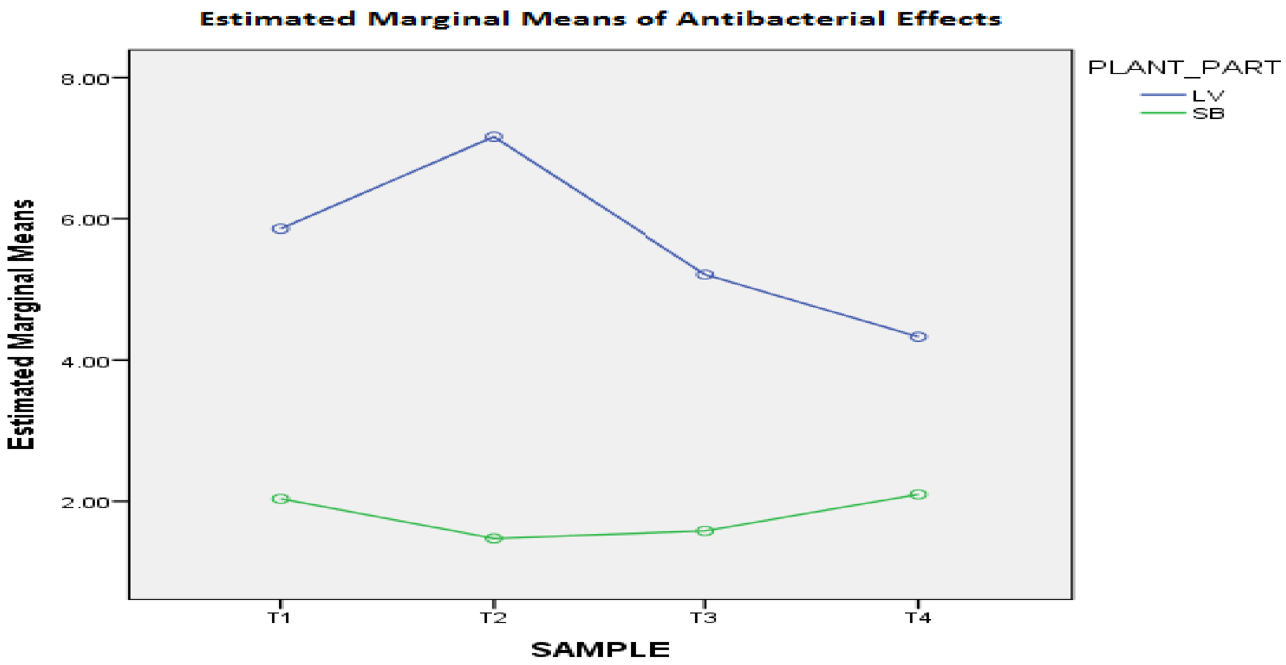


Figure 4.8: Profile plot for the interactions between samples and plant parts on antibacterial effects.

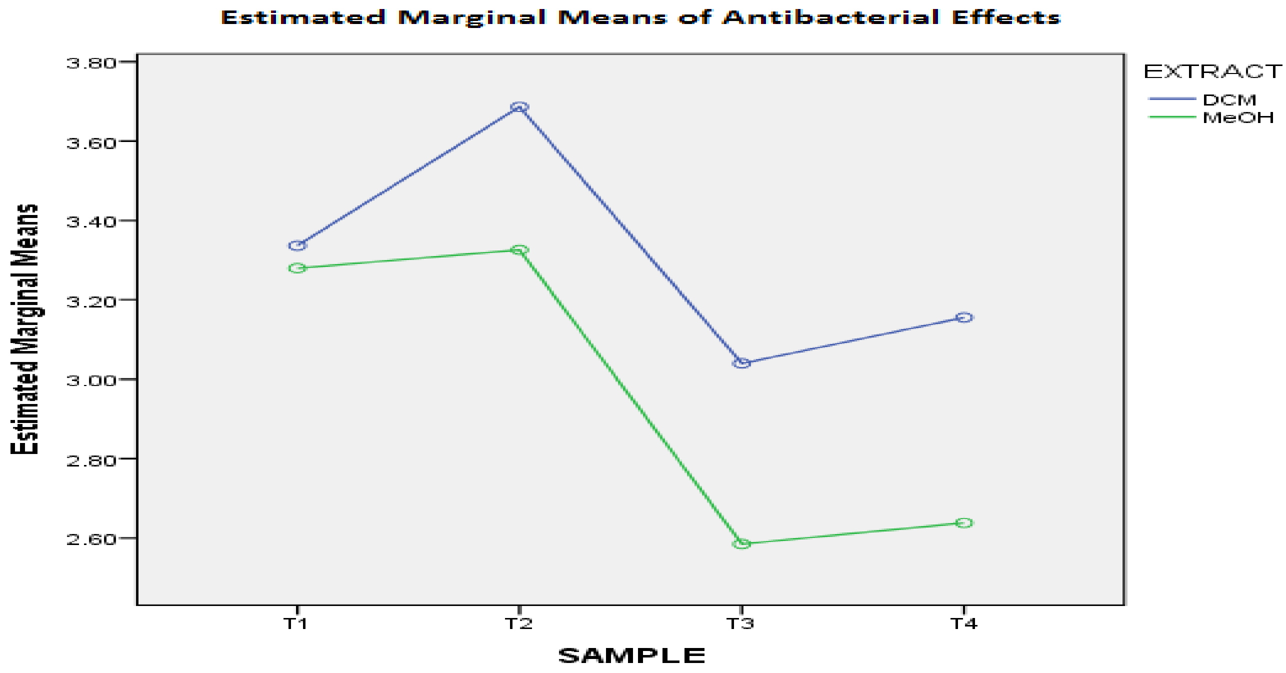


Figure 4.9: Profile plot for the interactions between samples and solvent (extract) types on antibacterial effects.

Analysis by two way ANOVA revealed significant interaction between the effects of site versus solvent type on the antifungal (*C. albicans*) activity (F (3, 84) = 5.445, $p < 0.05$) (Table 4.8). This is confirmed in the profile plot for the interaction between site and solvent (extract) type (Figure 4.12). There was also a statistically significant interaction between the effects of sample versus solvent type on the antifungal activity (F (3, 84) = 3.278, $p < 0.05$) (Table 4.8 and Figure 4.14). Other significant interactions were also observed following three way ANOVA for site versus sample versus solvent type on the antifungal activity of *C. albicans* (F (5, 84) = 2.808, $p < 0.05$). Non-significant interactions for plant part versus solvent type, site versus sample versus plant part, sample versus plant part, site versus plant part and site versus sample were also observed in this study ($p > 0.05$) (Table 4.8).

Multiple comparisons on the effects of sites revealed significant difference in the mean antifungal (*C. albicans*) activity among the different sites (Karura, Kinale, Kitale Londiani and Rumuruti) of *W. ugandensis* across the Kenyan Rift Valley (F (4, 84) = 3.250, $p < 0.05$) (Table 4.8 and 4.9, respectively). Similarly, there was a significant difference in the mean antifungal effect between the different solvent type (DCM and MeOH) (F (1, 84) = 6.162, $p < 0.05$) (Table 4.8). On the other hand, there was no significant difference in the mean antifungal activity between the different samples (T1, T2, T3 and T4) (Table 4.8 and 4.11, respectively) and plant parts (leaves and stem bark extracts) with all the subsets being homogeneous for the sites and samples, respectively (Table 4.10 and 4.12, respectively). The mean antibacterial (*S. aureus*) and antifungal (*C. albicans*) effects of extracts of *W. ugandensis* from the five populations were 3.17 ± 0.27

and 1.76 ± 0.21mg/ml, respectively regardless of the interactions of site versus sample, site versus plant part, site versus solvent type, sample versus plant part, sample versus solvent type and plant part versus solvent type as shown by the test for normality for the dependent variables (Table 4.13).

Table 4.8: Two way ANOVA for tests of between-subjects effects on antifungal activity

Dependent variable: antifungal activity (*C. albicans*)
Tukey's HSD test

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	367.603[a]	41	8.966	2.294	0.001
Intercept	265.304	1	265.304	67.880	0.000
Site	**50.816**	**4**	**12.704**	**3.250**	**0.016**
Sample	12.854	3	4.285	1.096	0.355
Plant Part	6.068	1	6.068	1.553	0.216
Solvent type	**24.085**	**1**	**24.085**	**6.162**	**0.015**
Site * Sample	51.391	12	4.283	1.096	0.375
Site * Plant Part	2.824	2	1.412	0.361	0.698
Site * Solvent Type	**63.850**	**3**	**21.283**	**5.445**	**0.002**
Sample * Plant Part	7.056	3	2.352	0.602	0.616
Sample * Solvent Type	**38.434**	**3**	**12.811**	**3.278**	**0.025**
Plant Part * Solvent Type	0.008	1	0.008	0.002	0.965
Site * Sample * Plant Part	5.856	1	5.856	1.498	0.224
Site * Sample * Solvent Type	**54.869**	**5**	**10.974**	**2.808**	**0.021**
Site * Plant Part * Solvent Type	0.000	0	.	.	.
Sample * Plant Part * Solvent Type	0.000	0	.	.	.
Site * Sample * Plant Part * Solvent Type	0.000	0	.	.	.
Error	328.309	84	3.908		
Total	1086.738	126			
Corrected Total	695.912	125			

R Squared = 0.528 (Adjusted R Squared = 0.298)
Interaction (in bold) is significant at $p < 0.05$.

Table 4.9: Multiple comparisons on effects of sites on antifungal activity

Dependent variable: antifungal activity (*C. albicans*)
Tukey’s HSD test

(I) Site	**(J) Site**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Karura	Kinale	-0.0546	0.54142	1.000	-1.5640	1.4548
	Kitale	1.1540	0.59074	0.298	-0.4929	2.8009
	Londiani	0.9171	0.61643	0.573	-0.8015	2.6356
	Rumuruti	**1.5803**	**0.53037**	**0.030**	**0.1016**	**3.0589**
Kinale	Karura	0.0546	0.54142	1.000	-1.4548	1.5640
	Kitale	1.2086	0.56249	0.210	-0.3596	2.7768
	Londiani	0.9717	0.58942	0.471	-0.6716	2.6149
	Rumuruti	**1.6348**	**0.49872**	**0.013**	**0.2445**	**3.0252**
Kitale	Karura	-1.1540	0.59074	0.298	-2.8009	0.4929
	Kinale	-1.2086	0.56249	0.210	-2.7768	0.3596
	Londiani	-0.2369	0.63502	0.996	-2.0073	1.5335
	Rumuruti	0.4263	0.55186	0.938	-1.1123	1.9648
Londiani	Karura	-0.9171	0.61643	0.573	-2.6356	0.8015
	Kinale	-0.9717	0.58942	0.471	-2.6149	0.6716
	Kitale	0.2369	0.63502	0.996	-1.5335	2.0073
	Rumuruti	0.6632	0.57929	0.782	-0.9518	2.2782
Rumuruti	**Karura**	**-1.5803**	**0.53037**	**0.030**	**-3.0589**	**-0.1016**
	Kinale	**-1.6348**	**0.49872**	**0.013**	**-3.0252**	**-0.2445**
	Kitale	-0.4263	0.55186	0.938	-1.9648	1.1123
	Londiani	-0.6632	0.57929	0.782	-2.2782	0.9518

Based on observed means

The error term is Mean Square (Error) = 3.908.
The mean difference is significant at $p < 0.05$.

Table 4.10: Homogeneous subsets for sites on antifungal activity

Tukey's HSD test

Site	N	Subset	
		1	2
Rumuruti	33	0.9052	
Kitale	21	1.3314	1.3314
Londiani	18	1.5683	1.5683
Karura	24	2.4854	2.4854
Kinale	30		2.5400
Sig.		0.053	0.223

Means for groups in homogeneous subsets are displayed based on observed means.
The error term is Mean Square (Error) = 3.908.

a. Uses harmonic mean sample size = 23.983.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha (α) = 0.05.

Table 4.11: Multiple comparisons on effects of samples on antifungal activity

Dependent Variable: antifungal activity (*C. albicans*)
Tukey's HSD test

(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
T1	T2	0.4129	0.48872	0.833	-0.8681	1.6940
	T3	-0.0553	0.54142	1.000	-1.4744	1.3639
	T4	-0.3709	0.48872	0.873	-1.6520	0.9101
T2	T1	-0.4129	0.48872	0.833	-1.6940	0.8681
	T3	-0.4682	0.52098	0.806	-1.8338	0.8974
	T4	-0.7839	0.46598	0.339	-2.0053	0.4375
T3	T1	0.0553	0.54142	1.000	-1.3639	1.4744
	T2	0.4682	0.52098	0.806	-.8974	1.8338
	T4	-0.3157	0.52098	0.930	-1.6813	1.0499
T4	T1	0.3709	0.48872	0.873	-0.9101	1.6520
	T2	0.7839	0.46598	0.339	-0.4375	2.0053
	T3	0.3157	0.52098	0.930	-1.0499	1.6813

Based on observed means
The error term is Mean Square (Error) = 3.908.

Table 4.12: Homogeneous subsets for samples on antifungal activity

Tukey's HSD test

Sample	**N**	**Subset**
		1
T2	36	1.3497
T1	30	1.7627
T3	24	1.8179
T4	36	2.1336
Sig.		0.412

Means for groups in homogeneous subsets are displayed based on observed means.
The error term is Mean Square (Error) = 3.908.

a. Uses harmonic mean sample size = 30.638.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha (α) = 0.05.

Table 4.13: Test for normality for dependent variables (antibacterial and antifungal effects)

		Antibacterial effects	**Antifungal effects**
N	Valid	168	126
	Missing	72	114
Mean		3.1686	1.7612
Std. Error of Mean		0.27266	0.21020
Std. Deviation		3.53406	2.35951
Skewness		**2.238**	**2.724**
Std. Error of Skewness		0.187	0.216
Kurtosis		**5.049**	**10.016**
Std. Error of Kurtosis		0.373	0.428

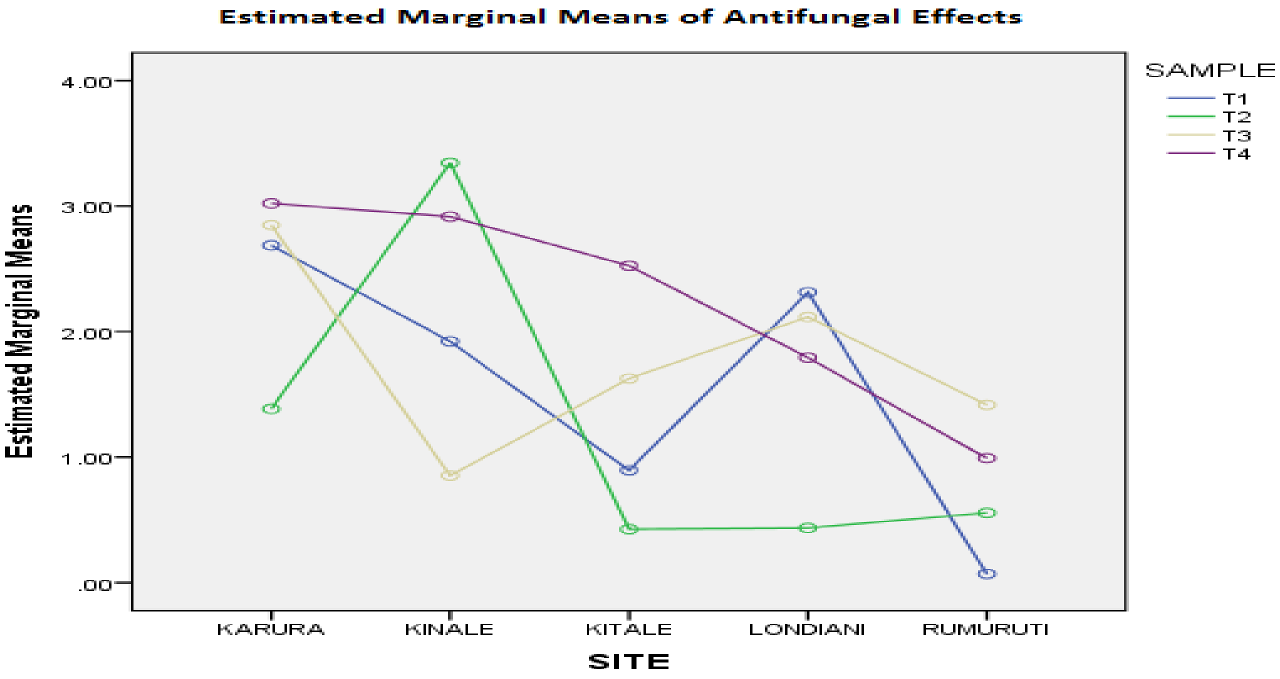


Figure 4.10: Profile plot for the interactions between sites and samples on antifungal effects.

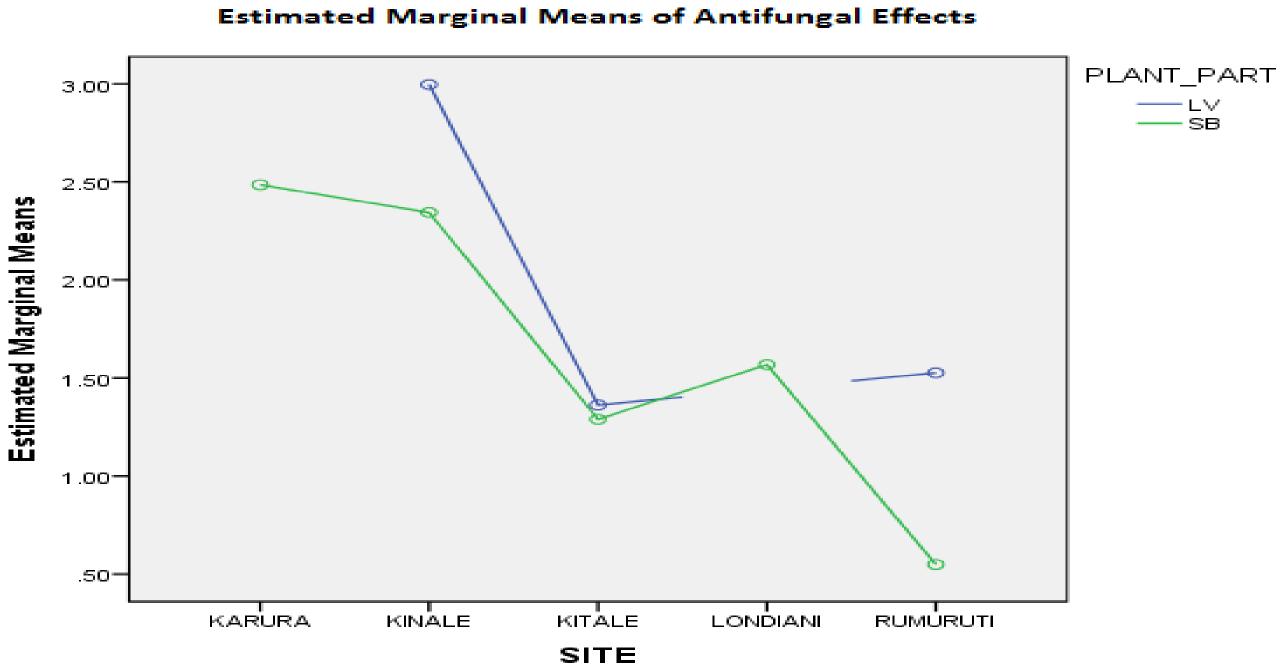


Figure 4.11: Profile plot for the interactions between sites and plant parts on antifungal effects.

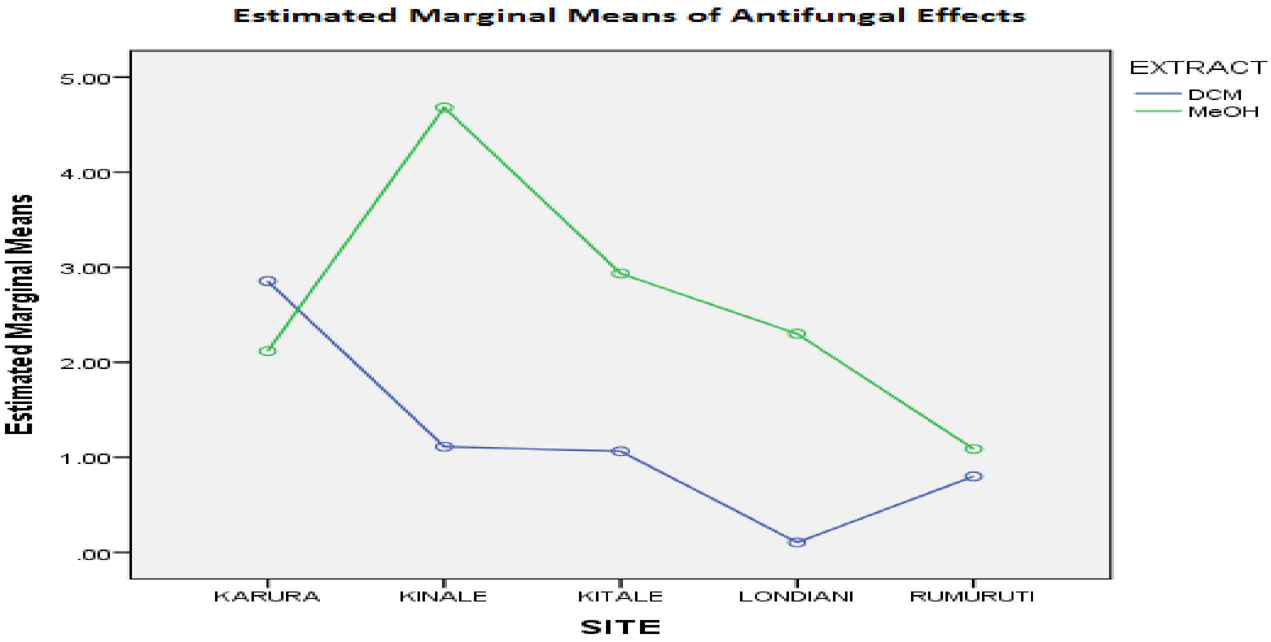


Figure 4.12: Profile plot for the interactions between sites and solvent (extract) types on antifungal effects.

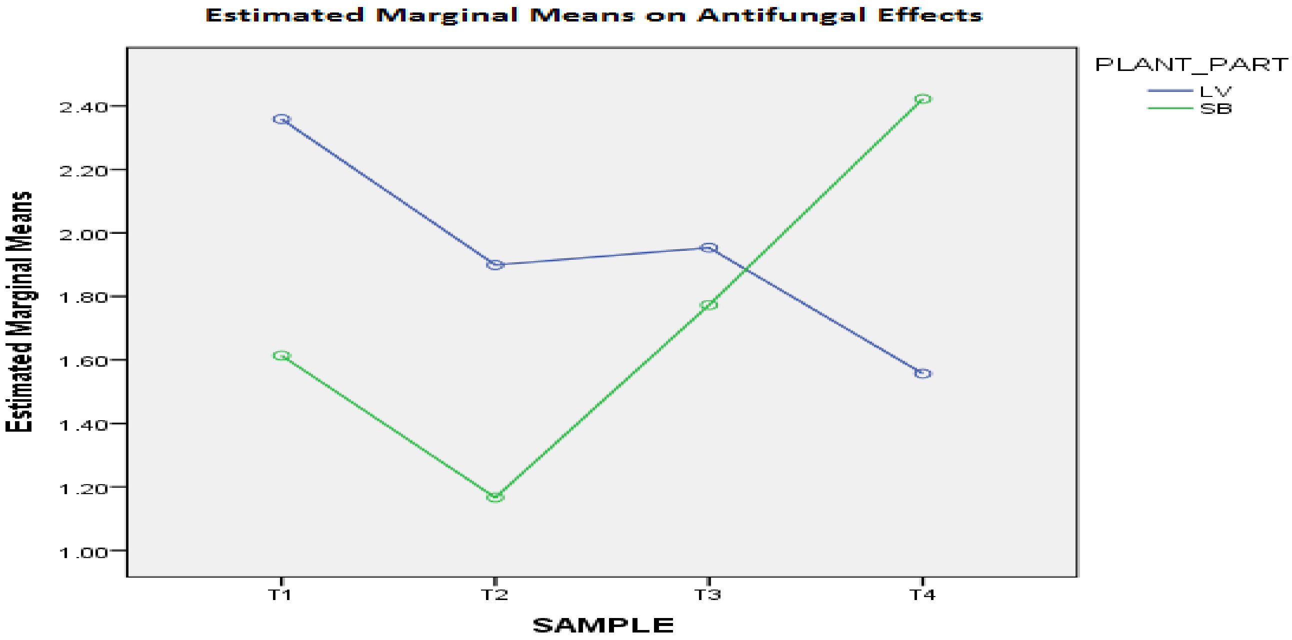


Figure 4.13: Profile plot for the interactions between samples and plant parts on antifungal effects.

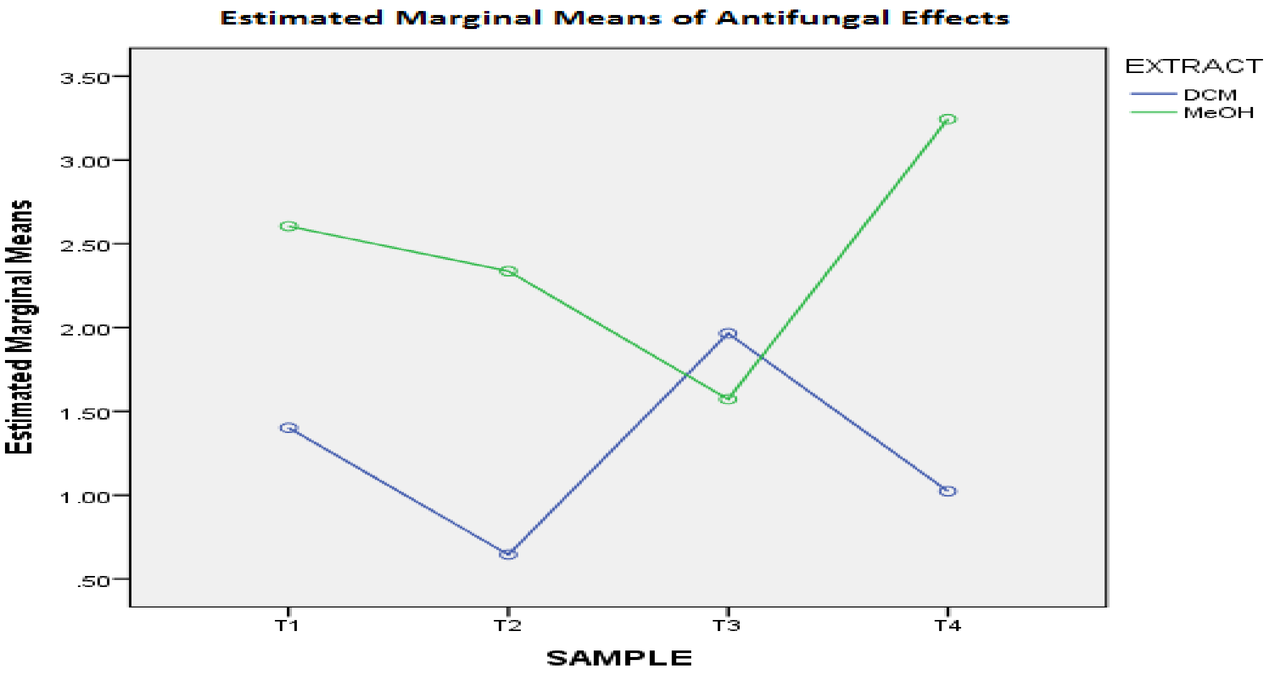


Figure 4.14: Profile plot for the interactions between samples and solvent (extract) types on antifungal effects.

4.5 Gas Chromatography Mass Spectrometry analyses of extracts of *W. ugandensis*

The compounds identified through GC-MS system were classified into different classes based on their biosynthetic origins: monoterpenoids, sesquiterpenoids, diterpenoids, fatty acid derivatives, carbohydrate derivatives, phenolics, coumarins, benzene derivatives, phytosterols, tocopherols, pyrans, alkaloids, ketones, aldehydes, alkaloids, flavonoids, naphthalene derivatives, anthracenes, phenanthracenes, furans and furanones. The chemical composition of the extracts varied greatly on the basis of classes of compounds and solvents used for extraction.

For Karura DCM extracts, 110 compounds were identified in leaf extracts while 111 compounds were identified in stem bark extracts. Karura DCM and MeOH extracts mostly comprised of sesquiterpenoids (34.55 to 56.76%) and fatty acid derivatives (11.7 to 19.09%) as the most dominant classes of compounds (Appendix 3). The major compounds in Karura DCM extracts based on peak area percentage were 1,5-diphenyl-1,4-pentadien-3-one (8.40%; leaf extracts), hexadecane (6.78%; leaf extracts) and n-hexadecanoic acid (4.37%; leaf extracts) while the minor compounds were vanillin (0.06%; stem bark extracts) and α-santalene (0.07%; stem bark extracts). There were qualitative and quantitative differences as well as similarities in the chemical profiles of compounds identified in *W. ugandensis* extracts. Some compounds were found to be common to both the leaf and stem bark extracts while others were present only in the leaf extracts and absent in the stem bark extracts and vice versa across the five populations of *W. ugandensis*.

Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Karura are shown in Table 4.14. On the other hand, some compounds present in DCM leaf extracts were absent in the DCM stem bark extracts from Karura. Such compounds isocarveol (0.26%), citronellol (0.74%), (1S,2R,5R)-(+)-isomenthol (0.90%), epizonarene (0.32%), muurolane (0.68%), berkheyaradulene (0.25%), γ-gurjunene (0.18%), widdrol (1.04%), shyobunone (1.01%), (-)-isolongifolol (3.51%), nerol acetate (1.28%), citronellyl iso-valerate (1.22%), stigmastan-3,5,22-trien (0.33%), pollinastanol (0.16%), stigmasterol acetate (0.21%), schottenol (2.31%), β-tocopherol (0.33%), geranylgeraniol (0.33%), (-)-isolongifolol, methyl ether (1.34%), phytol (0.51%), geranyl linalool (0.27%), cis-thujopsene (0.90%), p-mentha-1(7),8(10)-dien-9-ol (0.24%) and α-selinene (1.14%) (Appendix 4).

Table 4.14: Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Karura

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%)**	
				LV	**SB**
1	156	$C_{10}H_{20}O$	2,3,6-trimethylhept-3-en-1-ol (MT)	4.37	1.79
2	246	$C_{16}H_{22}O_2$	Cyclohexanecarboxylic acid, 3-phenylpropyl ester (FAD)	0.38	1.57
3	124	$C_8H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (KT)	1.32	1.16
4	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	2.51	2.09
5	204	$C_{15}H_{24}$	δ-cadinene (ST)	0.16	1.33
6	204	$C_{15}H_{24}$	β-humulene (ST)	0.36	1.68
7	220	$C_{15}H_{24}O$	7-oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)- (ST)	1.64	0.48
8	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy- (ST)	1.60	0.48
9	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	0.69	1.26
10	220	$C_{15}H_{24}O$	2-cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)- (ST)	0.59	1.27
11	222	$C_{15}H_{26}O$	Drimenol (ST)	1.05	4.04
12	410	$C_{30}H_{50}$	Squalene (TT)	1.18	0.26
13	226	$C_{16}H_{34}$	Hexadecane (H)	6.37	0.21
14	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	4.37	1.79
15	124	$C_7H_8O_2$	Guaiacol (P)	1.63	1.52
16	202	$C_{15}H_{22}$	Calamenene (ST)	0.12	0.16
17	206	$C_{15}H_{26}$	2,4a,8,8-tetramethyldecahydrocyclopropa[d] naphthalene (ST)	0.65	0.96
18	204	$C_{15}H_{24}$	γ-himachalene (ST)	0.28	0.52
19	222	$C_{15}H_{26}O$	1-methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane (ST)	0.19	0.85
20	332	$C_{22}H_{36}O_2$	2,6,10,14-hexadecatetraen-1-ol, 3,7,11,15-tetramethyl-, acetate, (E,E,E)- (DT)	0.32	0.60
21	298	$C_{19}H_{38}O_2$	i-propyl 14-methyl-pentadecanoate (FAD)	0.32	0.26
22	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester (FAD)	0.37	0.14
23	312	$C_{20}H_{40}O_2$	Hexadecanoic acid, 2-methylpropyl ester (FAD)	0.91	0.08

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone and N for naphthalene derivative.

Likewise, some compounds present in DCM stem bark extracts but absent in DCM leaf extracts from Karura included camphene (0.09%), α-fenchene (0.22%), p-menth-8(10)-en-9-ol (0.27%), cis-muurola-3,5-diene (0.08%), α-cubebene (1.35%), α-bergamotene (0.11%), (+)-epi-bicyclosesquiphellandrene (0.13%), α-santalene (0.07%), 7-epi-α-cadinene (0.20%), caryophyllene (0.35%), γ-muurolene (0.21%), α-muurolene (0.21%), α-calacorene (0.15%), acoradiene (0.31%), cadina-1(2),4-diene (0.36%), germacrene B (0.11%), (-)-δ-panasinsine (0.23%), 1,4-dihydrothujopsene-(I1) (1.87%), caryophyllene-(I1) (2.04%), thujopsene-I3 (3.33%), 7-epi-α-selinene (1.48%), β-cadinene (0.58%), α-bisabolol (0.39%), farnesol (0.24%), hanphyllin (0.77%), isolongifolene oxide (0.48%), khusilol (1.48%), ergosta-4,6,22-trien-3.beta.-ol (1.95%), carveol (1.41%) and (-)-α-neoclovene (0.25%) (Appendix 4).

Analysis of *W. ugandensis* MeOH extracts from Karura revealed the presence of 104 compounds in leaf extracts and 96 compounds in stem bark extracts (Appendix 3). The most abundant compounds in Karura MeOH extracts based on percentage composition were n-decanoic acid (6.53%; leaf extracts), sclaral (sclareolide lactol) (5.07%; stem bark extracts) and (-)-isolongifolol, methyl ether (4.33%; leaf extracts). The least abundant compound in MeOH extracts from Karura was vitamin E (0.07%; stem bark extracts). Meanwhile, table 4.15 shows the profiles of compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Karura.

Table 4.15: Compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Karura

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
1	204	$C_{15}H_{24}$	Himachala-2,4-diene (ST)	0.14	0.19
2	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.82	1.00
3	204	$C_{15}H_{24}$	Caryophyllene (ST)	0.43	0.19
4	204	$C_{15}H_{24}$	Cadina-1(10),6,8-triene (ST)	0.31	0.19
5	204	$C_{15}H_{24}$	δ-cadinene (ST)	0.71	0.57
6	204	$C_{15}H_{24}$	β-guaiene (ST)	1.63	2.91
7	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy- (ST)	0.72	0.50
8	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	0.53	0.69
9	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a,6,7,8, 9,9a-decahydro-6,6,9a-trimethyl (ST)	1.48	0.92
10	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide (ST)	0.55	0.33
11	246	$C_{15}H_{18}O_3$	α-santonin (ST)	0.31	0.33
12	222	$C_{15}H_{26}O$	Drimenol (ST)	2.02	1.15
13	410	$C_{30}H_{50}$	C(14a)-homo-27-norgammacer-14-ene (TT)	0.78	1.61
14	410	$C_{30}H_{50}$	Squalene (TT)	0.39	3.35
15	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	2.37	1.55
16	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester (FAD)	1.31	1.24
17	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	0.36	0.33
18	126	$C_6H_6O_3$	5-hydroxymethylfurfural (AD)	1.64	0.65
19	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (KT)	0.40	0.37
20	124	$C_8H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (KT)	0.52	0.46
21	248	$C_{16}H_{24}O_2$	4,4,5',5'-tetramethyl-bicyclohexyl-6-ene-2,3'-dione (KT)	0.81	2.37
22	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate (S)	0.20	0.17
23	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol (S)	4.05	0.27
24	414	$C_{29}H_{50}O$	Schottenol (S)	2.36	1.38
25	430	$C_{29}H_{50}O_2$	Vitamin E (TO)	0.44	0.07
26	162	$C_6H_{10}O_5$	β-D-glucopyranose, 1,6-anhydro- (CD)	0.70	1.12
27	206	$C_{11}H_{10}O_4$	Scoparone (C)	0.62	0.37
28	188	$C_{11}H_8O_3$	3-acetylcoumarin (C)	0.15	0.15

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, N for naphthalene derivative, AD for aldehyde, S for phytosterol, TO for tocopherol, CD for carbohydrate derivative, C for coumarin, B for benzene derivatives and AN for anthracene derivative.

Table 4.15: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	**SB**
29	230	$C_{14}H_{14}O_3$	4-(6-methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one (B)	0.87	0.70
30	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl- (B)	2.10	2.90
31	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl- (AN)	1.53	1.52
32	246	$C_{16}H_{22}O_2$	3-cyclopentylpropionic acid, 3,5-dimethylphenyl ester (FAD)	1.66	1.20

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, N for naphthalene derivative, AD for aldehyde, S for phytosterol, TO for tocopherol, CD for carbohydrate derivative, C for coumarin, B for benzene derivatives and AN for anthracene derivative.

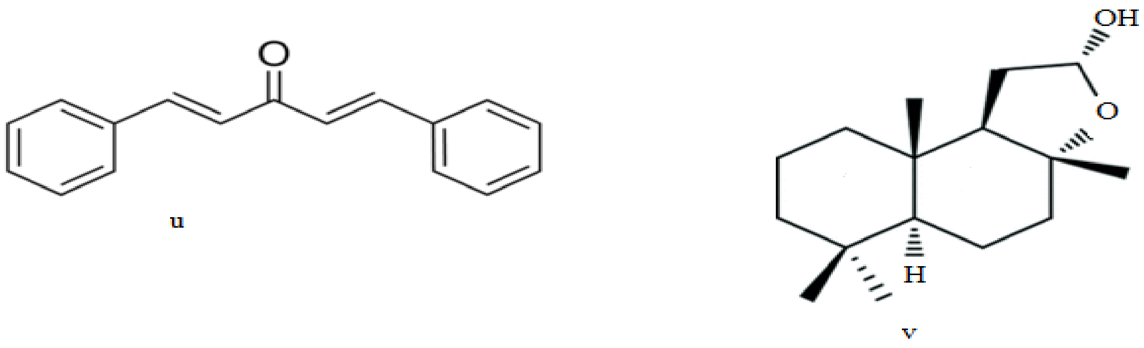
Based on qualitative differences between MeOH leaf and stem bark extracts from Karura, some compounds present in the leaf extracts were absent in the stem bark extracts. The compounds included santolina triene (0.71%), verbenone,(l) (0.37%), copaene (0.45%), α-bergamotene (0.16%), fukinane (2.27%), (-)-neoclovene-(II), dihydro- (0.40%), cis-thujopsene (0.42%), α-calacorene (0.11%), cadalene (0.17%), guaia-1(10),11-diene (0.40%), bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl- (0.18%), (-)-δ-panasinsine (0.18%), β-cadinene (1.20%), 9-methyl-S-octahydrophenanthrene (0.80%), aristolan-9-ol (0.25%), mansonone C (0.23%), β-dihydroagarofuran (0.32%), α-caryophyllene alcohol (0.20%), 11,12-dihydroxyseychellane (0.43%), achillicin (0.22%), confertin (0.69%), (-)-isolongifolol (0.47%), hanphyllin (0.21%), 3a-bromolongifolene (1.34%), (-)-isolongifolol, methyl ether (4.33%), geranyl linalool (0.28%), phytol (1.90%), cycloartane-3.beta.,25-diol (0.10%), cis-jasmone (0.99%), hyodeoxycholic acid (2.51%), γ-sitosterol (1.71%), stigmasterol acetate (0.68%), β-tocopherol (0.24%), (+)-.alpha.-tocopherol, O-methyl- (0.09%), δ-tocopherol (0.10%), 3,4-altrosan (1.39%), methyl 2-O-benzyl-d-arabinofuranoside (1.06%), benzyl .beta.-d-glucoside (1.74%), cerulignol (0.38%), coniferol (2.63%) and guaiacol (0.93%) (Appendix 4).

On the other hand, some of the compounds present in MeOH stem bark extracts were absent in MeOH leaf extracts from Karura. Such compounds included α-terpineol (0.11%), selina-3,7(11)-diene (0.10%), cadala-1(10),3,8-triene (0.15%), α-cubebene (0.31%), cycloisolongifolene (0.58%), α-gurjunene (1.58%), aromadendrene, dehydro- (0.18%), longipinane, (E)- (0.72%), β-humulene (0.36%), aristolone (0.83%), platambin (0.39%), ar-himachalen-2-ol (0.18%), drimenin (0.53%), humulane-1,6-dien-3-ol (0.42%), bakkenolide A (3.35%), widdrol hydroxyether (0.41%), sclaral (sclareolide lactol) (5.07%), davana ether (0.61%), γ-costol (0.41%), longifolenaldehyde (0.40%), 3-cyclohexene-1-carboxaldehyde, 1,3,4-trimethyl- (0.35%), bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (0.78%), glaucyl alcohol (0.31%), asarinin (0.10%), α-muurolene (0.19%), manool (0.58%), podocarp-12-en-14-ol (0.44%) and citronellyl iso-valerate (0.24%) (Appendix 4). Chemical structures of the major compounds in Karura are shown in figure 4.15. Meanwhile, table 4.16 below shows the profiles of compounds present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Karura.

Table 4.16: Compounds present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Karura

S/N	MWT	Formula	Compound name	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
1	204	$C_{15}H_{24}$	δ-cadinene (ST)	0.16	1.33	0.71	0.57
2	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy- (ST)	1.60	1.60	0.72	0.50
3	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	0.69	1.26	0.53	0.69
4	222	$C_{15}H_{26}O$	Drimenol (ST)	1.05	4.04	2.02	1.15
5	410	$C_{30}H_{50}$	Squalene (TT)	1.18	0.26	0.39	3.35
6	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	4.37	1.79	2.37	1.55
7	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester (FAD)	0.37	0.14	1.31	1.24
8	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	0.45	0.31	0.36	0.33
9	124	$C_8H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (KT)	1.32	1.16	0.52	0.46
10	230	$C_{14}H_{14}O_3$	4-(6-methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one (B)	0.28	0.14	0.87	0.70

Legend: R.A stands for relative abundance, MWT for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, ST for sesquiterpenoids, KT for ketone, B for benzene derivative and TT for triterpenoid.


u

v

Figure 4.15: Chemical structures of the major compounds in Karura: 1,5-diphenyl-1,4-pentadien-3-one (DCM leaf extracts) (u) and sclaral (sclareolide lactol) (MeOH stem bark extracts) (v).

The GC-MS analyses of DCM leaf and stem bark extracts of *W. ugandensis* from Kinale region also revealed diversity in the phytochemical profiles. For instance, 126 compounds were identified in leaf extracts while 105 compounds were identified in stem bark extracts. Kinale extracts were also largely composed of sesquiterpenoids (36.22 to 48.41%) and fatty acid derivatives (11.43 to 17.70%) as the most dominant classes of compounds (Appendix 3). The most dominant compounds in Kinale DCM extracts were hexadecane (5.16%; leaf extracts), alloaromadendrene (3.53%; stem bark extracts) and n-hexadecanoic acid (3.24%; leaf extracts). The least dominant compounds in Kinale DCM extracts were D-galactono-1,4-lactone, 5,6-O-octylidene (0.06%; stem bark extracts) and α-curcumene (0.06%; stem bark extracts).

There were qualitative and quantitative differences in phytochemical profiles of extracts from Kinale. Some compounds were present in DCM leaf extracts but absent in DCM stem bark extracts from Kinale. These compounds included santolina triene (0.29%), isoterpinolene (0.23%), safranal (0.34%), citronellol (0.63%), α-copaene (0.34%), cadina-1(2),4-diene (0.16%), calamenene (0.09%), cis-muurola-3,5-diene (0.21%), epizonarene (0.23%), α-calacorene (0.11%), cycloisolongifolene, 8,9-dehydro- (1.34%), (-)-α-panasinsen (0.54%), γ-elemene (0.28%), α-patchoulene (0.45%), γ-patchoulene (0.76%), farnesane (0.47%), aromadendrene, dehydro- (1.86%), germacrene B (0.32%), (-)-δ-panasinsine (0.27%), aristolone (1.20%), cubedol (0.30%), cis-α-copaene-8-ol (0.18%), (-)-isolongifolol (1.31%), β-santalol (1.32%), drimenol (0.59%), austricin (0.31%), nootkaton-11,12-epoxide (0.39%), 7-hydroxycadalenal (0.60%), (+)-beyerene (2.45%), phytol (0.98%), trans-geranylgeraniol (0.50%) and nerol acetate (1.13%)

(Appendix 5). Table 4.17 shows compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Kinale.

Table 4.17: Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Kinale

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	**SB**
1	204	$C_{15}H_{24}$	α-cubebene (ST)	0.44	0.07
2	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	0.92	1.15
3	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.32	2.54
4	206	$C_{15}H_{26}$	2,4a,8,8-tetramethyldecahydrocyclopropa[d] naphthalene (ST)	0.42	0.27
5	204	$C_{15}H_{24}$	β-bisabolene (ST)	0.76	0.37
6	202	$C_{15}H_{22}$	1,4-methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro- (ST)	1.17	1.36
7	204	$C_{15}H_{24}$	Bicyclo[5.3.0]decane, 2-methylene-5-(1-methylvinyl)-8-methyl- (ST)	0.40	1.48
8	204	$C_{15}H_{24}$	Guaia-1(10),11-diene (ST)	0.17	1.48
9	202	$C_{15}H_{22}$	Cycloisolongifolene, 9,10-dehydro- (ST)	0.22	1.34
10	204	$C_{15}H_{24}$	Bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl- (ST)	0.51	0.20
11	204	$C_{15}H_{24}$	(-)-α-neoclovene (ST)	0.17	0.19
12	204	$C_{15}H_{24}$	β-humulene (ST)	0.39	1.44
13	204	$C_{15}H_{24}$	β-cadinene (ST)	0.43	1.53
14	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.17	1.36
15	220	$C_{15}H_{24}O$	Longifolenaldehyde (ST)	1.34	0.94
16	220	$C_{15}H_{24}O$	2-cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)- (ST)	2.34	0.79
17	230	$C_{15}H_{18}O_2$	2,4,6-cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (ST)	0.37	2.39
18	250	$C_{15}H_{22}O_3$	5,8-dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone (ST)	0.86	4.56

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, H for hydrocarbon, KT for ketone, F for furan, S for phytosterol, AN for anthracene derivative, H for hydrocarbon.

Table 4.17: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
19	184	$C_{13}H_{28}$	Nonane, 3-methyl-5-propyl- (H)	0.48	0.13
20	164	$C_{12}H_{20}$	Cyclohexane, 1,5-diethenyl-2,3-dimethyl-, (1.alpha.,2.alpha.,3.alpha.,5.beta.)- (H)	0.60	0.59
21	226	$C_{16}H_{34}$	Hexadecane (H)	5.16	0.44
22	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl- (H)	0.61	0.17
23	298	$C_{19}H_{38}O_2$	i-propyl 14-methyl-pentadecanoate (FAD)	0.33	0.14
24	242	$C_{16}H_{34}O$	1-decanol, 2-hexyl- (FAD)	0.51	0.20
25	228	$C_{15}H_{32}O$	n-pentadecanol (FAD)	0.67	0.68
26	202	$C_{14}H_{18}O$	11-isopropylidenetricyclo[4.3.1.1(2,5)] undec-3- en-10-one (KT)	1.22	0.84
27	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (KT)	0.33	0.52
28	124	$C_7H_8O_2$	2-acetyl-5-methylfuran (F)	0.39	0.22
29	414	$C_{29}H_{50}O$	Schottenol (S)	1.77	0.40
30	124	$C_7H_8O_2$	Guaiacol (P)	0.24	1.28
31	230	$C_{16}H_{22}O$	Phenol, 2-(3,7-dimethylocta-2,6-dienyl)- (P)	0.26	0.27
32	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl- (AN)	0.23	1.64

Legend: R.A stands for relative abundance, MWT for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, H for hydrocarbon, KT for ketone, F for furan, S for phytosterol, AN for anthracene derivative, H for hydrocarbon.

Similarly, some compounds present in DCM stem extracts were absent in DCM leaf extracts from Kinale. The compounds included α-fenchene (0.32%), linalool (0.13%), terpinen-4-ol (0.09%), endo-borneol (0.13%), α-terpineol (0.27%), α-bergamotene (0.67%), α-santalene (0.30%), α-curcumene (0.06%), 7-epi-α-Selinene (0.08%), (-)-zingiberene (0.22%), caryophyllene (1.83%), α-selinene (0.25%), γ-gurjunene (0.56%), neoisolongifolene, 8,9-dehydro- (1.28%), aromadendrene, dehydro- (2.92%), alloaromadendrene (3.53%), isocaryophyllene (0.46%), dodecane, 2,7,10-trimethyl- (0.14%), α-terpinyl isovalerate (0.10%), borneol, acetate, (1S,2R,4S)-(-)- (0.33%), neoisolongifolene, 8-bromo- (1.18%), trans-nuciferol (0.23%), isolongifolen-9-one

(0.49%), confertin (0.61%), eudesma-5,11(13)-dien-8,12-olide (1.77%), D-galactono-1,4-lactone, 5,6-O-octylidene- (0.06%), podocarp-13-en-12-ol (0.46%), squalene (0.39%), phellopterin (0.18%), ergosta-4,6,22-trien-3.beta.-ol (1.21%) and δ-selinene (1.06%) (Appendix 5). Figure 4.16 shows the comparison of chemical classes identified in DCM leaf extracts of *W. ugandensis*.

Evaluation of *W. ugandensis* MeOH extracts from Kinale revealed the existence of 127 compounds in leaf extracts and 113 compounds in stem bark extracts (Appendix 3). The most abundant compounds in Kinale MeOH extracts were 3-cyclopentylpropionic acid, 3,5-dimethylphenyl ester (5.03%; stem bark extracts), β-guaiene (4.63%; stem bark extracts), longifolenaldehyde (3.15%; leaf extracts), stigmastan-3-ol, 5-chloro-, acetate, (3.beta.,5.alpha.)- (3.89%; stem bark extracts) and ergosta-4,6,22-trien-3.beta.-ol (3.41%; stem bark extracts) while the least abundant compounds were africanone (0.06%; stem bark extracts), stigmast-5-en-3-ol, oleate (0.06%; leaf extracts) and (+)-α-tocopherol, O-methyl- (0.05%; leaf extracts). Table 4.18 shows compounds commonly found in both MeOH leaf and stem bark extracts from Kinale.

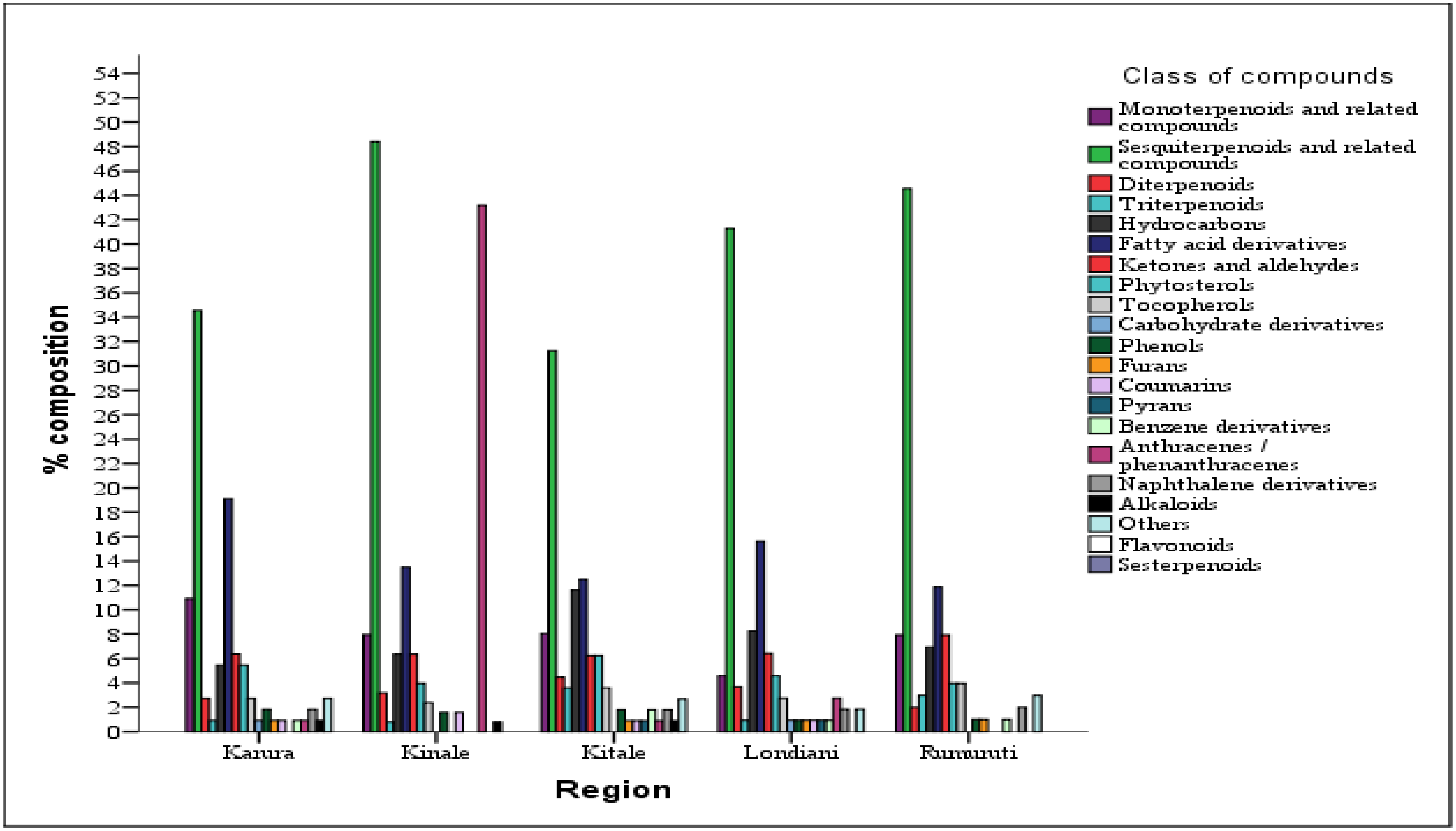


Figure 4.16: Comparison of chemical classes identified in DCM leaf extracts of *W. ugandensis*.

Table 4.18: Compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Kinale

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
1	204	$C_{15}H_{24}$	α-cubebene (ST)	0.20	0.51
2	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	0.42	2.06
3	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.31	1.20
4	202	$C_{15}H_{24}$	1,4-methanobenzocyclodecene, 1,2,3,4,4a,5,8,9, 12,12a-decahydro- (ST)	0.70	0.56
5	204	$C_{15}H_{24}$	β-guaiene (ST)	2.64	4.63
6	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	0.84	0.83
7	220	$C_{15}H_{24}O$	Longifolenaldehyde (ST)	3.15	1.11
8	222	$C_{15}H_{26}O$	Drimenol (ST)	2.35	1.65
9	230	$C_{15}H_{18}O_2$	2,4,6-cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (ST)	1.02	0.35
10	220	$C_{15}H_{24}O$	9-isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane (ST)	1.82	1.29
11	222	$C_{15}H_{26}O$	1,3a-ethano(1H)inden-4-ol, octahydro-2,2,4,7a-tetramethyl- (ST)	0.18	0.24
12	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide (ST)	1.35	2.78
13	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a, 6,7,8,9,9a-decahydro-6,6,9a-trimethyl (ST)	0.26	0.34
14	234	$C_{15}H_{22}O_2$	Bakkenolide A (ST)	1.54	1.34
15	272	$C_{15}H_{12}O_5$	6H-dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl- (ST)	0.16	0.04
16	296	$C_{20}H_{40}O$	Phytol (DT)	2.78	2.34
17	410	$C_{30}H_{50}$	Squalene (TT)	0.10	0.34
18	410	$C_{30}H_{50}$	C(14a)-homo-27-norgammacer-14-ene (TT)	0.27	0.53
19	164	$C_{12}H_{20}$	1,Z-5,E-7-dodecatriene (H)	0.35	0.57
20	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester (FAD)	1.25	1.86
21	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	2.92	2.86
22	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	0.52	0.29
23	280	$C_{18}H_{32}O_2$	9,12-octadecadienoic acid (Z,Z)- (FAD)	0.44	0.51

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, N for naphthalene derivative, F for furan, S for phytosterol, AN for anthracene derivative, H for hydrocarbon, TO for tocopherol, CD for carbohydrate derivative and B for benzene derivative.

Table 4.18: Cont’d

24	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester (FAD)	2.77	5.03
25	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester (FAD)	0.10	0.24
26	192	$C_{13}H_{20}O$	Tricyclo[6.3.0.0(1,5)]undecan-4-one, 5,9-dimethyl- (KT)	1.26	1.49
27	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)- (KT)	1.01	0.57
28	208	$C_{13}H_{20}O_2$	2,10,10-Trimethyl-6-methylene-1-oxaspiro[4.5]decan-7-one (KT)	1.19	2.55
29	206	$C_{13}H_{18}O_2$	Ethanone, 1-(3-butyl-2-hydroxy-5-methylphenyl)- (KT)	1.55	1.18
30	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (KT)	1.73	1.27
31	414	$C_{29}H_{50}O$	Schottenol (S)	1.99	1.61
32	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate (S)	0.06	1.76
33	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol (S)	2.05	3.41
34	416	$C_{28}H_{48}O_2$	β-tocopherol (TO)	0.18	0.14
35	430	$C_{29}H_{50}O_2$	Vitamin E (TO)	0.42	0.16
36	444	$C_{30}H_{52}O_2$	(+)-α-tocopherol, O-methyl- (TO)	0.05	0.08
37	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside (CD)	1.47	0.19
38	124	$C_7H_8O_2$	Guaiacol (P)	1.26	1.33
39	126	$C_6H_6O_3$	1,2,3-benzenetriol (B)	2.06	2.27
40	230	$C_{14}H_{14}O_3$	4-(6-methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one (B)	0.41	0.37
41	228	$C_{14}H_{12}O_3$	2H,8H-benzo[1,2-b:5,4-b']dipyran-2-one, 8,8-dimethyl- (B)	0.27	0.34
42	246	$C_{18}H_{30}$	Benzene, hexaethyl- (B)	2.47	1.95
43	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl- (AN)	1.14	0.86
44	200	$C_{15}H_{20}$	9-methyl-S-octahydroanthracene (AN)	0.77	0.71

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, N for naphthalene derivative, F for furan, S for phytosterol, AN for anthracene derivative, H for hydrocarbon, TO for tocopherol, CD for carbohydrate derivative and B for benzene derivative.

In addition, some compounds present in MeOH leaf extracts were absent in MeOH stem bark extracts from Kinale, including cinerone (0.76%), (2R,4R)-p-mentha-6,8-diene, 2-hydroperoxide (0.37%), 2,3-dehydro-1,8-cineole (0.35%), α-terpinyl acetate (0.22%), caryophyllene (0.81%), δ-cadinene (0.39%), 1,4-dihydrothujopsene-(I1) (0.23%), δ-neoclovene (0.28%), (-)-β-elemene (0.23%), isoledene (0.47%), β-humulene (0.41%), berkheyaradulene (1.10%), β-cadinene (0.12%), (-)-δ-panasinsine (0.57%), (-)-isolongifolol, methyl ether (0.44%), (-)-isolongifolol (0.70%), β-santalol (1.00%), 9H-cycloisolongifolene, 8-oxo- (0.46%), isolongifolene, 5-acetoxy-3-hydroxy- (0.44%), α-cyperone (0.23%), austricin (0.59%), 2-cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)- (0.52%), α-santonin (0.83%), cycloartane-3.beta.,25-diol (0.15%), 4,8,12,16-tetramethylheptadecan-4-olide (0.15%), stigmasterol acetate (0.38%), xylose (1.51%), D-mannitol (2.10%) and β-D-glucopyranose, 1,6-anhydro- (0.97%) (Appendix 5).

Some compounds present in MeOH stem bark extracts were also absent in MeOH leaf extracts from Kinale, such as citral (1.61%), o-mentha-1(7),8-dien-3-ol (0.35%), α-copaene (0.19%), cadina-1(10),6,8-triene (0.07%), α-bergamotene (0.82%), himachala-2,4-diene (0.80%), β-bisabolene (1.33%), α-curcumene (0.25%), muurolane (0.28%), ylangene (0.27%), neoisolongifolene, 8,9-dehydro- (0.15%), cycloisolongifolene (0.78%), alloaromadendrene (1.26%), isocaryophyllene (0.98%), γ-patchoulene (0.19%), γ-costol (0.25%), humulene epoxide 2 (0.17%), bergamotol, Z-α-trans- (0.28%), isolongifolene, 9-hydroxy- (0.96%), achillicin (0.17%), cedrol (1.70%), sericealactone, deoxy- (0.74%), sclaral (sclareolide lactol) (0.82%), isolongifolen-9-one (0.14%), 9H-cycloisolongifolene, 8-oxo- (0.40%), manool (0.55%), grindelene (0.94%) and 9,10-dibromo-(+)-camphor (0.41%), (Appendix 5). Table 4.19 shows the profiles of compounds present in both DCM and MeOH leaf and stem bark extracts of *W.*

ugandensis from Kinale. Chemical structures of the major compounds in Kinale are shown in figure 4.17.

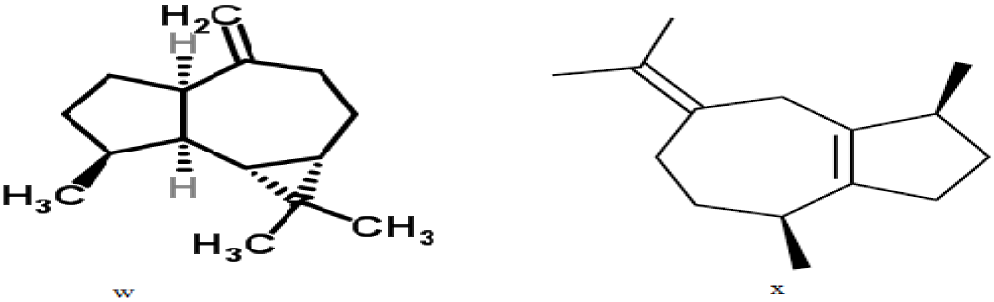


Figure 4.17: Chemical structures of the major compounds in Kinale: alloaromadendrene (DCM stem bark extracts) (w) and β-guaiene (MeOH stem bark extracts) (x).

Table 4.19: Compounds present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Kinale

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%)**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
1	204	$C_{15}H_{24}$	α-cubebene (ST)	0.44	0.07	0.20	0.51
2	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	0.92	1.15	0.42	2.06
3	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.32	2.54	0.31	1.20
4	202	$C_{15}H_{22}$	1,4-methanobenzocyclodecene, 1,2, 3,4,4a,5,8,9,12,12a-decahydro- (ST)	1.17	1.36	0.70	0.56
5	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.17	1.36	0.84	0.83
6	220	$C_{15}H_{24}O$	Longifolenaldehyde (ST)	1.34	0.94	3.15	1.11
7	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (KT)	0.33	0.52	1.73	1.27
8	414	$C_{29}H_{50}O$	Schottenol (S)	1.77	0.40	1.99	1.61

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, ST for sesquiterpenoid, KT for ketone, S for phytosterol, P for phenolic, AN for anthracene derivative and B for benzene derivative.

Table 4.19: Cont'd

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%)**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
9	230	$C_{15}H_{18}O_2$	2,4,6-cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (ST)	0.37	2.39	1.02	0.35
10	124	$C_7H_8O_2$	Guaiacol (P)	0.24	1.28	1.26	1.33
11	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl- (AN)	0.23	1.64	1.14	0.86

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, ST for sesquiterpenoid, KT for ketone, S for phytosterol, P for phenolic, AN for anthracene derivative and B for benzene derivative.

Similar trend of chemical polymorphism was observed in Kitale extracts. Sesquiterpenoids (31.25 to 37.40%) and fatty acid derivatives (10.28 to 17.07%) were the most dominant classes of compounds in Kitale extracts. A total of 112 compounds were identified in DCM leaf extracts while 97 compounds were identified in DCM stem bark extracts from Kitale (Appendix 3). Based on percentage relative abundance, the principal components in Kitale DCM extracts were hexadecane (5.27%; leaf extracts), guaiacol (3.92%; leaf extracts), 2,4,4-trimethyl-3-(3-methylbuta-1,3-dienyl)cyclohexanone (3.91%; leaf extracts), 4-(2', 4', 4'-trimethyl-yciclo[4.1.0]hept-2'-en-3'-yl)-3-buten-2-one (3.70%; stem bark extracts), β-patchoulene (3.24%; leaf extracts) and bicyclo[2.2.2]oct-5-ene-2,3-dicarboxylic anhydride, 1-(3-oxo-1-butenyl)-6,7,7-trimethyl- (3.23%; stem bark extracts) while the least prominent compounds were δ-tocopherol (0.06%; leaf extracts), nonane, 5-methyl-5-propyl- (0.05%; stem bark extracts) and α-terpineol (0.05%; stem bark extracts). Table 4.20 shows compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Kitale.

Table 4.20: Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Kitale

S/N	**MWT**	**Formula**	**Compound name**	**Mean**	
				LV	**SB**
1	204	$C_{15}H_{24}$	α-Cubebene (ST)	0.08	0.81
2	204	$C_{15}H_{24}$	β-Bisabolene (ST)	0.84	0.43
3	204	$C_{15}H_{24}$	γ-Gurjunene (ST)	0.19	0.58
4	202	$C_{15}H_{22}$	1,4-methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro- (ST)	0.10	1.62
5	222	$C_{15}H_{26}O$	Nerolidol 1 (ST)	2.40	1.42
6	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol (ST)	0.24	0.30
7	220	$C_{15}H_{24}O$	7-oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)- (ST)	1.74	1.20
8	222	$C_{15}H_{26}O$	(-)-isolongifolol (ST)	1.34	1.14
9	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide (ST)	0.33	0.83
10	220	$C_{15}H_{24}O$	γ-costol (ST)	0.91	0.75
11	290	$C_{20}H_{34}O$	trans-geranylgeraniol (DT)	0.60	0.10
12	410	$C_{30}H_{50}$	Squalene (TT)	0.64	1.68
13	226	$C_{16}H_{34}$	Hexadecane (H)	5.27	0.28
14	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	2.00	1.59
15	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	1.18	0.31
16	242	$C_{16}H_{34}O$	1-decanol, 2-hexyl- (FAD)	0.20	0.09
17	246	$C_{16}H_{22}O_2$	3-cyclopentylpropionic acid, 3,5-dimethylphenyl ester (FAD)	0.31	1.02
18	124	$C_8H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (KT)	1.84	1.18
19	400	$C_{28}H_{48}O$	Pollinastanol (S)	0.16	0.12
20	412	$C_{29}H_{48}O$	Stigmasterol (S)	0.17	0.13
21	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate (S)	0.47	0.13
22	430	$C_{29}H_{50}O_2$	Vitamin E	0.52	0.08
23	124	$C_7H_8O_2$	Guaiacol (P)	3.92	1.54
24	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	0.93	1.70
25	216	$C_{14}H_{16}O_2$	2,3-naphthalenedione, 1,4-dihydro-1,1,4,4-tetramethyl- (N)	0.15	1.40
26	204	$C_{15}H_{24}$	Caryophyllene (ST)	1.95	2.20
27	234	$C_{15}H_2O_2$	Drimenin (ST)	1.14	1.61

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol and N for naphthalene derivative.

In spite of the compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Kitale, some compounds present in DCM leaf extracts were absent in DCM stem bark extracts from Kitale. These compounds included 3a,6-methano-3aH-indene, 2,3,4,5,6,7-hexahydro- (0.78%), teresantalol (0.15%), p-menth-8-en-3-one, trans (0.15%), (1S,2R,5R)-(+)-isomenthol (0.64%), 9-methyl-10-methylenetricyclo[4.2.1.1(2,5)]decan-9-ol (0.61%), 7-epi-α-Selinene (0.17%), (-)-neoclovene-(II), dihydro (0.11%), selina-3,7(11)-diene (0.18%), cis-thujopsene (0.59%), β-patchoulene (3.24%), cycloisolongifolene (2.34%), patchoulane (0.41%), himachala-2,4-diene (1.71%), bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl- (0.42%), thujopsene-I3 (2.52%), β-humulene (0.37%), cycloisolongifolene, 8,9-dehydro- (0.33%), isolongifolene, 9-hydroxy- (1.74%), drimenol (1.65%), (-)-isolongifolol, methyl ether (0.83%), α-caryophyllene alcohol (1.51%), isothujopsene-5,14-diylborane, B-ethyl-dihydro- (0.45%), 2-(fench-2-yl)fenchane (0.25%), phytol (0.54%), supraene (0.43%), lup-20(29)-en-3-one (0.18%) and cycloartane-3.beta.,25-diol (0.06%) (Appendix 6).

Further analysis of volatile components from Kitale revealed the existence of some compounds in DCM stem bark extracts that were absent in the corresponding leaf extracts. Such compounds included α-fenchene (0.18%), α-terpinene (0.25%), α-terpineol (0.05%), thujanol (0.13%), α-santalene (0.30%), α-curcumene (0.18%), α-muurolenem (0.12%), α-cedrene (0.45%), (-)-zingiberene (1.22%), α-calacorene (0.10%), δ-selinene (0.71%), α-guaiene (0.12%), bergamotene (1.23%), 1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (1.13%), (-)-aristolene (1.92%), isolongifolene, 9,10-dehydro- (0.29%), thujopsene-(I2) (1.61%), δ-cadinene (0.56%), caryophyleine-(I3) (1.26%), γ-himachalene (0.11%), α-bisabolol (0.79%), longifolenaldehyde (0.30%), epi-10-γ-eudesmol (0.33%), germacrone (0.18%), methyl (25rs)-3.beta.-acetoxy-5-cholesten-26-oate (0.29%), chondrillasterol (0.15%), neryl propionate (0.35%) and ergosta-4,6,22-trien-3.beta.-ol (2.30%) (Appendix 6).

For Kitale MeOH extracts, 107 compounds were identified in leaf extracts while 123 compounds were identified in stem bark extracts (Appendix 3). The most abundant compounds in Kitale MeOH extracts were n-decanoic acid (6.12%; stem bark extracts), coniferol (4.96%; stem bark extracts), tridecanoic acid (4.79%; stem bark extracts), 1,2,3-benzenetriol (4.60%; leaf extracts), D-mannitol (4.26%; leaf extracts), dewar benzene, hexamethyl- (3.30%; stem bark extracts) and n-hexadecanoic acid (3.20%; stem bark extracts) while the least abundant compounds were 1,6,10,14,18,22-tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)- (0.08%; stem bark extracts) and artemisia triene (0.05%; leaf extracts). Table 4.21 shows compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Kitale. Figure 4.18 shows comparison of chemical classes identified in DCM stem bark extracts of *W. ugandensis*.

Table 4.21: Compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Kitale

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
1	182	$C_{12}H_{22}O$	2-(2-ethyl-1,3-dimethyl-cyclopent-2-enyl)-propan-2-ol (MT)	1.05	1.48
2	204	$C_{15}H_{24}$	α-cubebene (ST)	0.14	0.15
3	204	$C_{15}H_{24}$	Caryophyllene (ST)	0.42	0.49
4	204	$C_{15}H_{24}$	β-bisabolene (ST)	0.36	0.18
5	204	$C_{15}H_{24}$	(-)-zingiberene (ST)	0.49	0.86
6	204	$C_{15}H_{24}$	Bergamotene (ST)	0.33	0.68
7	204	$C_{15}H_{24}$	Isocaryophillene (ST)	0.19	0.60
8	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.62	0.71
9	202	$C_{15}H_{22}$	1,2,3,3a,4a,5,6,7,8,9,9a,9b-dodecahydrocyclopenta [def]phenanthrene (ST)	0.64	0.48
10	206	$C_{15}H_{26}$	2,4a,8,8-tetramethyldecahydrocyclopropa[d] naphthalene (ST)	0.48	0.57
11	222	$C_{15}H_{26}O$	Nerolidol 1 (ST)	0.98	0.92
12	222	$C_{15}H_{26}O$	(-)-isolongifolol (ST)	1.19	0.79
13	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy- (ST)	0.91	0.37
14	222	$C_{15}H_{26}O$	Drimenol (ST)	2.47	2.50
15	220	$C_{15}H_{24}O$	Bicyclo[6.3.0]undec-1(8)-en-3-one, 2,2,5,5-tetramethyl- (ST)	0.20	0.44
16	220	$C_{15}H_{24}O$	γ-costol (ST)	0.57	0.96
17	296	$C_{20}H_{40}O$	Phytol (DT)	2.01	2.11
18	410	$C_{30}H_{50}$	Squalene (TT)	0.16	1.32
19	272	$C_{15}H_{12}O_5$	6H-dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl- (ST)	0.09	0.12
20	220	$C_{15}H_{24}O$	9-isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane (ST)	0.31	1.47
21	410	$C_{30}H_{50}$	C(14a)-homo-27-norgammacer-14-ene (TT)	1.33	0.99
22	354	$C_{21}H_{38}O_4$	Fumaric acid, decyl 3-heptyl ester (FAD)	1.84	1.44
23	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	0.61	0.40
24	354	$C_{22}H_{26}O_4$	Succinic acid, di(2-propylphenyl) ester (FAD)	2.91	1.49

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, CD for carbohydrate derivative, F for furan, B for benzene derivative, AL for alkaloid, PY for pyran, DKT for diketone and TO for tocopherol.

Table 4.21: Cont'd

25	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester (FAD)	0.10	0.10
26	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)- (KT)	1.31	1.54
27	206	$C_{13}H_{18}O_2$	Ethanone, 1-(3-butyl-2-hydroxy-5-methylphenyl)- (KT)	1.79	1.77
28	202	$C_{14}H_{18}O$	11-isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one (KT)	0.57	0.99
29	248	$C_{16}H_{24}O_2$	4,4,5',5'-tetramethyl-bicyclohexyl-6-ene-2,3'-dione (DKT)	0.91	0.69
30	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)-(S)	0.18	0.37
31	414	$C_{29}H_{50}O$	Schottenol (S)	2.08	1.24
32	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol (S)	2.76	1.02
33	416	$C_{28}H_{48}O_2$	β-tocopherol (TO)	0.16	0.11
34	430	$C_{29}H_{50}O_2$	Vitamin E (TO)	0.28	0.28
35	146	$C_6H_{10}O_4$	Dianhydromannitol (CD)	1.69	1.17
36	154	$C_8H_{10}O_3$	Phenol, 2,6-dimethoxy- (P)	0.77	0.52
37	124	$C_7H_8O_2$	2-acetyl-5-methylfuran (F)	0.36	0.38
38	126	$C_6H_6O_3$	1,2,3-Benzenetriol (B)	4.60	2.77
39	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl- (B)	2.18	3.30
40	295	$C_{18}H_{17}NO_3$	(+)-mecambroline (AL)	0.33	0.10
41	144	$C_6H_8O_4$	4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl- (PY)	0.70	0.82

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, CD for carbohydrate derivative, F for furan, B for benzene derivative, AL for alkaloid, PY for pyran, DKT for diketone and TO for tocopherol.

Moreover, some compounds present in MeOH leaf extracts were absent in MeOH stem bark extracts from Kitale. Such compounds included 3-methoxyflavone (0.27%), fukinane (0.66%), artemisia triene (0.05%), β-ocimene (0.60%), p-menth-3-en-9-ol (0.60%), sabinol (0.81%), 7-epi-α-selinene (0.51%), berkheyaradulene (0.68%), β-cadinene (0.92%), cedrol (0.42%), γ-elemene (0.28%), cadina-1(10),6,8-triene (0.13%), (-)-β-elemene (0.81%), cis-muurola-3,5-diene (0.44%), thujopsene-(I2) (0.22%), himachala-2,4-diene (0.42%), β-cedrene (0.40%), δ-cadinene (0.59%), d-norandrostane

(5.alpha.,14.alpha.) (0.58%), stigmasta-4,22-dien-3.beta.-ol (0.09%), β-D-glucopyranose, 1,6-anhydro- (0.47%), nerolidol, hexahydro- (1.84%), sesquirosefuran (0.36%), isolongifolen-9-one (0.20%), cis-jasmone (0.97%), benzyl .beta.-d-glucoside (1.01%) and D-mannitol (4.26%) (Appendix 6).

Consequently, some compounds present in MeOH stem bark extracts were absent in MeOH leaf extracts of *W. ugandensis* from Kitale. These compounds included 3-pinanone, cis (0.37%), citral (1.02%), 1(3H)-isobenzofuranone, 3,3-dimethyl- (0.12%), 3,6-dimethyl-2,3,3a,4,5,7a-hexahydrobenzofuran (0.40%), 1-hydroxymethyladamantan-2-ol (0.71%), copaene (0.13%), epizonarene (0.43%), isoledene (0.46%), β-cadinene (2.06%), (-)-δ-panasinsine (0.70%), cascarilladiene (0.53%), 10.alpha.-eremophilane (0.84%), β-humulene (0.52%), bergamotol, Z-.alpha.-trans- (0.21%), aristolone (0.36%), 3a-bromolongifolene (1.87%), isodrimenin (0.64%), deoxynivalenol (0.89%), α-santonin (0.23%), bakkenolide A (2.16%), dihydrocostunolide (0.26%), γ-gurjunenepoxide-(2) (0.26%), (-)-isolongifolol, methyl ether (0.93%), eudesma-5,11(13)-dien-8,12-olide (0.61%), manool (0.52%), 9,12-octadecadienoic acid (Z,Z)- (1.73%), n-decanoic acid (6.12%), tridecanoic acid (4.79%), delta.4-androstene-3.beta.,17.beta.-diol (0.43%), 3,4-altrosan (0.59%), methyl 2-O-benzyl-d-arabinofuranoside (1.42%) and coniferol (4.96%) (Appendix 6). Table 4.22 shows profiles of compounds present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Kitale. Figure 4.19 shows chemical structures of the major compounds in Kitale.

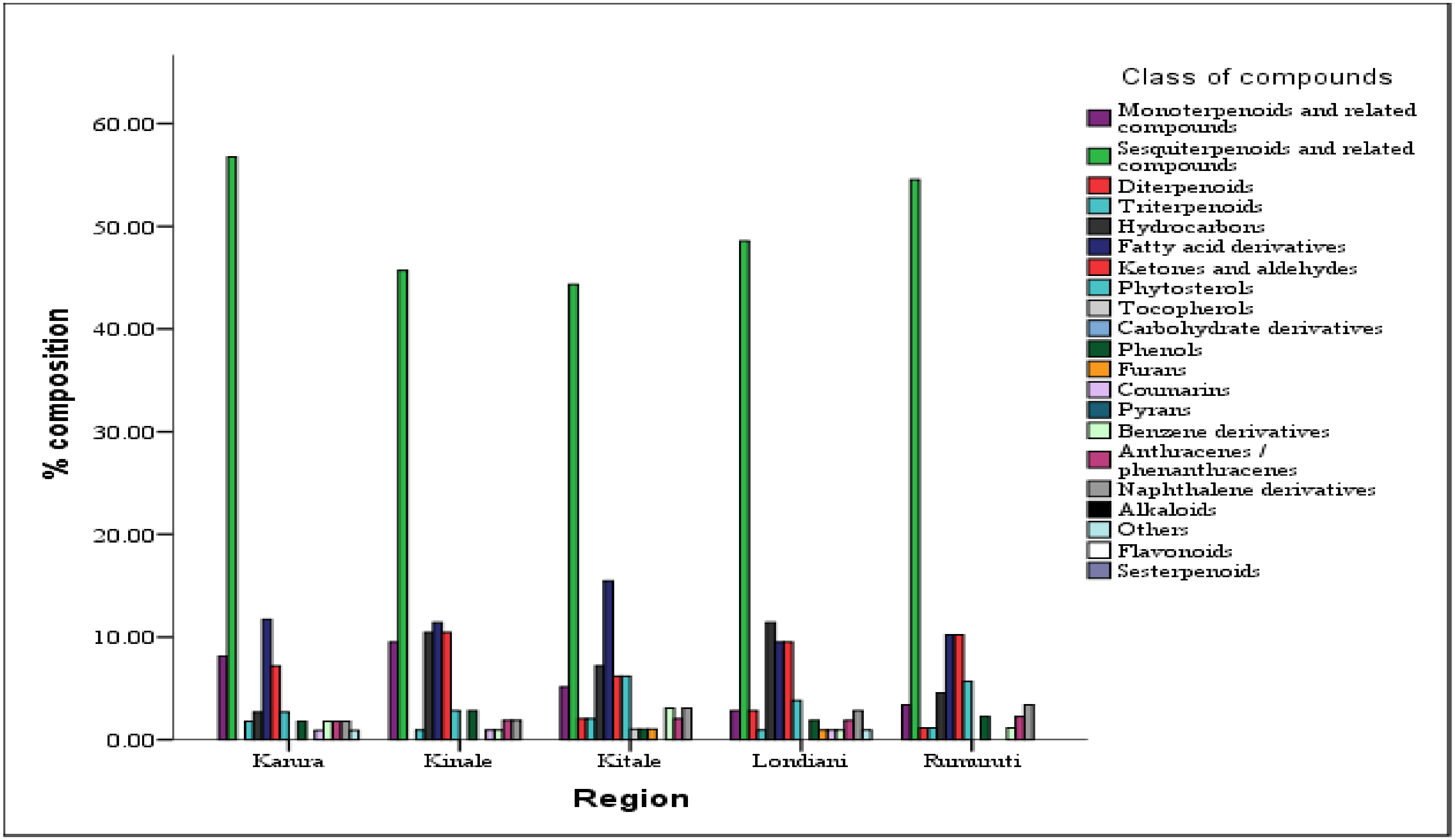
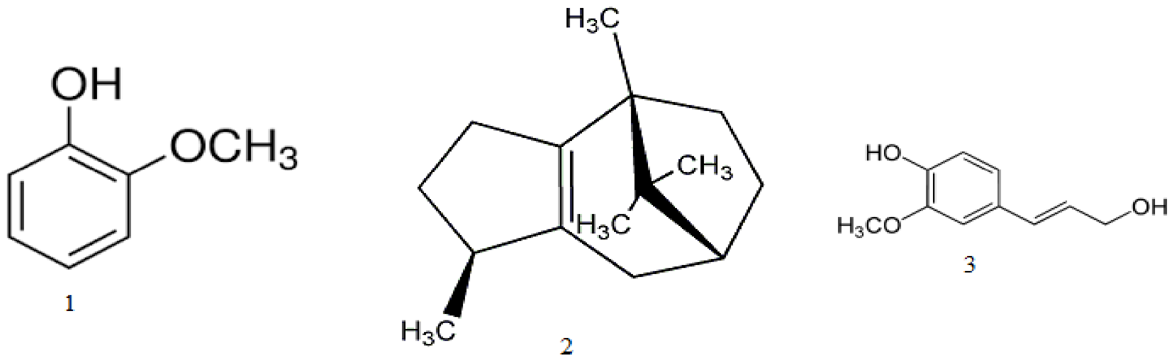


Figure 4.18: Comparison of chemical classes identified in DCM stem bark extracts of *W. ugandensis*.



1 2 3

Figure 4.19: Chemical structures of the major compounds in Kitale: guaiacol (DCM leaf extracts) (1), β-patchoulene (DCM leaf extracts) (2) and coniferol (MeOH stem bark extracts) (3).

Table 4.22: Compounds present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Kitale

				Mean (%) R.A			
				DCM extracts		**MeOH extracts**	
S/N	**MWT**	**Formula**	**Compound name**	**LV**	**SB**	**LV**	**SB**
1	204	$C_{15}H_{24}$	α-cubebene (ST)	0.08	0.81	0.14	0.15
2	204	$C_{15}H_{24}$	Caryophyllene (ST)	1.95	2.20	0.42	0.49
3	204	$C_{15}H_{24}$	β-bisabolene (ST)	0.84	0.43	0.36	0.18
4	222	$C_{15}H_{26}O$	Nerolidol 1 (ST)	2.40	1.42	0.98	0.92
5	222	$C_{15}H_{26}O$	(-)-isolongifolol (ST)	1.34	1.14	1.19	0.79
6	220	$C_{15}H_{24}O$	γ-costol (ST)	0.91	0.75	0.57	0.96
7	410	$C_{30}H_{50}$	Squalene (TT)	0.64	1.68	0.16	1.32
8	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	1.18	0.31	0.61	0.40
9	430	$C_{29}H_{50}O_2$	Vitamin E (TO)	0.52	0.08	0.28	0.28
10	124	$C_7H_8O_2$	2-acetyl-5-methylfuran (F)	0.37	0.28	0.36	0.38

Legend: R.A stands for relative abundance, MWT for molecular weight, LV for leaves, SB for stem barks, ST for sesquiterpenoid, TT for triterpenoid, FAD for fatty acid derivative, TO for tocopherol and F for furan.

Chemical diversity was also observed in Londiani extracts where sesquiterpenoids (30.77-48.57%) and fatty acid derivatives (9.52-15.60%) were the most dominant classes of compounds. A total of 109 compounds were identified in DCM leaf extracts while 105 compounds were identified in DCM stem bark extracts from Londiani (Appendix 3). The most abundant compounds in Londiani DCM extracts were copaen-15-ol (9.83%; stem bark extracts), caryophyllene (4.29%; stem bark extracts), 9,12-octadecadiynoic acid, methyl ester (3.37%; leaf extracts), 9-isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane (3.15%; stem bark extracts), 3-isopropyl-tricyclo[4.3.1.1(2,5)]undec-3-en-10-one (3.06%; leaf extracts), and hexadecane (3.05%; leaf extracts) while the least abundant compounds were cycloartane-3.beta.,25-diol (0.07%; leaf extracts), α-cadinene (0.07%; stembark extracts) and (+)-α-tocopherol, O-methyl- (0.04%; leaf extracts). Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Londiani are shown in table 4.23.

Table 4.23: Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Londiani

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%)**	
				LV	**SB**
1	204	$C_{15}H_{24}$	cis-muurola-3,5-diene (ST)	0.30	0.10
2	204	$C_{15}H_{24}$	δ-cadinene (ST)	0.33	0.96
3	204	$C_{15}H_{24}$	β-bisabolene (ST)	1.49	0.20
4	204	$C_{15}H_{24}$	α-cubebene (ST)	0.41	1.79
5	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	2.07	1.42
6	204	$C_{15}H_{24}$	Cycloisolongifolene (ST)	0.67	0.14
7	204	$C_{15}H_{24}$	β-cadinene (ST)	0.54	0.41
8	204	$C_{15}H_{24}$	β-Humulene (ST)	0.65	1.68

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, F for furan and AN for anthracene derivative.

Table 4.23: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
9	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.40	0.93
10	202	$C_{15}H_{22}$	1,4-methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro- (ST)	0.54	0.29
11	206	$C_{15}H_{26}$	2,4a,8,8-tetramethyldecahydrocyclopropa[d] naphthalene (ST)	0.83	1.02
12	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl- (ST)	0.88	0.95
13	220	$C_{15}H_{24}O$	9-isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane (ST)	1.38	3.15
14	220	$C_{15}H_{24}O$	β-santalol (ST)	0.83	0.10
15	222	$C_{15}H_{24}O$	Drimenol (ST)	1.30	0.76
16	250	$C_{15}H_{22}O_3$	5,8-dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9, 10-decahydro-2(3H)-phenanthrenone (ST)	2.90	1.24
17	290	$C_{20}H_{34}O$	Geranylgeraniol (DT)	1.02	0.98
18	192	$C_{14}H_{24}$	Cyclohexane, 1,2-dimethyl-3,5-bis(1-methyl ethenyl)-,(1.alpha.,2.beta.,3.beta.,5.beta.)- (H)	0.45	0.13
19	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.58	1.41
20	188	$C_{14}H_{20}$	Pentacyclo[7.5.0.0(2,8).0(5,14).0(7,11)] tetradecane (H)	1.05	1.16
21	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl- (H)	0.15	0.29
22	242	$C_{16}H_{34}O$	1-decanol, 2-hexyl- (FAD)	0.44	0.67
23	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	2.01	1.45
24	298	$C_{19}H_{38}O_2$	i-propyl 14-methyl-pentadecanoate (FAD)	0.16	0.22
25	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (ST)	0.92	0.42
26	202	$C_{14}H_{18}O$	11-isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one (KT)	2.89	0.88

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, F for furan and AN for anthracene derivative.

As seen in other extracts of *W. ugandensis* from different populations in this study, some compounds present in DCM leaf extracts from Londiani were absent in the corresponding DCM stem bark extracts. These compounds included (0.28%), isocarveol (0.29%), (1S,2R,5R)-(+)-isomenthol (0.91%), 2,3,6-trimethylhept-3-en-1-ol (1.08%), epizonarene

(0.21%), cis-thujopsene (0.47%), berkheyaradulene (0.19%), (-)-α-panasinsen (0.93%), β-guaiene (0.97%), calamenene (0.49%), γ-patchoulene (1.32%), cycloisolongifolene, 8,9-dehydro- (1.25%), γ-himachalene (0.96%), isolongifolene, 4,5,9,10-dehydro- (0.50%), cubedol (0.55%), ar-himachalen-2-ol (0.10%), 9H-cycloisolongifolene, 8-oxo- (1.44%), longifolenaldehyde (1.34%), γ-gurjunene poxide (2) (0.78%), β-elemenone (0.31%), farnesol, acetate (0.63%), (+)-.alpha.-tocopherol, O-methyl- (0.04%), (-)-isolongifolol (1.95%), α-santonin (0.48%), (+)-beyerene (2.58%), androst-1-en-3-one, (5.alpha.)- (2.35%), cycloartane-3.beta.,25-diol (0.07%), 9,12-octadecadiynoic acid, methyl ester (3.37%), stigmastan-3,5,22-trien (0.25%), androstan-17-one, 3-ethyl-3-hydroxy-, (5.alpha.)- (1.17%), β-tocopherol (0.10%), 7-propylidene-bicyclo[4.1.0]heptane (2.58%), vitamin E (0.64%), and geranyl linalool (1.22%) (Appendix 7). Figure 4.20 shows comparison of chemical classes identified in MeOH leaf extracts of *W. ugandensis*.

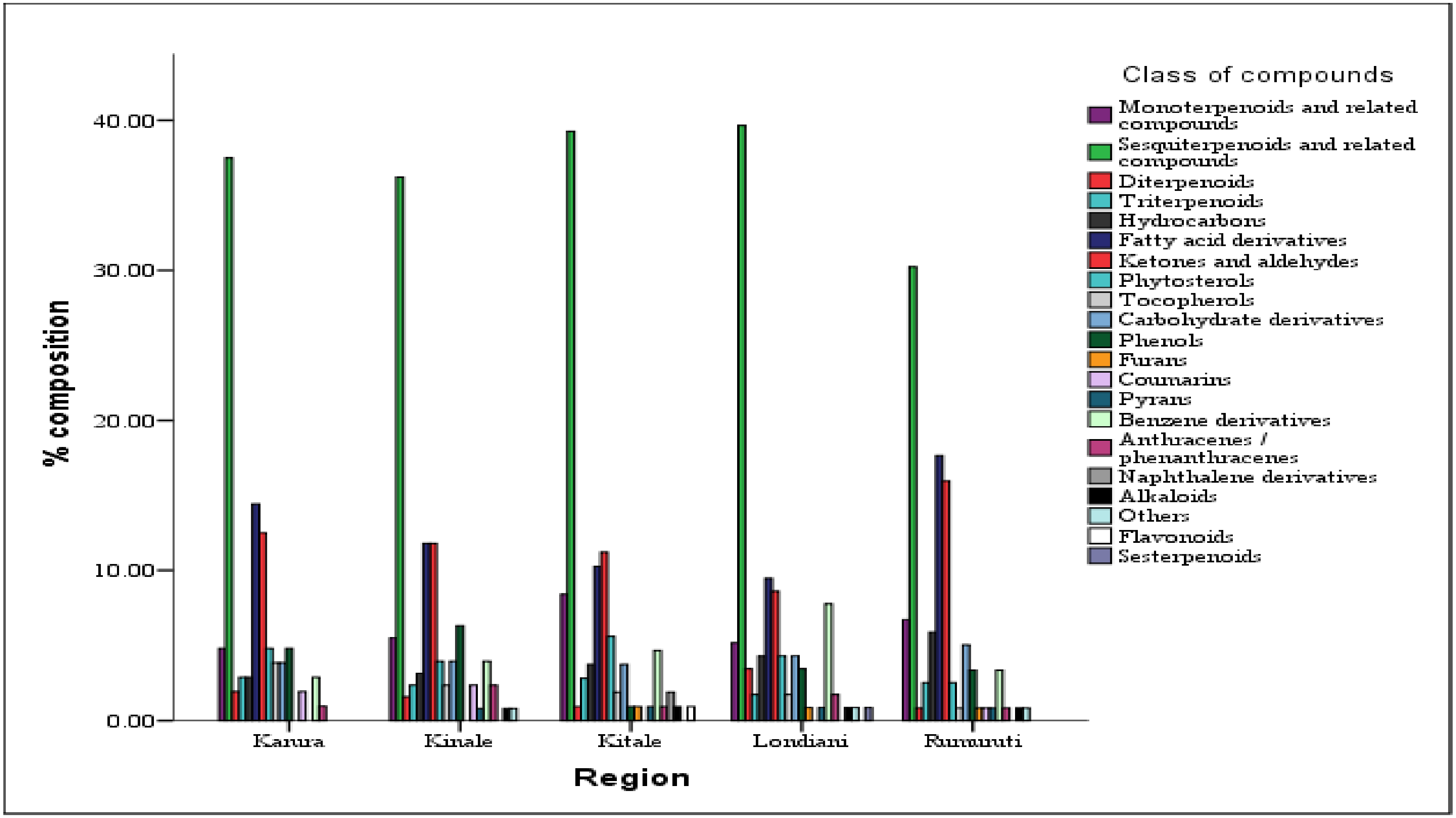


Figure 4.20: Comparison of chemical classes identified in MeOH leaf extracts of *W. ugandensis*.

Similarly, some components present in DCM stem bark extracts from Londiani were absent in the corresponding DCM leaf extracts. These compounds included camphene (0.11%), (7R)-cis-anti-cis-tricyclo[7.3.0.0(2,6)]dodecan-7-ol (0.14%), (-)-zingiberene (0.14%), bergamotene (0.28%), ylangene (0.18%), α-cadinene (0.07%), γ-muurolene (0.86%), 7-epi-α-cadinene (0.10%), cadina-1(2),4-diene (0.26%), α-guaiene (0.79%), caryophyllene (4.29%), α-calacorene (0.15%), copaene (0.70%), (+)-epi-bicyclosesquiphellandrene (1.13%), α-selinene (0.61), caryophyleine-(I3) (1.34%), alloaromadendrene (1.87%), neoisolongifolene, 8,9-dehydro- (1.09%), δ-selinene (0.67%), (-)-δ-panasinsine (0.21%), 7-octylidenebicyclo[4.1.0]heptane (0.38%), mansonone C (0.14%), copaen-15-ol (9.83%), isolongifolene, 9-hydroxy- (1.24%), (-)-aristolene (1.57%), confertin (0.20%), eudesma-5,11(13)-dien-8,12-olide (1.61%), podocarp-13-en-12-ol (1.11%), grindelene (2.33%), squalene (0.51%), 1-tetradecanol (0.66%), ergosta-4,6,22-trien-3.beta.-ol (1.91%), 4,4,5,8-tetramethyl-chroman-2-one (2.69%) and 2-acetyl-9,10-dimethylanthracene (1.05%) (Appendix 7).

Londiani MeOH extracts were characterized by the presence of 116 compounds in leaf extracts and 117 compounds in stem bark extracts. The most prominent compounds in Londiani MeOH extracts were 3-cyclopentylpropionic acid, 3,5-dimethylphenyl ester (5.27%; leaf extracts) 1,2,3-benzenetriol (4.07%; leaf extracts), n-hexadecanoic acid (3.19% in leaf extracts and 4.21% in stem bark extracts) and β-guaiene (3.10%; leaf extracts) while the least prominent compounds were (+)-mecambroline (0.05%; stem bark extracts) and 5,7,7-trimethyl-4,5,7,8-tetrahydroazuleno[4,5-c]furan (0.05% in leaf extracts and 0.04% in stem bark extracts). Table 4.24 shows compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Londiani.

Table 4.24: Compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Londiani

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	**SB**
1	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	0.32	0.75
2	204	$C_{15}H_{24}$	Caryophyllene (ST)	1.36	1.25
3	204	$C_{15}H_{24}$	β-guaiene (ST)	3.10	2.34
4	204	$C_{15}H_{24}$	β-cadinene (ST)	1.14	0.50
5	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl- (ST)	0.76	0.82
6	204	$C_{15}H_{24}$	(-)-δ-Panasinsine (ST)	0.35	0.32
7	220	$C_{15}H_{24}O$	9-isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane (ST)	1.64	1.52
8	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.24	0.95
9	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol (ST)	0.30	0.23
10	222	$C_{15}H_{24}O$	Drimenol (ST)	1.25	1.48
11	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a, 6,7,8,9,9a-decahydro-6,6,9a-trimethyl (ST)	1.95	0.88
12	230	$C_{15}H_{18}O_2$	2,4,6-cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (ST)	0.80	0.42
13	220	$C_{15}H_{24}O$	5.alpha.-hydroxy-4.alpha.,8,10,11-tetramethyl tricyclo[6.3.0.0(2,4)]undec-10-ene (ST)	0.84	0.19
14	290	$C_{20}H_{34}O$	Manool (ST)	0.96	0.55
15	410	$C_{30}H_{50}$	Squalene (ST)	0.71	0.42
16	296	$C_{20}H_{40}O$	Phytol (ST)	2.37	2.65
17	214	$C_{15}H_{18}O$	5,7,7-trimethyl-4,5,7,8-tetrahydroazuleno[4,5-c]furan (ST)	0.05	0.04
18	272	$C_{15}H_{12}O_5$	6H-dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl- (ST)	0.06	0.10

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, F for furan, TO for tocopherol, CD for carbohydrate derivative, P for pyran, B for benzene derivative and AN for anthracene derivative.

Table 4.24: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	**SB**
19	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	3.19	4.21
20	272	$C_{20}H_{32}$	2,6,11,15-tetramethyl-hexadeca-2,6,8,10,14-pentaene (DT)	0.54	0.26
21	912	$C_{14}H_{24}$	Cyclohexane, 1,2-dimethyl-3,5-bis(1-methyl ethenyl)-, (1.alpha.,2.beta.,3.beta.,5.beta.)- (H)	1.68	1.16
22	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester (FAD)	1.42	2.37
23	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	0.36	0.34
24	354	$C_{12}H_{38}O_4$	Fumaric acid, decyl 3-heptyl ester (FAD)	1.40	1.42
25	246	$C_{16}H_{22}O_2$	3-cyclopentylpropionic acid, 3,5-dimethylphenyl ester (FAD)	2.37	5.27
26	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester (FAD)	0.19	0.16
27	126	$C_6H_6O_3$	5-hydroxymethylfurfural (AD)	1.22	0.94
28	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)- (KT)	0.64	0.83
29	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (KT)	2.10	1.79
30	124	$C_8H_{12}O$	2-cyclopenten-1-one, 2,3,4-trimethyl- (KT)	0.37	0.63
31	192	$C_{13}H_{20}O$	Tricyclo[6.3.0.0(1,5)]undecan-4-one, 5,9-dimethyl- (KT)	0.69	0.78
32	414	$C_{29}H_{50}O$	Schottenol (S)	1.76	2.56
33	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)- (S)	0.35	0.33
34	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol (S)	1.78	1.17
35	416	$C_{29}H_{48}O_2$	β-tocopherol (TO)	0.15	0.16
36	146	$C_6H_{10}O_4$	Dianhydromannitol (CD)	1.14	1.53
37	162	$C_6H_{10}O_5$	beta.-D-glucopyranose, 1,6-anhydro- (CD)	0.98	1.27
38	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside (CD)	0.60	0.22
39	124	$C_7H_8O_2$	Guaiacol (P)	1.22	2.35
40	318	$C_{21}H_{34}O_2$	2-[(1R,3S)-3-hydroxycyclohexyl]5-(2-methyloctan-2-yl)phenol (P)	0.64	0.68
41	124	$C_7H_8O_2$	2-acetyl-5-methylfuran (F)	1.50	0.40
42	144	$C_6H_8O_4$	4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl- (P)	0.88	1.14
43	230	$C_{14}H_{14}O_3$	4-(6-methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one (B)	0.13	0.25

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, F for furan, TO for tocopherol, CD for carbohydrate derivative, P for pyran, B for benzene derivative and AN for anthracene derivative.

Table 4.24: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
44	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl- (AN)	0.75	1.13
45	126	$C_6H_6O_3$	1,2,3-Benzenetriol (B)	1.28	4.07
46	246	$C_{18}H_{30}$	Benzene, hexaethyl- (B)	2.66	1.77
47	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl- (B)	1.27	2.26
48	200	$C_{15}H_{20}$	9-Methyl-S-octahydrophenanthrene (AN)	0.83	1.10

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, H for hydrocarbon, KT for ketone, S for phytosterol, F for furan, TO for tocopherol, CD for carbohydrate derivative, P for pyran, B for benzene derivative and AN for anthracene derivative.

Some compounds present in MeOH leaf extracts from Londiani were absent in the corresponding MeOH stem bark extracts. Such compounds included α-phellandrene-8-ol (0.22%), photocitral B (0.36%), γ-hujaplicin (0.16%), β-bisabolene (0.99%), α-cubebene (0.18%), himachala-2,4-diene (1.30%), α-calacorene (0.13%), cis-chujopsene (1.27%), α-selinene (0.42%), (-)-α-panasinsen (0.47%), (-)-β-elemene (0.68%), γ-patchoulene (0.17%), α-chamigrene (0.18%), α-patchoulene (0.49%), β-santalol (0.98%), neoisolongifolene, 8-oxo- (0.66%), trans-farnesol (0.17%), germacrene D-4-ol (0.42%), confertin (0.81%), (-)-isolongifolol (0.54%), bakkenolide A (1.05%), α-santonin (0.17%), eudesma-5,11(13)-dien-8,12-olide (0.83%), geranylgeraniol (0.20%), citronellyl iso-valerate (1.07%), cis-Jasmone (1.58%), stigmast-5-en-3-ol, oleate (0.52%), androstenediol (0.27%), D-mannitol (1.25%), alloaromadendrene (0.30%) and coniferol (1.03%) (Appendix 7).

Similarly, some compounds present in MeOH stem bark extracts from Londiani were absent in the corresponding MeOH leaf extracts. Such compounds included pseudo-cyclocitral (0.79%), 1-hydroxymethyladamantan-2-ol (0.73), cyclohexanol, 3,3,5-trimethyl-, acetate, cis- (0.23%), (S)-(+)-6-methyl-1-octanol (1.68%), (1S,2R,5R)-(+)-isomenthol (1.07%), isocaryophyllene (1.05%), δ-cadinene (0.16%), cadina-1(10),6,8-triene (0.12%), 1,4-dihydrothujopsene-(I1) (0.48%), α-guaiene (1.73%), caryophyllene-(I1) (0.50%), γ-elemene (0.28%), cycloisolongifolene (0.17%), γ-himachalene (0.35%), humulane-1,6-dien-3-ol (0.43%), dihydrocostunolide (0.22%), isolongifolene, 9-hydroxy- (0.48%), γ-costol (0.55%), C(14a)-homo-27-norgammacer-14-ene (1.59%), n-decanoic acid (1.01%), 9,12-octadecadienoic acid (Z,Z)- (0.68%) and α-ergostenol (Appendix 7). Figure 4.21 shows chemical structures of the major compounds in Londiani while figure 4.22 shows comparison of chemical classes identified in MeOH leaf extracts of *W. ugandensis*.

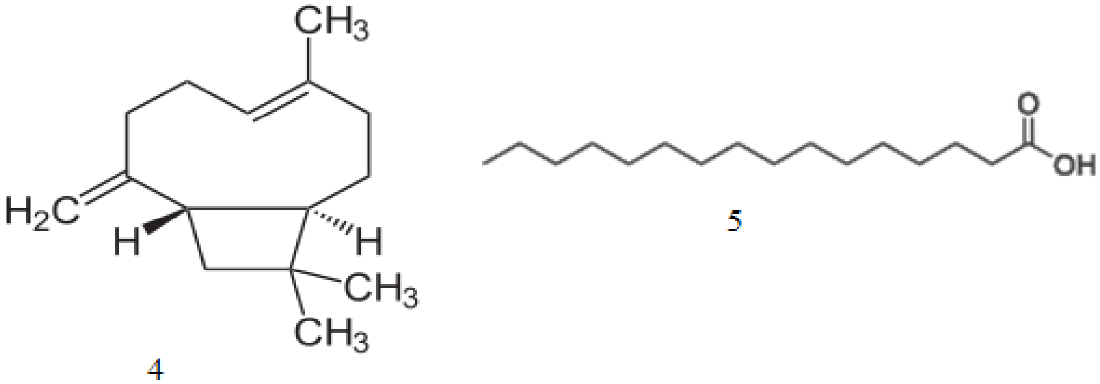


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Figure 4.21: Chemical structures of the major compounds in Londiani: caryophyllene (DCM stem bark extracts) (4) and n-hexadecanoic acid (MeOH leaf extracts) (5).

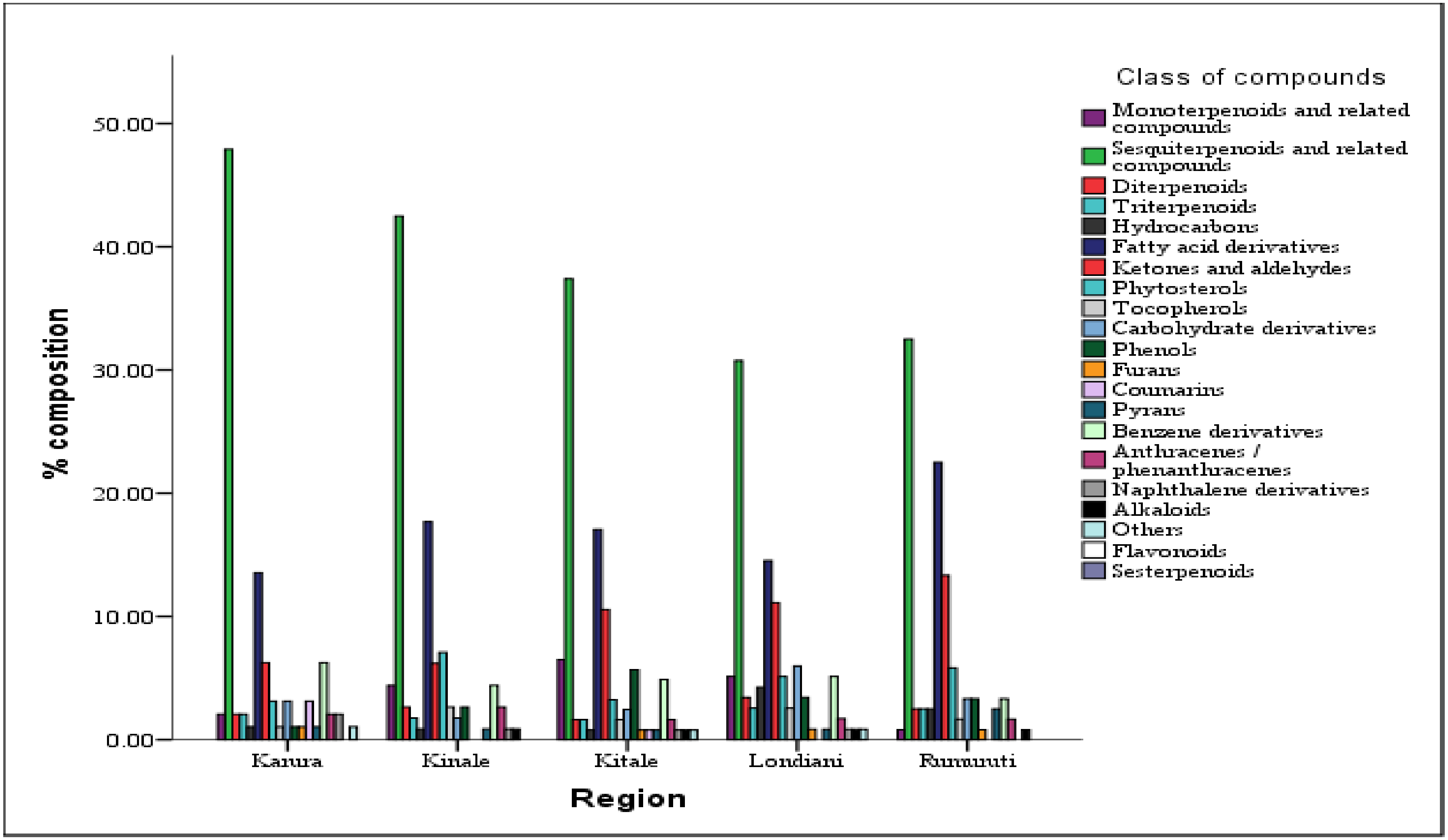

Figure 4.22: Comparison of chemical classes identified in MeOH stem bark extracts of *W. ugandensis*.

A comparative analysis of all extracts from Londiani revealed that certain compounds were present in both DCM and MeOH leaf and stem bark extracts as shown in table 4.25 below.

Table 4.25: Compounds found to be present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Londiani

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
1	204	$C_{15}H_{24}$	β-cadinene (ST)	0.54	0.41	1.14	0.50
2	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.58	1.41	1.24	0.95
3	222	$C_{15}H_{26}O$	Drimenol (ST)	1.30	0.76	1.25	1.48
4	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	2.01	1.45	3.19	4.21
5	206	$C_{13}H_{18}O_2$	3-keto-β-ionone (KT)	0.92	0.42	2.10	1.79
6	414	$C_{29}H_{50}O$	Schottenol (S)	1.12	0.45	1.76	2.56
7	124	$C_7H_8O_2$	Guaiacol (P)	1.16	2.16	1.22	2.35

Legend: R.A stands for relative abundance, MWT for molecular weight, LV for leaves, SB for stem barks, ST for sesquiterpenoid, KT for ketone, FAD for fatty acid derivative, P for phenolic andS for phytosterol.

Results from Rumuruti DCM extracts revealed the presence of 101 compounds in leaf extracts and 88 compounds in stem bark extracts. Sesquiterpenoids (30.25-54.55%) and fatty acid derivatives (20.23-22.50%) were the most dominant classes of compounds in Rumuruti (Appendix 5). Based on peak area percentage, the most abundant compounds in Rumuruti DCM extracts were alloaromadendrene (9.69%; stem bark extracts), 2,4,4-trimethyl-3-(3-methylbuta-1,3-dienyl)cyclohexanone (7.94%; stem bark extracts), bicyclo[4.1.0]heptane, 7-methylene- (6.57%; stem bark extracts), hexadecane (5.67%; leaf extracts), 4-isopropyl-3,4-dimethylcyclohexa-2,5-dienone (5.81%; stem bark extracts), 1H-cycloprop[e]azulene, decahydro-1,1,4,7-tetramethyl-, [1aR-(1a.alpha.,4.beta.,4a.beta.,7.beta.,7a.beta.,7b.alpha.)]- (4.06%; stem bark extracts), isolongifolene oxide (3.91%; stem bark extracts), β-patchoulene (3.50%; leaf extracts), guaiacol (3.35%; stem bark extracts), 2-cyclopenten-1-one, 3,4,5-trimethyl- (3.15%; leaf extracts) and (-)-isolongifolol, methyl ether (3.08%; leaf extracts). The least abundant compounds in Rumuruti DCM extracts were α-muurolene (0.06%; leaf extracts) stigmast-5-en-3-ol, oleate (0.06%; leaf extracts) and (-)-zingiberene (0.06%; stem bark extracts). Table 4.26 shows compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Rumuruti.

Table 4.26: Compounds commonly found in both DCM leaf and stem bark extracts of *W. ugandensis* from Rumuruti

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	**SB**
1	204	$C_{15}H_{24}$	α-cubebene (ST)	0.15	0.31
2	204	$C_{15}H_{24}$	β-bisabolene (ST)	0.16	0.14
3	204	$C_{15}H_{24}$	Caryophyllene (ST)	0.59	0.86
4	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- (ST)	1.27	0.92
5	206	$C_{15}H_{26}$	2,4a,8,8-tetramethyldecahydrocyclopropa[d] naphthalene (ST)	0.87	1.37
6	204	$C_{15}H_{24}$	Cycloisolongifolene (ST)	1.29	0.30
7	204	$C_{15}H_{24}$	β-humulene (ST)	0.59	0.66
8	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.49	1.65
9	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol (ST)	0.11	0.39
10	222	$C_{15}H_{26}O$	Drimenol (ST)	1.55	1.99
11	410	$C_{30}H_{50}$	Squalene (TT)	0.20	0.71
12	226	$C_{16}H_{34}$	Hexadecane (H)	5.67	0.30
13	172	$C_{10}H_{20}O_2$	n-decanoic acid (FAD)	1.69	1.64
14	242	$C_{16}H_{34}O$	1-decanol, 2-hexyl- (FAD)	2.58	0.34
15	124	$C_8H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (ST)	3.15	1.30

Legend: MWTstands for molecular weight, LV for leaves, SB for stem barks, P for phenolic, ST for sesquiterpenoid, TT for triterpenoid, KT for ketone, S for phytosterol, H for hydrocarbon and FAD for fatty acid derivative.

Table 4.26: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	**SB**
16	220	$C_{15}H_{24}O$	7-oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)- (ST)	2.45	0.84
17	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy- (ST)	1.35	1.82
18	232	$C_{15}H_{20}O_2$	Furan, 2-[(2-ethoxy-3,4-dimethyl-2-cyclohexen-1-ylidene)methyl]- (ST)	0.76	0.22
19	206	$C_{14}H_{22}O$	2,4,4-trimethyl-3-(3-methylbuta-1,3-dienyl) cyclohexanone (KT)	2.05	7.94
20	414	$C_{29}H_{50}O$	Schottenol (S)	1.01	0.42
21	124	$C_7H_8O_2$	Guaiacol (P)	3.35	0.96

Legend: MWTstands for molecular weight, LV for leaves, SB for stem barks, P for phenolic, ST for sesquiterpenoid, TT for triterpenoid, KT for ketone, S for phytosterol, H for hydrocarbon and FAD for fatty acid derivative.

Consequently, some compounds present in DCM leaf extracts from Rumuruti were absent in the corresponding DCM stem bark extracts. These compounds included (-)-δ-panasinsine (0.52%), pinocarvone (0.13%), rose oxide (1.11%), 1(3H)-isobenzofuranone, 3,3-dimethyl- (0.22%), tetrahydrolavandulol (0.17%), α-copaene (0.29%), cadina-1(2),4-diene (0.12%), isolongifolene, 9,10-dehydro- (0.10%), α-cadinene (0.26%), α-muurolene (0.06%), isoledene (0.22%), cadalene (0.07%), calamenene (0.08%), (-)-α-neoclovene (2.99%), cis-thujopsene (1.27%), α-calacorene (0.12%), farnesane (0.28%), isocaryophillene (0.25%), β-patchoulene (3.50%), caryophyleine-(I3) (0.49%), himachala-2,4-diene (0.40%), berkheyaradulene (1.54%), muurolane (2.59%), phytol (0.67%) and epizonarene (0.18%) (Appendix 8).

Similarly, some compounds present in DCM stem bark extracts from Rumuruti were absent in the corresponding DCM leaf extracts. Such compounds included confertin (0.98%), α-terpineol (0.14%), carveol (0.24%), α-terpinyl acetate (0.13%), (-)-

zingiberene (0.06%), cloven (0.10%), guaia-1(10),11-diene (0.25%), α-bergamotene (0.27%), δ-cadinene (0.48%), 7-epi-α-selinene (0.08%), α-chamigrene (0.32%), β-cadinene (0.52%), neoisolongifolene, 8,9-dehydro- (1.47%), α-selinene (0.33%), alloaromadendrene (9.69%), β-selinene (1.97%), aromadendrene, dehydro- (1.73%), γ-elemene (2.44%), cubedol (0.10%), isolongifolene oxide (3.91%), eudesma-5,11(13)-dien-8,12-olide (1.45%), (-)-Isolongifolol (1.30%), longifolenaldehyde (1.76%), γ-Costol (0.79%), podocarp-12-en-14-ol (2.35%), stigmasterol (0.10%), ergosta-4,6,22-trien-3.beta.-ol (2.98%) and trans-geranylgeraniol (0.32%) (Appendix 8).

Chemical profiles of MeOH extracts from Rumuruti revealed the presence of 119 compounds in leaf extracts and 120 compounds in stem bark extracts. The most dominant compounds in Rumuruti MeOH extracts were 1,2,3-benzenetriol (7.95%; leaf extracts), sorbitol (6.36%; leaf extracts), beta.-l-arabinopyranoside, methyl (6.07%; leaf extracts), n-decanoic acid (5.70%; leaf extracts), tridecanoic acid (5.65%; stem bark), guaiacol (4.78%; stem bark extracts), D-mannitol (4.08%; leaf extracts), cyclohexane, 1,2-diethenyl-4-(1-methylethylidene)-, cis- (3.72%; stem bark extracts) and n-hexadecanoic acid (3.09% in stem bark extracts and 3.44% in leaf extracts). The least dominant compounds were (+)-mecambroline (0.06%; stem bark extracts) and 6H-dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl- (0.03%; stem bark extracts). Table 4.27 shows compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Rumuruti.

Table 4.27: Compounds commonly found in both MeOH leaf and stem bark extracts of *W. ugandensis* from Rumuruti

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%)**	
				LV	**SB**
1	204	$C_{15}H_{24}$	Caryophyllene (ST)	0.62	1.47
2	204	$C_{15}H_{24}$	1,4,7,-cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z- (ST)	1.46	0.53
3	204	$C_{15}H_{24}$	cis-thujopsene (ST)	0.14	0.55
4	204	$C_{15}H_{24}$	β-humulene (ST)	1.11	0.30
5	202	$C_{15}H_{22}$	1,2,3,3a,4a,5,6,7,8,9,9a,9b-dodecahydrocyclopenta [def]phenanthrene (ST)	0.22	0.35
6	222	$C_{15}H_{26}O$	α-bisabolol (ST)	0.79	0.16
7	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	0.78	1.15
8	220	$C_{15}H_{24}O$	Cyclopenta[c]pentalen-3(3aH)-one, octahydro-1,2,3a,6-tetramethyl- (ST)	0.42	0.33
9	222	$C_{15}H_{26}O$	Drimenol (ST)	1.46	1.46
10	250	$C_{15}H_{22}O_3$	5,8-dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone (ST)	0.22	0.45
11	220	$C_{15}H_{24}O$	Longifolenaldehyde (ST)	0.54	0.29
12	308	$C_{18}H_{28}O_4$	1(2H)-phenanthrenone, 7-(acetyloxy)dodecaHydro -8a-hydroxy-2,4b-dimethyl-, [2S-(2.alpha.,4a.alpha., 4b.beta.,7.beta.,8a.alpha.,10a.beta.)]- (ST)	2.97	1.33
13	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a, 6,7,8,9,9a-decahydro-6,6,9a-trimethyl (ST)	0.99	1.74
14	220	$C_{15}H_{24}O$	γ-costol (ST)	1.59	0.57
15	230	$C_{15}H_{18}O_2$	2,4,6-cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (ST)	1.15	0.36
16	272	$C_{15}H_{12}O_5$	6H-dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl- (ST)	0.10	0.03
17	296	$C_{20}H_{40}O$	Phytol (DT)	2.12	1.05
18	410	$C_{30}H_{50}$	Squalene (TT)	0.23	0.55
19	444	$C_{30}H_{52}O_2$	Cycloartane-3.beta.,25-diol (TT)	0.09	0.13
20	172	$C_{10}H_{20}O_2$	n-decanoic acid (FAD)	5.70	1.51
21	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester (FAD)	1.14	2.54
22	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid (FAD)	3.44	3.09
23	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid, methyl ester (FAD)	0.35	0.98

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, KT for ketone, DKT for diketone, AL for alkaloid, F for furan, PY for pyran, B for benzene derivative, AN for anthracene derivative, CD for carbohydrate derivative, AD for aldehyde and S for phytosterol.

Table 4.27: Cont'd

S/N	MWT	Formula	Compound name	Mean (%)	
				LV	SB
24	298	$C_{19}H_{38}O_2$	Methyl stearate (FAD)	0.19	0.43
25	280	$C_{18}H_{32}O_2$	9,12-octadecadienoic acid (Z,Z)- (FAD)	0.52	0.58
26	282	$C_{18}H_{34}O_2$	9-octadecenoic acid, (E)- (FAD)	1.05	1.03
27	284	$C_{18}H_{36}O_2$	Octadecanoic acid (FAD)	2.53	0.41
28	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester (FAD)	1.39	2.23
29	330	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester (FAD)	1.01	0.92
30	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)- (KT)	1.00	0.91
31	164	$C_{11}H_{16}O$	cis-jasmone (KT)	1.49	0.18
32	166	$C_{11}H_{18}O$	Cyclohexanone, 2,5-dimethyl-2-(1-methylethenyl)-(KT)	0.79	1.55
33	124	$C_{18}H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (KT)	1.11	0.22
34	202	$C_{14}H_{18}O$	11-isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one (KT)	1.95	0.65
35	230	$C_{14}H_{14}O_3$	4-(6-methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one (KT)	0.34	0.31
36	248	$C_{16}H_{24}O_2$	4,4,5',5'-tetramethyl-bicyclohexyl-6-ene-2,3'-dione (DKT)	0.75	0.80
37	295	$C_{18}H_{17}NO_3$	(+)-mecambroline (AL)	0.10	0.06
38	126	$C_6H_6O_3$	5-hydroxymethylfurfural (AD)	1.78	0.83
39	430	$C_{29}H_{50}O_2$	Vitamin E (TO)	0.11	0.56
40	162	$C_6H_{10}O_5$	3,4-altrosan (CD)	2.75	1.62
41	162	$C_6H_{10}O_5$	.beta.-D-glucopyranose, 1,6-anhydro- (CD)	2.83	0.71
42	124	$C_7H_8O_2$	Guaiacol (P)	1.30	4.78
43	124	$C_7H_8O_2$	2-acetyl-5-methylfuran (F)	0.36	0.45
44	144	$C_6H_8O_4$	4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl- (PY)	1.66	0.95
45	126	$C_6H_6O_3$	1,2,3-benzenetriol (B)	7.95	2.82
46	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl- (B)	2.70	2.57
47	200	$C_{15}H_{20}$	9-methyl-S-octahydroanthracene (AN)	0.33	0.80

Legend: MWT stands for molecular weight, LV for leaves, SB for stem barks, FAD for fatty acid derivative, P for phenolic, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, KT for ketone, DKT for diketone, AL for alkaloid, F for furan, PY for pyran, B for benzene derivative, AN for anthracene derivative, CD for carbohydrate derivative, AD for aldehyde and S for phytosterol.

Analysis of Rumuruti MeOH extracts revealed the presence of some compounds in leaf extracts which were absent in the corresponding stem bark extracts. These compounds included bicyclo[2.2.1]heptane, 1,3,3-trimethyl- (0.39%), cinerone (2.17%), β-homocyclocitral (0.37%), teresantalol (0.56%), p-mentha-1(7),8-dien-2-ol (0.62%), (1S,2R,5R)-(+)-isomenthol (0.61%), acoradiene (0.69%), γ-elemene (1.05%), fukinane (2.72%), germacrene B (0.95%), longipinane, (E)- 90.33%), selina-3,7(11)-diene (0.41%), β-elemenone (0.89%), humulane-1,6-dien-3-ol (0.43%), α-cedrene epoxide (0.69%), sclaral (sclareolide lactol) (2.94%), davana ether (0.44%), anobin (0.21%), gleenol (0.51%), luciferin aldehyde (Latia) (0.77%), copaen-15-ol (1.27%), adamantine (0.70%), citronellyl propionate (0.48%), 2-propenoic acid, 3-(4-methoxyphenyl)- (0.65%), i-propyl 16-methyl-heptadecanoate (0.81%), coniferaldehyde (0.26%), β-Ionone (1.44%), allyl ionone (0.67%), γ-sitosterol (1.63%), β-l-Arabinopyranoside, methyl (6.07%), D-mannitol (4.08%) and sorbitol (6.36%) (Appendix 8).

Some compounds present in MeOH stem bark extracts of *W. ugandensis* from Rumuruti were absent in MeOH leaf extracts from the same region. The compounds included α-cubebene (0.14%), cadina-1(10),6,8-triene (0.09%), δ-cadinene (0.28%), alloaromadendrene (0.57%), aromadendrene, dehydro- (0.33%), epizonarene (0.26%), germacrone (0.49%), dihydrokaranone (0.29%), β-santalol (1.07%), glaucyl alcohol (0.18%), 3a-bromolongifolene (1.60%), widdrol hydroxyether (0.89%), isolongifolene, 9-hydroxy- (0.68%), manool (0.65%), geranyl linalool (0.44%), C(14a)-homo-27-norgammacer-14-ene (1.01%), tridecanoic acid (5.65%), oleic acid (1.30%), eudesma-5,11(13)-dien-8,12-olide (1.01%), cholest-5-en-3-ol, 6-methyl-, (3.beta.)- (0.15%), ergosta-4,6,22-trien-3.beta.-ol (2.99%), schottenol (1.90%), β-tocopherol (0.21%), stigmast-5-en-3-ol, oleate (1.15%) and dianhydromannitol (1.74%) (Appendix 8). Meanwhile, table 4.28 shows compounds present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Rumuruti while figure 4.23 shows chemical structures of the major compounds in Rumuruti.

Table 4.28: Compounds found to be present in both DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from Rumuruti

S/N	**MWT**	**Formula**	**Compound name**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
1	204	$C_{15}H_{24}$	Caryophyllene (ST)	0.59	0.86	0.62	1.47
2	204	$C_{15}H_{24}$	β-humulene (ST)	0.59	0.66	1.11	0.30
3	222	$C_{15}H_{26}O$	Nerolidol 2 (ST)	1.49	1.65	0.78	1.15
4	222	$C_{15}H_{26}O$	Drimenol (ST)	1.55	1.99	1.46	1.46
5	410	$C_{30}H_{50}$	Squalene (ST)	0.20	0.71	0.23	0.55
6	172	$C_{10}H_{20}O_2$	n-decanoic acid (FAD)	1.69	1.64	5.70	1.51
7	124	$C_7H_8O_2$	Guaiacol (P)	3.35	0.96	1.30	4.78
8	124	$C_8H_{12}O$	2-cyclopenten-1-one, 3,4,5-trimethyl- (KT)	3.15	1.30	1.11	0.22

Legend: R.A stands for relative abundance, MWT for molecular weight, LV for leaves, SB for stem barks, KT for ketones, ST for sesquiterpenoid, FAD for fatty acid derivative and P for phenolic.

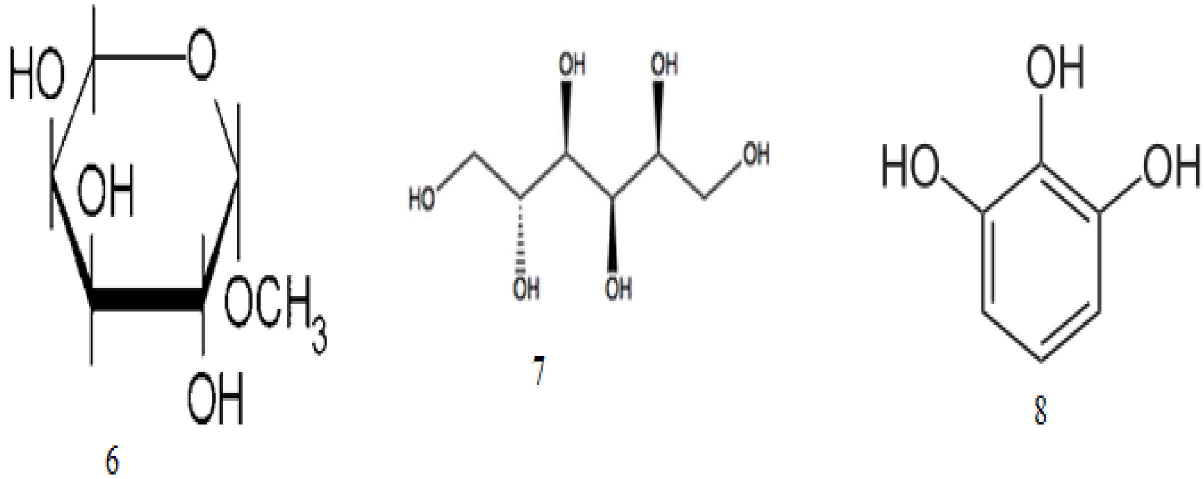

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Figure 4.23: Chemical structures of the major compounds in Rumuruti: methyl β-L-arabinopyranoside (MeOH leaf extracts) (6), sorbitol (MeOH leaf extracts) (7) and 1,2,3-benzenetriol (MeOH leaf extracts) (pyrogallol) (8).

A unique finding in this study was the occurrence of several compounds common in all the DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from the five populations across the Kenyan Rift Valley regardless of the solvents used for extraction. These compounds were expressed in different perecentage (%) relative abundances as summarized in table 4.29. In addition, this study also reports the presence of some compounds for the first time in the extracts of *W. ugandensis* as shown in table 4.30. These compounds have not been previously mentioned in literature to occur in the extracts of *W. ugandensis* in Kenya.

Table 4.29: Some of the compounds identified for the first time in the extracts of *W. ugandensis*

S/ N	Name of compound and molecular formula	S/ N	Name of compound and molecular formula
1	α-terpineol / $C_{10}H_{18}O$ / MT	24	γ-himachalene /$C_{15}H_{24}$ / ST
2	α-bergamotene / $C_{15}H_{24}$ / ST	25	Hanphyllin / $C_{15}H_{20}O_3$ / ST
3	Muurolene / $C_{15}H_{24}$ / ST	26	Isolongifolene oxide / $C_{15}H_{24}O$ / ST
4	Octadecanoic acid / $C_{18}H_{36}O_2$ / FAD	27	Cadina-1(2),4-diene / $C_{15}H_{24}$ / ST
5	α-calacorene / $C_{15}H_{20}$ / ST	28	(+)-mecambroline / $C_{18}H_{17}NO_3$ / AL
6	Germacrene B / $C_{15}H_{24}$ / ST	29	cis-Jasmone /$C_{11}H_{16}O$ / KT
7	Ergosta-4,6,22-trien-3.beta.-ol (S) /$C_{28}H_{44}O$ / S	30	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)- / $C_{31}H_{50}O_2$ / S
8	Longifolenaldehyde / $C_{15}H_{24}O$ / ST	31	Epizonarene / $C_{15}H_{24}$ / ST
9	Squalene / $C_{15}H_{24}$ / TT	32	cis-muurola-3,5-diene / $C_{15}H_{24}$ / ST
10	Fumaric acid, decyl 3-heptyl ester / $C_{21}H_{38}O_4$ /FAD	33	9-methyl-S-octahydroanthracene / $C_{15}H_{20}$ / AN
11	Shyobunone / $C_{15}H_{24}O$ / ST	34	α-Santalene / $C_{15}H_{24}$ / ST
12	Selinene / $C_{15}H_{24}$ / ST	35	Acoradiene / $C_{15}H_{24}$ / ST
13	Patchoulene / $C_{15}H_{24}$ / ST	36	Sabinol / $C_{10}H_{16}$ / MT
14	β-bisabolene / $C_{15}H_{24}$ / ST	37	Guaiazulene / $C_{15}H_{18}$ / ST
15	(-)-isolongifolol / $C_{15}H_{26}O$ / ST	38	Cycloisolongifolene / $C_{15}H_{24}$ / ST
16	Phytol / $C_{20}H_{40}O$ / DT	39	cis-thujopsene / $C_{15}H_{24}$ / ST
17	Berkheyaradulene / $C_{15}H_{24}$ / ST	40	Widdrol / $C_{15}H_{26}O$ / ST
18	Geranylgeraniol / $C_{20}H_{34}O$ / DT	41	(-)-δ-panasinsine / $C_{15}H_{24}$ / ST
19	(1S,2R,5R)-(+)-isomenthol / $C_{10}H_{20}O$ / MT	42	Citronellol / $C_{10}H_{20}O$ / MT
20	β-tocopherol / $C_{28}H_{48}O_2$ / TO	43	Aristolone / $C_{15}H_{22}O$ / ST
21	(-)-zingiberene / $C_{15}H_{24}$ / ST	44	Austricin / $C_{15}H_{18}O_4$ / ST
22	α-terpinyl isovalerate / $C_{15}H_{26}O_2$ / ST	45	(+)-beyerene / $C_{20}H_{32}$ / DT
23	α-curcumene / $C_{15}H_{22}$ / ST	46	Phenol, 2,6-dimethoxy- / $C_8H_{10}O_3$ / P

Legend: FAD stands for fatty acid derivative, P for phenolic, MT for monoterpenoid, ST for sesquiterpenoid, DT for diterpenoid, TT for triterpenoid, KT for ketone, S for phytosterol, AL for alkaloid, AN for anthracene derivative and TO for tocopherol.

Table 4.30: Compounds commonly found in all the DCM and MeOH leaf and stem bark extracts of *W. ugandensis* from the five populations

Name of compound / molecular formula	**Karura mean (%)**				**Kinale mean (%)**				**Kitale mean (%)**				**Londiani mean (%)**				**Rumuruti mean (%)**			
	DCM		**MeOH**		**DCM**		**MeOH**		**DCM**		**MeOH**		**DCM**		**MeOH**		**DCM**		**MeOH**	
	LV	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**
α-terpineol / $C_{10}H_{18}O$	0.35	0.08	1.03	0.11	0.34	0.27	0.24	0.04	1.09	0.05	0.95	1.06	0.26	0.03	0.36	0.98	0.12	1.25	0.84	0.09
Copaene / $C_{15}H_{24}$	0.90	0.38	0.45	1.01	0.34	1.05	0.37	0.19	2.23	1.37	0.93	0.08	0.47	2.42	0.38	0.34	1.12	0.37	0.39	0.42
α-tergamotene / $C_{15}H_{24}$	0.11	0.16	0.75	0.93	1.19	0.67	1.91	0.82	0.32	1.23	0.33	0.67	0.44	0.28	0.14	0.12	0.97	2.39	3.42	1.57
Himachala-2,4-diene / $C_{15}H_{24}$	0.44	0.89	0.14	0.19	0.19	0.76	0.39	0.80	1.71	2.02	0.42	1.42	2.49	0.56	1.30	0.91	0.99	1.75	0.77	1.96
β-bisabolene / $C_{15}H_{24}$	0.22	0.37	1.53	1.34	0.76	0.37	0.56	1.33	0.84	0.43	0.36	0.18	1.49	0.20	0.99	1.82	0.22	1.03	0.39	1.00
Cycloisolongifolene / $C_{15}H_{24}$	0.88	1.79	2.12	0.58	0.03	0.08	1.67	0.78	0.07	0.29	1.57	0.06	0.24	0.19	0.14	1.10	1.07	0.27	3.02	0.27
Caryophyllene / $C_{15}H_{24}$	0.49	0.35	0.43	0.19	1.44	1.84	1.09	1.79	1.95	2.20	0.42	0.49	0.54	4.29	1.36	1.25	0.99	0.48	1.11	0.42
δ-cadinene / $C_{15}H_{24}$	0.16	1.33	0.71	0.57	1.21	1.87	0.39	1.19	2.13	0.56	0.59	0.94	0.33	0.96	0.05	0.16	0.52	1.33	1.71	1.97
Calamenene / $C_{15}H_{22}$	0.12	0.16	0.87	1.56	0.09	2.28	0.22	1.50	1.34	0.10	1.01	0.42	0.48	1.06	1.39	1.96	0.29	1.45	0.92	1.02
(-)-zingiberene / $C_{15}H_{24}$	0.38	2.53	1.44	1.76	1.30	0.22	1.06	1.80	0.33	1.22	0.49	0.86	1.67	0.14	1.37	1.23	1.94	1.76	0.36	0.16
Epizonarene / $C_{15}H_{24}$	0.32	1.16	0.25	1.90	0.23	1.37	1.23	2.01	1.42	1.89	1.18	0.43	0.21	0.29	1.56	0.25	1.91	2.40	1.81	9.42
(-)-δ-panasinsine / $C_{15}H_{24}$	0.21	0.23	0.18	2.09	0.27	0.18	0.57	1.22	1.98	0.94	0.11	0.70	1.01	0.04	1.87	0.28	1.07	0.56	1.69	0.92
β-humulene / $C_{15}H_{24}$	0.36	1.68	1.03	0.36	0.39	1.44	0.41	0.92	0.37	1.10	1.29	0.52	1.20	1.46	1.05	0.73	1.04	1.19	1.01	0.87
γ-himachalene / $C_{15}H_{24}$	0.28	0.52	0.18	1.19	0.16	1.87	1.06	1.09	2.20	0.11	2.76	1.98	4.88	1.09	0.12	0.68	2.03	1.08	1.50	0.93
7-epi-α-selinene / $C_{15}H_{24}$	0.97	1.48	1.73	1.24	0.86	0.08	1.12	0.47	0.17	0.98	0.51	2.21	0.26	1.80	0.59	1.01	1.21	0.95	1.89	0.90
β-cadinene / $C_{15}H_{24}$	1.06	0.58	1.20	0.32	0.43	1.53	0.12	1.11	0.28	1.14	0.92	2.06	1.49	1.66	1.09	2.91	0.04	1.78	019	2.82
α-Cubebene / $C_{15}H_{24}$	1.86	1.35	1.14	0.31	0.07	0.20	0.51	0.08	0.81	0.14	0.15	0.41	1.79	0.18	1.89	0.04	0.76	1.07	2.01	1.03
1,4,7,-cycloundecatriene, 1,5,9, 9-tetramethyl-, Z,Z,Z- / $C_{15}H_{24}$	1.45	2.34	0.82	1.00	0.32	2.54	0.31	1.20	0.93	1.13	0.62	0.71	0.40	0.93	0.32	0.75	0.89	2.49	0.37	1.45
Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl- / $C_{15}H_{24}$	2.51	2.09	2.65	0.78	0.92	1.15	0.42	2.06	0.93	1.70	0.69	0.83	2.07	1.42	0.98	2.12	1.19	0.46	0.29	0.27
Isolongifolene, 9-hydroxy- / $C_{15}H_{24}O$	1.60	1.60	0.72	0.50	1.44	1.79	1.15	0.96	1.74	1.11	0.91	0.37	2.21	1.00	0.04	1.91	1.42	1.55	1.80	1.93
γ-costol / $C_{15}H_{24}O$	0.54	0.84	0.29	0.41	0.74	1.21	1.82	0.25	0.91	0.75	0.57	0.96	0.34	0.09	1.14	0.10	0.07	0.37	3.82	0.57
Nerolidol 2 / $C_{15}H_{26}O$	0.69	1.26	0.53	0.69	1.17	1.36	0.84	0.83	2.40	1.42	0.98	0.92	0.01	0.82	0.32	1.03	0.46	1.07	0.79	1.38
Eudesma-5,11(13)-dien-8,12-olide / $C_{15}H_{20}O_2$	0.94	0.52	0.55	0.19	1.22	1.77	1.35	2.78	0.33	0.83	0.67	0.61	0.16	0.69	2.80	1.75	2.52	1.42	1.53	0.07

Legend: LV stands for leaves, SB for stem barks, DCM for dichloromethane, MeOH for methanol

Table 4.30: Cont'd

Name of compound / molecular formula	**Karura mean (%)**				**Kinale mean (%)**				**Kitale mean (%)**				**Londiani mean (%)**				**Rumuruti mean (%)**			
	DCM		**MeOH**		**DCM**		**MeOH**		**DCM**		**MeOH**		**DCM**		**MeOH**		**DCM**		**MeOH**	
	LV	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**	**LV**	**SB**
Longifolenaldehyde / $C_{15}H_{24}O$	0.69	0.31	0.49	0.40	1.31	0.94	3.15	1.11	2.18	0.30	0.77	0.42	1.37	1.03	1.94	0.6	0.37	0.86	0.23	0.51
(-)-Isolongifolol / $C_{15}H_{26}O$	3.51	2.14	0.47	0.38	1.31	0.35	0.70	0.65	1.34	1.14	1.19	0.79	1.31	0.18	1.30	1.09	0.41	0.81	1.01	1.65
Drimenol / $C_{15}H_{26}O$	1.05	4.04	2.02	1.15	0.59	1.03	2.35	1.65	1.65	0.98	2.47	2.50	2.08	0.34	0.06	1.85	1.40	0.22	0.04	0.01
Procerin / $C_{15}H_{18}O_2$	0.96	0.93	1.03	0.29	0.37	2.39	1.02	0.35	0.34	0.81	1.09	0.65	1.49	1.56	1.37	1.91	0.09	1.05	0.57	2.96
Geranyl linalool / $C_{20}H_{34}O$	0.27	0.11	0.28	0.46	0.12	2.03	0.38	0.60	1.05	0.08	0.47	2.52	0.39	1.35	0.70	0.95	1.34	0.41	1.69	2.65
Phytol / $C_{20}H_{40}O$	0.51	0.03	1.90	1.04	0.98	0.39	2.78	2.34	0.54	1.65	2.01	2.11	1.25	1.04	0.06	0.96	1.12	1.05	1.85	1.03
Geranylgeraniol / $C_{20}H_{34}O$	0.33	0.08	0.24	0.59	0.50	1.04	0.43	0.15	0.60	0.10	0.03	0.34	0.91	0.92	1.32	1.33	0.43	0.07	0.59	0.38
Manool / $C_{20}H_{34}O$	0.45	0.28	0.55	0.58	0.37	1.98	1.44	0.55	2.20	0.59	0.29	0.52	0.47	1.04	2.04	2.24	1.7	0.92	0.47	0.59
Squalene / $C_{30}H_{50}$	1.18	0.26	0.39	3.35	0.87	0.39	0.10	0.34	0.64	1.68	0.16	1.32	1.04	0.14	0.09	0.76	2.01	1.90	0.85	0.27
n-hexadecanoic acid / $C_{16}H_{32}O_2$	4.37	1.79	2.37	1.55	3.24	1.58	2.92	2.86	2.00	1.59	1.43	3.20	0.97	1.44	1.94	0.47	0.28	2.87	1.07	0.06
Hexadecanoic acid, methyl ester / $C_{17}H_{34}O_2$	0.37	0.14	1.31	1.24	0.23	1.48	1.25	1.86	0.26	0.98	0.37	2.29	0.29	0.09	1.03	0.58	0.40	1.29	0.38	0.73
1-decanol, 2-hexyl- / $C_{16}H_{34}O$	0.56	0.46	0.33	0.56	0.51	0.20	0.46	0.75	0.20	0.09	1.22	1.98	0.77	0.34	0.89	0.94	1.29	0.70	0.20	0.94
Octadecanoic acid / $C_{18}H_{36}O_2$	0.45	0.31	0.36	0.33	0.45	0.58	0.52	0.29	1.18	0.31	0.61	0.40	0.14	0.02	1.52	1.59	0.64	0.34	0.15	1.01
3-keto-β-ionone / $C_{13}H_{18}O_2$	0.28	0.20	0.40	0.37	0.33	0.52	1.73	1.27	1.39	0.98	0.14	0.86	0.39	0.26	0.52	1.06	0.49	0.98	0.43	0.77
Stigmast-5-en-3-ol, oleate / $C_{47}H_{82}O_2$	0.13	0.28	0.20	0.17	0.08	1.04	0.06	1.76	0.47	0.13	0.59	0.95	1.04	2.03	1.08	0.01	0.07	0.48	0.02	0.07
Ergosta-4,6,22-trien-3.beta.-ol / $C_{28}H_{44}O$	2.58	1.95	4.05	0.27	2.89	1.22	2.05	3.41	1.94	2.30	2.76	1.02	1.09	0.98	3.11	0.49	2.48	1.09	0.07	0.49
Stigmasterol acetate /$C_{31}H_{50}O_2$	0.21	0.58	0.68	0.48	0.22	0.38	0.38	1.04	1.58	0.04	0.18	0.37	0.39	0.67	0.48	0.28	0.35	0.85	0.92	1.59
Schottenol / $C_{29}H_{50}O$	2.31	1.40	2.36	1.38	1.77	0.40	1.99	1.61	2.12	0.06	2.08	1.24	0.05	0.39	1.79	0.59	0.38	1.12	1.16	0.09
β-tocopherol / $C_{28}H_{48}O_2$	0.33	0.40	0.24	0.21	0.26	1.89	0.18	0.14	0.17	1.22	0.16	0.11	0.08	0.48	0.97	1.40	0.59	0.36	0.91	1.98
Vitamin E / $C_{29}H_{50}O_2$	0.50	0.35	0.44	0.07	0.74	0.79	0.42	0.16	0.52	0.08	0.28	0.28	0.45	0.10	0.47	0.59	0.27	0.40	0.26	1.04
Guaiacol / $C_7H_8O_2$	1.63	1.52	0.93	1.57	0.24	1.28	1.26	1.33	3.92	1.54	1.49	1.85	0.23	0.58	1.48	2.05	0.78	0.60	3.02	0.50
2-acetyl-5-methylfuran / $C_7H_8O_2$	0.22	0.28	0.95	0.71	0.39	0.22	1.80	1.39	0.37	0.28	0.36	0.38	1.40	0.78	1.09	2.99	0.38	2.98	1.87	0.84
Phellopterin / $C_{17}H_{16}O_5$	0.09	0.26	1.22	0.14	0.98	0.18	0.45	0.67	0.38	1.46	1.74	0.14	0.40	0.93	0.32	0.75	1.24	0.67	0.98	1.48
1,Z-5,E-7-dodecatriene / $C_{12}H_{20}$	1.57	3.50	0.24	0.08	0.36	1.85	0.35	0.57	1.15	1.04	0.05	1.22	2.07	1.42	0.98	0.97	0.22	1.68	0.34	0.29

Legend: LV stands for leaves, SB for stem barks, DCM for dichloromethane, MeOH for methanol

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Antimicrobial activity of extracts of *W. ugandensis*

The leaf and stem bark extracts of *W. ugandensis* displayed some antimicrobial activities against *Staphylococcus aureus* (ATCC 25923) and *Candida albicans* (ATCC 90028) while *Escherichia coli* (ATCC 25922) was resistant to the plant extracts. This was confirmed in the test for normality for dependent variables (antibacterial and antifungal effects) where the plant extracts exhibited antimicrobial activity with mean MICs of 3.17 ± 0.27 and 1.76 ± 0.21mg/ml against *S. aureus* and *C. albicans*, respectively regardless of the interactions of sites, samples, plant parts and solvent types on either the antibacterial or antifungal properties. This observation is in agreement with the work of Yibeltal *et al.* (2013), who noted that *S. aureus* and *C. albicans* were the most susceptible microbes to the crude extracts of *W. ugandensis* from Ethiopia. Due to the observed difference in mean antibacterial (3.17 ± 0.27 mg/ml) and antifungal (1.76 ± 0.21mg/ml) activities, it is worth noting that the antimicrobial activity was more pronounced against *C. albicans* than *S. aureus*. The varied sensitivities could be attributed to the reinforced defense mechanisms acquired by these microorganisms as well as difference in the strains of the pathogens under investigation (Suffredini *et al.*, 2006).

These findings also coincides with the results of previous studies which demonstrated that *S. aureus* and *C. albicans* were the most susceptible microbes while *E. coli* was the least susceptible pathogen to the extracts of *W. ugandensis* (Olila *et al.*, 2001a; Maobe *et* *al.,* 2013). The differences in the susceptibility of *S. aureus, C. albicans* and *E. coli* to the plant extracts could be linked to the variation in diffusibility of the bioactive compounds through the culture medium (Rios *et al.,* 1988). Furthermore, the hydrophobic nature of most plant extracts prevents the uniform diffusion of active components through the agar medium (Janssen *et al.,* 1987). The diversity in the antimicrobial activity of the extracts in this study could also be explained by the fact that generally, plant extracts are more effective against Gram-positive than Gram-negative bacteria (Suffredini *et al.,* 2006). This is likely due to the differences in chemical composition and cell wall structure of these microorganisms (Pankaj *et al.,* 2008). The variation in morphological constitution of these microbes influences their reaction to antimicrobial agents (Jagessar *et al.,* 2008). Gram-negative bacteria contain a very restrictive outer membrane with structural lipopolysaccharide components. This makes the cell wall impermeable to antimicrobial agents. On the other hand, Gram-positive bacteria are more susceptible having only an outer peptidoglycan layer which is not an effective permeability barrier (Jagessar *et al.,* 2008).

5.1.1.1 The effects of plant parts, solvents and extract types on antimicrobial activity of *W. ugandensis*

The extracting solvents and plant parts used during the preparation of extracts will considerably influence their pharmacological properties. So far, there is no comparative study available on the antimicrobial activities of the different parts or extracts of *W. ugandensis* in Kenya. Taking this into consideration, the present study reports the effects of solvents, plant parts and extract types on antimicrobial activity of *W. ugandensis* from different populations across the Kenyan Rift Valley.

The results revealed significant differences in the mean antibacterial effects between the different parts of *W. ugandensis* (leaves and stem bark) ($p < 0.001$) while for antifungal effects, there was no significant difference between the different plant parts (leaves and stem bark) and samples (T1, T2, T3 and T4) ($p > 0.05$). This was observed in the stem bark extracts which exhibited higher antimicrobial activity against the test microbes compared to the leaf extracts which showed weak to moderate activity regardless of the solvents used for extraction. For instance, DCM stem bark extracts from Kitale and Rumuruti exhibited the highest antimicrobial activity with mean zones of inhibition of 19.75mm against *S. aureus* and *C. albicans,* respectively. Moderate antimicrobial activity was displayed by the DCM leaf extracts from Rumuruti and Kitale with mean zones of inhition of 12 and 13mm against *C. albicans*, respectively. The strong antimicrobial activity displayed the stem barks could be due to the synergistic effects of the bioactive compounds present in plant species (Franzios *et al.,* 1997). Such bioactive components include flavonols, drimane sesquiterpene dialdehydes and lactones (Rabe and van Staden, 1997; Mashimbye *et al.,* 1999; Mang'uro *et al.,* 2003). Other studies have found that antagonistic effects of the same compounds could reduce their antimicrobial efficacy and thus a possible explanation for the weak antimicrobial activity displayed by the leaf extracts (Berger, 2007).

The MIC analyses revealed that DCM stem bark extracts from Londiani, Rumuruti, Kitale and Kinale were the most active against *C. albicans* with mean MICs of 0.11 ±

0.03, 0.32 ± 0.10, 0.47 ± 0.12 and 0.56 ± 0.20 mg/ml while DCM stem bark extracts from Kitale and Kinale had the highest activity against *S. aureus* with mean MICs of 1.10 ± 0.16 and 1.18 ± 0.29mg/ml, respectively. Similarly the high bioactivity displayed by stem barks compared to the leaves in the MIC analyses could also be linked to the different secondary metabolites found in these organs (stem barks) (Saronjic, 2012). The difference in activity between plant parts indicates a possible corresponding difference in accumulation of some constituents responsible for the activity since most of the secondary metabolites are produced in response to external stimuli (Koptur, 1985; Derita *et al.,* 2009). It is likely therefore, that according to the level of plant exposure to the stimuli, the content and existence of these bioactive components could differ in parallel with the presence or absence of the stimuli, resulting in varied antimicrobial activities (Ncube *et al.,* 2011). The variation in mean MICs of different parts (leaves and stem barks) and samples (T1, T2, T3 and T4) of *W. ugandensis* against *S. aureus* and *C. albicans* could be attributed to the difference in the exposure level of the plant extracts to the test microbes; the paper disk used in antimicrobial tests could have retained the active components of the plant extracts and thus restricts their diffusion into the culture medium (Olila *et al.,* 2001a).

The bioactive compounds are generally accumulated as secondary metabolites in all plant cells but their concentration could vary in different plant parts (Chanda and Kaneria, 2011). In this regard, the stem bark is one of the highest accumulatory plant parts and its compounds are normally preferred for medicinal use (Pires *et al.,* 2003). Therefore, the level and amount of plant secondary metabolites expressed in the stem barks is indicative of their high bioactivity compared to the leaves of this plant species. Saronjic (2012) reported that the stem bark extracts of *W. ugandensis* contained relatively higher amounts of bioactive compounds particularly drimane sesquiterpenoids that could be responsible for the antimicrobial activity and inhibition of the growth of microbes. In addition, Fukayama *et al.* (1982) also reported that plant extracts containing terpenoids as major or minor components normally possess antimicrobial properties. Saronjic (2012) also attributed the weak antimicrobial property of *W. ugandensis* leaf extracts to the lower amounts of phytochemicals expressed in the in leaves compared to the stem barks.

The pattern of antimicrobial inhibition of the various extracts of *W. ugandensis* varied with the solvent used for extraction and the part of the plant used as well as the regions where the samples were collected. It was observed that the DCM extracts exhibited the highest antimicrobial activity than the MeOH extracts regardless of the plant part analyzed. Compared to previous studies on other plant species, Saggoo *et al.* (2010), in their work comparing antibacterial activity of three morphotypes of *Eclipta alba* showed that different solvents have the capacity to extract different compounds depending on their solubility or polarity in the solvents. Similarly, Thongson *et al.* (2004) attributed the difference in MIC between *Salmonella typhimurium* DT 104 strains to solvent-extract component affinity. According to these researchers, the solubility of plant active components in solvents determines the composition of the extract. Therefore, the DCM solvent in this study dissolved many non-polar bioactive compounds from *W. ugandensis* and is, therefore, a very useful extractant for antimicrobial studies where terpenoids and other compounds should be extracted (Tiwari *et al.*, 2011). Thus, the active compounds responsible for the antimicrobial activity were more soluble in the DCM solvent than the MeOH solvent.

Plant extracts activity can be significantly affected by the effects of interactions among plant parts, solvent types and samples. Significant interactions for the effects of samples, sites, solvent types and plant parts on the antifungal activities were observed in this study ($p < 0.05$) while non-significant interactions for sites and samples ($p > 0.05$) on the antibacterial activities were also reported in this study. The type and level of antimicrobial activity exhibited by any plant material depends on the interactions of many factors, including plant parts screened, extraction procedure, extraction temperature, harvesting time, soil type, test strain, drying methods and storage conditions among others. For instance, the fairly high temperature of 50^{o}C and above that are generated during plant tissue grinding can denature chemical constituents of the plant and affects the level of biological activity and chemical composition of secondary metabolites extracted from the plant tissues (Anwar *et al.,* 2009). Biological interactions such as intra and interspecific competitions could have great impact on growth and fitness of plant species (Cordell, 2000), especially by affecting metabolism and secondary metabolites production and thus resulting in varied antimicrobial properties (Shen *et al.,* 2004).

Combined antimicrobial effects for the five populations of *W. ugandensis* across the Kenyan Rift Valley showed non-significant difference ($p > 0.05$, $\alpha = 0.05$, one way ANOVA) in mean MICs for both DCM and MeOH leaf extracts tested against *S. aureus* and *C. albicans*. There was no significant difference in mean MIC for DCM and MeOH stem bark extracts from the five populations tested against *S. aureus* ($p > 0.05$), while for *C. albicans*, there was significant difference in mean MIC for the same extracts ($p < 0.05$). The independent t-test showed significant difference ($p < 0.05$) in mean MICs of DCM stem bark extracts from Kitale, Londiani and Rumuruti tested against *C. albicans*. Similarly, DCM leaf extracts from Kitale exhibited significant difference in mean MIC against *C. albicans* ($p < 0.05$). The observation that the DCM stem bark extracts of *W. ugandensis* from Kitale, Londiani and Rumuruti regions displayed statistically significant variation in mean antimicrobial activities against the test microbes is in agreement with the results of Binns *et al*., 2002; White, 2006) who reported diversity in biological properties of different plant species from South Africa. The authors attributed the differences in the antimicrobial effect of plants to a number of intrinsic (adaptive metabolism, genetic, epigenetic) and extrinsic (environmental, eco-geographical) factors.

Genetic variation among different populations of *W. ugandensis* could lead to diversity in the medicinal properties of the plant species across the Kenyan Rift Valley (Muchugi *et al.,* 2008). Previous molecular genetic studies revealed interspecific variation ($p > 0.0001$) within and among populations of *W. ugandensis* from western (Kitale) and eastern (Karura) arms of the Rift Valley to an extent of suggesting speciation due to allopatry (Muchugi *et al.,* 2008; Muchugi *et al.,* 2012). Genetic distinction was also observed within the Rift Valley specifically in Laikipia. These differences could be due to the geographical and genetic isolation among the populations of *W. ugandensis* (Muchugi *et al.,* 2008; Muchugi *et al.,* 2012). Similarly, the observed variation in antimicrobial activity could be related to the plant’s ecological range or edaphic (soil) factors of the forests from which the samples were collected. Several researchers considered the composition and type of soil as one of the determinant factors in secondary metabolites composition and that of volatiles in particular, in addition to other explanations for the diversity in compounds profiles and antimicrobial properties of the same species (Figueiredo *et al.,* 2008; Nikolic and Zlatkovic, 2010). According to Hornok (1988), survival of most plant species is extremely depressed in poorly drained soil, thereby immensely reducing the plant secondary metabolite yield as well as affecting their antimicrobial activity. Therefore, it is possible to link the observed difference ($p > 0.05$) in antimicrobial effects for Kitale, Londiani and Rumuruti populations to environmental and genetic factors.

It has been shown that plant origin, plant part analyzed, type of solvent used and their relationships are important parameters to consider when analyzing plants for their medicinal properties (Figueiredo *et al.*, 2008). In the present study, there was non-significant interaction for sites versus plant parts, sites versus solvent types, samples versus plant parts, samples versus solvent types, plant parts versus solvent types on antibacterial activity ($p > 0.05$). Similarly, there was no significant difference in the mean antibacterial effect for the different samples and solvent types while for the antifungal effect, there was significant difference between the different solvent types ($p < 0.05$). Plant parts, solvents and extraction procedures are crucial when evaluating the antimicrobial effects of compounds from plants. Solvent types (for example ethanol, acetone, methanol, chloroform, hexane and water) among others are known to affect plant extract antimicrobial effects due to polarity differences between solvents. Such differences in antimicrobial effects were observed with regard to the solvents used for extraction in this study ($p > 0.05$) (Muthuvelan and Balaji, 2008).

The observation that there were variations in the mean antimicrobial activities for the different sites could be justified by the fact that the plant samples were collected from different eco-geographical regions across the Kenyan Rift Valley. In addition, there were notable differences in the altitude and climatic conditions (Jaetzold *et al.*, 2006; Teel, 1984) of these regions to the level that could affect the antimicrobial activity of the plant species. For instance, the mean annual temperature of the study sites ranged from 14-20^{o}C while the mean annual rainfall and altitude varied from 800-1400mm and 1500-2450m, respectively. Temperature regimes are known to be different at different micro-sites within a forest and such variations in temperature may cause chilling injury in the plants thereby leading to reduction in the production of bioactive compounds and consequently lowering their antimicrobial properties (Chokoe *et al.*, 2008; Kairu *et al.*, 2014). Therefore, changes in rainfall and corresponding chages in temperature, which are also related to altitude variation, appeared to influence the antimicrobial activity of *W. ugandensis*. Hence, the occurrence of the plant materials in different geographical regions across the Kenyan Rift Valley could have contributed to the differences in the mean antimicrobial effects for the different populations of *W. ugandensis*.

5.1.2 Phytochemical profiles of extracts of *W. ugandensis*

Previous studies have reported the presence of diverse bioactive compounds in different plant parts of *W. ugandensis* (Kioy *et al.*, 1990; Wube *et al.*, 2005). Muchugi *et al.* (2012)

reported significant genetic diversity within and among *W. ugandensis* population with regard to the eastern and western arms of the Kenyan Rift Valley. These genetic differences were thought to be linked to the plant's environmental condition to the level of influencing its phytochemical profiles (Muchugi *et al.,* 2008). These findings prompted the need to establish differences in phytochemical profiles in different parts of *W. ugandensis* from the five populations across the Kenyan Rift Valley.

5.1.2.1 The effects of plant parts, solvents and extract types on phytochemical profiles of *W. ugandensis*

There were variations in the numbers of compounds present in the leaf and stem bark extracts of *W. ugandensis* from the five populations across the Kenyan Rift Valley. The amounts of compounds were distinctly different between the leaf and stem bark extracts. For instance, the numbers of compounds in the stem bark extracts were slightly higher compared to the leaf extracts in almost all the five populations. Wang *et al.* (2015) reported dramatic differences in the expression levels of unigenes between the leaves and stem barks of *W. ugandensis*; where many unigenes were specifically expressed in the stem barks compared to the leaves. These observations are in consonance with the findings of Saronjic (2012) who reported that *W. ugandensis* contained slightly higher amounts of compounds in the stem bark compared to the leaf extracts. These results are also in agreement with the findings of Kuglerova *et al.* (2011) who noted that the stem barks of *W. ugandensis* contained other compounds (or different combinations of compounds) not present in the leaves. These could be due to the environmental (ecological) conditions of the forests from which *W. ugandensis* samples were collected (Perry *et al.*, 1999).

Significant solvent-dependent differences in compound profiles in different parts of *W. ugandensis* were observed. The solvent effects identified in this study revealed that MeOH extracted higher numbers (amount) of compounds from *W. ugandensis* compared to DCM regardless of the plant parts. This was observed in Kinale with 127 compounds in MeOH stem bark extracts while MeOH stem bark extracts from Kitale, Rumuruti and Londiani had 123, 120 and 117 compounds, respectively. These findings support the work of Iloki *et al.* (2013) who reported that MeOH extracts of *Phoradendron californicum* (oak and mesquite) contained the highest numbers of compounds compared to extraction yields of other solvents such as dichloromethane, ethanol, hexane and ethyl acetate. These observations are also similar to those reported by Sun and Ho (2005), where MeOH solvent was the most effective in extracting phytoconstituents of oat bran. The content of phytochemicals were higher in MeOH, a more polar solvent than DCM, hence MeOH seems to be a good solvent for the recovery of optimum yield of phytochemicals in different parts of *W. ugandensis*.

Remarkable differences were observed in the percentage content of some of the major and minor compounds in the leaf and stem bark extracts of *W. ugandensis*. These could be attributed to the type of solvent used, its polarity index and the solubility of the compounds in the extraction solvent as well as the plant part analyzed and origin of the plant samples (Iloki-Assanga *et al.*, 2015). Most of the dominant compounds were not terpenoids even though the overall chemical composition of the extracts of *W. ugandensis* constituted approximately 80% terpenoids. The hydrocarbon hexadecane (5.16-6.78%) was the dominant compound in Karura, Kinale and Kitale while the sesquiterpenes alloaromadendrene (9.69%) and copaen-15-ol (9.83%) were dominant in Rumuruti and Londiani. These observations are consistent with the work of Kuglerova *et al.* (2011), who attributed the bioactivity of different parts (extracts) of *W. ugandensis* to other kinds of compounds alongside drimane sesquiterpenoids. Saronjic (2012) also reported the presence of carbohydrates and sugar alcohols such as galactitol, ribitol, xylitol, mannitol and quercitol, the monosaccharides glucose and fructose, disaccharides sucrose and trehalose and trisaccharide raffinose in *W. ugandensis* extracts. This concurs with the present study since carbohydrate derivatives and sugar alcohols like mannitol and xylitol were also identified in the present study. Thus, according to Maroti *et al.* (1994), variations in chemical profiles are not only due to extraction techniques and geographic divergence but are also due to other factors such as temperature, relative humidity and rainfall.

Qualitative and quantitative differences as well as similarities were observed in the chemical composition of extracts of *W. ugandensis*. Some compounds were present in the leaf extracts and absent in the stem bark extracts and vice versa. For instance, the diterpene alcohol phytol was present in MeOH leaf and stem bark extracts from Kinale, Kitale, Londiani and Rumuruti while the sesquiterpene drimenin was only present in Kitale DCM leaf and stems bark extracts. Similarly, the sesquiterpene alcohol β-santolol was only present in DCM leaf and stem bark extracts from Londiani while the sesquiterpene α-santonin was only present in MeOH leaf and stem bark extracts from Karura. Phytosterols pollinastanol and stigmasterol were only present in DCM leaf and stem bark extracts from Kitale while β-tocopherol was present in MeOH leaf and stem bark extracts from Kinale, Kitale and Londiani. The possible reason for these variations is that different parts of the plant may synthesize and accumulate different compounds or different amounts of a specific compound due to their differential gene expression, which in turn affects chemical profiles of the plant (Jaffery *et al.*, 2003).

The present study revealed a high abundance of polyunsaturated fatty acids (PUFAs) such as as arachidonic acid (20:4), linoleic acid (18:2) and linolenic acid (18:3) in the leaves compared to the stem barks of *W. ugandensis* across the five populations. Monounsaturated omega-9 fatty acids such as oleic acid (18:1) and erucic acid 9 (22:1) were also identified in the leaf extracts. These observations correlate with the findings of Wube *et al.* (2005) and Wang *et al.* (2015) who reported the presence of several monounsaturated omega-9 fatty acids and PUFAs including linoleic acid (omega-6) and linolenic acid (omega-3) in *W. ugandensis* even though their proportions varied between the leaf and stem bark extracts. Saronjic (2012) also reported the presence of fatty acid (n-hexadecanoic acid / palmitic acid) in all the extracts of *W. ugandensis* tested in varying concentrations. This study also reports the occurance of fatty acids and derivatives such as n-hexadecanoic acid, octadecanoic acid, 1-decanol, 2-hexyl and hexadecanoic acid, methyl ester in all the DCM and MeOH extracts of *W. ugandensis*. This could be due to the presence and expression of fatty acid desaturases (enzymes) in the tissues of this plant species. These are key enzymes which control and regulate the biosynthetic pathways of fatty acids (Wang *et al.,* 2015).

The study revealed high variability among compounds in different plant part extracts with sesquiterpenoids (30.25-56.76%) being the main class of compounds. Fatty acid derivatives (9.48-22.50%) were the second major class while monoterpenoids (0.83-15.97%) were the third major class of compounds. The other classes of compounds were expressed in low concentrations. This pattern of compound class distribution was consistent in all the five populations of *W. ugandensis* across the Kenyan Rift Valley. These observations are similar to those reported by Drage *et al.* (2014) and Wang *et al.* (2015) who reported the abundance of terpenoids and fatty acid derivatives in the leaf and stem bark extracts of *W. ugandensis*. Similarly, these findings also correlate with the results of Oladipupo *et al.* (2014), who reported that the main classes of compounds in *Warburgia salutaris*, a related species from South Africa were sesquiterpene and monoterpene hydrocarbons. The same consistency in compositional pattern of compound category was observed in *Warburgia stuhlmanii* Oladipupo *et al.* (2014).

Terpenoids are hydrocarbon natural products based on five carbon (isoprene) units. They are one the largest and most diverse class of plant secondary metabolites (PSMs) and play key roles in plant growth development and ecological applications (Lange and Ahkami, 2013). The biosynthetic pathway of terpenoids may be influenced by ecological or environmental conditions (De Martino *et al.,* 2009) and they possess diverse biological activities (Wang *et al.,* 2015). The mode of action of terpenoids on microorganisms is not wholly understood. However, given their hydrophobicity, it is thought that they are involved in mechanisms such as coagulation of cell contents, disturbance of cytoplasmic membrane and disruption of proton motive force (Burt, 2004). For instance, the sesquiterpene alcohol copaen-15-ol identified in this plant species possesses antifungal activity (Gallori *et al.,* 2001) while caryophyllene possesses central and peripheral analgesic properties as well as anti-inflammatory, cytotoxic and aintmicrobial activity (Peng *et al.,* 2013). Thus, considering the diversity in chemical profiles of *W. ugandensis*, it is likely that their antimicrobial effects are due to several mechanisms brought about by different compounds identified in the extracts of this plant species.

On the other hand, polyunsaturated fatty acids are a class of fatty acids that have two or more double bonds in their backbones. A few PUFAs like linoleic acid and linolenic acid cannot be synthesized in humans or mammals, and human only consumes them through the diet. Polyunsaturated fatty acids particularly those omega-3 (ω-3) and omega-6 (ω-6) classes are crucial for maintaining the human body’s normal metabolism and provide several health benefits including treatment of coronary heart disease, anticancer properties, hypertension, type-2 diabetes, anti-inflammatory, regulation of neuronal activity and enhancement of immune system (Murray, 2014; Wang *et al.*, 2015). Deficiency of these PUFAs could lead to growth retardation, defective wound healing and dermatitis (Hashimoto *et al.,* 1988; Soyland *et al.,* 1993). Fatty acids n-hexadecanoic acid and n-decanoic acid have been shown to possess antitumor, anticancer, immunostimulant, hypocholesterolemic, antihemolytic and pesticidal properties (Aparna *et al.,* 2012; Jagadeeswari *et al.,* 2012; Sermakkani and Thangapandian, 2012). Most of these fatty acids were highly expressed in the leaves than in the stem barks of *W. ugandensis.* Therefore, this study has revealed the therapeutic and biomedical significance of the leaves of *W. ugandensis,* and that, in the interest of conservation, the leaves could be sustainably used as a good replacement for stem barks.

The general chemical profile of extracts of *W. ugandensis* from the five populations was found to be quite different from what was previously reported. Compounds that were earlier reported to occur in this tree species such as warburganal, muzigadial and polygodial (Kioy *et al.,* 1990; Wube *et al.,* 2005) were not identified in the present study. This may reveal not only the difference in plant parts analyzed and extraction method used, but also the influence of geographic circumstance and climate on the chemical composition of plants. In fact, there have been many reports that the chemical compositions of plants are variable between seasons, sites, altitudes, species, and ages, even in individual plants (Perry *et al.,* 1999). The effect of age on chemical profiles was observed in the Londiani population, which was relatively younger with diameter at breast height ranging from 5 to 8.5cm compared to the Kinale population whose diameter at breast height ranged of 17.2 to 65.9cm. The Londiani population yielded 117 compounds while the Kinale population had 127 compounds. This could be linked to the age of the *W. ugandensis* trees in the above regions.

Compounds such as manool, himachala-2,4-diene, cycloisolongifolene, α-terpineol, α-copaene, α-bergamotene, nerolidol, drimenol, squalene, caryophyllene, β-tocopherol, longifolenaldehyde, schottenol, stigmast-5-en-3-ol, oleate, ergosta-4,6,22-trien-3.beta.-ol, stigmasterol acetate, phellopterin, vitamin E, guaiacol, 2-acetyl-5-methylfuran, 3-keto-β-ionone, procerin and eudesma-5,11(13)-dien-8,12-olide were present in all the parts (leaves and stem barks) of *W. ugandensis* across the Kenyan Rift Valley. This could be as a result of sharing of similar constitutive genes that influence phenotypic characteristics of the plants. The constitutive genes are continuously expressed in cells of plants and they are responsible the biosynthesis similar secondary metabolites in plants as seen in *W. ugandensis* (Kombrink and Somssich, 1995). This leads to the notion of chemotypes; which classifies plants of distinct chemical composition (Homer *et al.,* 2000; Djilani and Dicko, 2012). Furthermore, both the type and quantity of many plant secondary metabolites may vary greatly across physical and biotic environments. This could be due to local adaptation, genotypic sorting and selection across habitats. Nevertheless, much of this variation is attributable to phenotypic plasticity of genotypes in response to variations in resources for growth including soil nutrients, soil moisture, light, and atmospheric carbon dioxide. Such changes to concentration of secondary metabolites in plant tissues may be a result of specific up- or down- regulation of their biosynthesis (Moore *et al.,* 2014).

Since the plant materials in this study were collected from different eco-geographic locations namely Kinale forest (along the Kikuyu escarpment), Londiani forest (along the Mau escarpment), Rumuruti forest (within the Rift Valley), Kitale (west) and Karura (east) of the Kenyan Rift Valley; it is likely that the plants could undergo some genetic differentiation as a consequence of local adaptation to different ecological conditions emanating from random genetic drift (Heywood, 1991). It has been documented that plant populations that are distantly or geographically isolated evolve separately as they adapt to new ecological habitats leading to alterations in allele frequencies hence genetic variation and diversity in chemical profiles as well as presumed antimicrobial activity (Epperson, 1992).

5.2 Conclusions

In conclusion, this study demonstrated that:

i. *Staphylococcus aureus* and *C. albicans* were sensitive to the dichloromethane and methanolic leaf and stem bark extracts of *W. ugandensis* while *E. coli* was resistant.
ii. The stem bark extracts of *W. ugandensis* displayed stronger antimicrobial activity against the test microoganisms compared to the leaf extracts.
iii. The dichloromethane extracts were more active than the methanolic extracts regardless of the plant parts analyszed.
iv. The plant sites, samples, parts, solvent types and their interactions had significant effects on antibacterial and antifungal activities.
v. Sesquiterpenoids, fatty acid derivatives and monoterpenoids were the dominant classes of compounds.

5.3 Recommendations

From this study’s findings, the following recommendations are suggested:

i. There is need for sustainable utilization of *W. ugandensis* as an antimicrobial agent.

ii. There is need for efficient conservation strategies for the Kenyan populations of *W. ugandensis* due to their high bioactivity and abundance in phytochemicals.

5.4 Future research prospects

i. Screening of the individual phytochemical compounds against the studied microorganisms.
ii. Screening the extracts of *W. ugandensis* against other bacterial and fungal species.
iii. Investigation of the relationship between genetic and chemotypic diversity in *W. ugandensis* from different regions in Kenya.
iv. Identification of genes linked to the biosynthesis of other compounds than terpenoids in *W. ugandensis* extracts from different regions in Kenya.

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APPENDICES

Appendix 1: Zones of inhibition of the extracts of *W. ugandensis*

(a) Zones of inhibition of the extracts from Karura

Sample	**Plant part**	**Extract type**	**Zone of inhibition (mm)**		
			S. aureus	***C. albicans***	***E. coli***
T1	LV	DCM	13	6	6
		MeOH	6	6	6
	SB	DCM	17	10	6
		MeOH	17	11	6
T2	LV	DCM	11	6	6
		MeOH	6	6	6
	SB	DCM	18	11	6
		MeOH	18	13	6
T3	LV	DCM	14	6	6
		MeOH	6	6	6
	SB	DCM	19	11	6
		MeOH	18	15	6
T4	LV	DCM	12	6	6
		MeOH	6	6	6
	SB	DCM	19	12	6
		MeOH	18	15	6
C 30			20	-	20
FL 25			-	20	-
DMSO			6	6	6

(b) Zones of inhibition of the extracts from Kitale

Sample	**Plant part**	**Extract type**	**Zone of inhibition (mm)**		
			S. aureus	***C. albicans***	***E. coli***
T1	LV	DCM	11	12	6
		MeOH	7	6	6
	SB	DCM	20	19	6
		MeOH	20	6	6
T2	LV	DCM	11	14	6
		MeOH	13	6	6
	SB	DCM	20	21	6
		MeOH	23	6	6
T3	LV	DCM	9	14	6
		MeOH	6	6	6
	SB	DCM	20	6	6
		MeOH	17	6	6
T4	LV	DCM	13	14	6
		MeOH	10	6	6
	SB	DCM	19	6	6
		MeOH	20	18	6
C 30			20	-	20
FL 25			-	20	-
DMSO			6	6	6

Appendix 1: Cont’d

(c) Zones of inhibition of the extracts from Kinale

Sample	**Plant part**	**Extract type**	**Zone of inhibition (mm)**		
			S. aureus	***C. albicans***	***E. coli***
T1	LV	DCM	7	7	6
		MeOH	9	6	6
	SB	DCM	17	19	6
		MeOH	18	6	6
T2	LV	DCM	7	6	6
		MeOH	7	9	6
	SB	DCM	19	22	6
		MeOH	18	6	6
T3	LV	DCM	8	6	6
		MeOH	7	6	6
	SB	DCM	19	10	6
		MeOH	6	11	6
T4	LV	DCM	6	6	6
		MeOH	7	6	6
	SB	DCM	17	14	6
		MeOH	6	13	6
C 30			20	-	20
FL 25			-	20	-
DMSO			6	6	6

(d) Zones of inhibition of the extracts from Rumuruti

Sample	**Plant part**	**Extract type**	**Zone of inhibition (mm)**		
			S. aureus	***C. albicans***	***E. coli***
T1	LV	DCM	6	6	6
		MeOH	6	6	6
	SB	DCM	12	20	6
		MeOH	12	6	6
T2	LV	DCM	6	12	6
		MeOH	6	6	6
	SB	DCM	14	20	6
		MeOH	13	11	6
T3	LV	DCM	6	15	6
		MeOH	6	6	6
	SB	DCM	10	19	6
		MeOH	11	14	6
T4	LV	DCM	13	13	6
		MeOH	6	10	6
	SB	DCM	13	20	6
		MeOH	16	16	6
C 30			20	-	-
FL 25			-	20	-
DMSO			6	6	6

Appendix 1: Cont'd

(e) Zones of inhibition of the extracts from Londiani

Sample	Plant part	Extract type	Zone of inhibition (mm)		
			S. aureus	***C. albicans***	***E. coli***
T1	LV	DCM	6	8	6
		MeOH	6	6	6
	SB	DCM	7	13	6
		MeOH	14	11	6
T2	LV	DCM	6	7	6
		MeOH	6	6	6
	SB	DCM	6	12	6
		MeOH	14	8	6
T3	LV	DCM	7	6	6
		MeOH	6	6	6
	SB	DCM	13	6	6
		MeOH	11	13	6
T4	LV	DCM	8	6	6
		MeOH	6	6	6
	SB	DCM	15	6	6
		MeOH	6	13	6
C 30			20	-	20
FL 25			-	20	-
DMSO			6	6	6

Appendix 2: MICs of *W. ugandensis* extracts

(a) Minimum inhibitory concentrations of the extracts from Karura

Sample	**Plant part**	**Extract type**	**Antibacterial activity**			**Antifungal activity**		
			Staphylococcus aureus			***Candida albicans***		
			MIC (mg/ml)			**MIC (mg/ml)**		
T1	LV	DCM	7.81	3.91	1.95	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	1.95	0.98	1.95	7.81	3.91	0.98
		MeOH	0.49	0.98	0.49	1.95	0.98	0.49
T2	LV	DCM	15.63	7.81	3.91	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	1.95	0.98	0.24	3.91	1.95	0.49
		MeOH	3.91	1.95	0.98	0.49	0.98	0.49
T3	LV	DCM	15.63	7.81	3.91	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	0.49	1.95	0.98	7.81	3.91	1.95
		MeOH	3.91	1.95	0.98	1.95	0.98	0.49
T4	LV	DCM	3.91	1.95	0.98	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	3.91	0.98	1.95	0.98	0.49	0.06
		MeOH	0.98	0.49	0.49	7.81	1.95	0.98

(b) Minimum inhibitory concentrations of the extracts from Kitale

Sample	**Plant part**	**Extract type**	**Antibacterial activity**			**Antifungal activity**		
			Staphylococcus aureus			***Candida albicans***		
			MIC (mg/ml)			**MIC (mg/ml)**		
T1	LV	DCM	7.81	7.81	3.91	1.95	0.49	0.98
		MeOH	15.63	7.81	3.91	-	-	-
	SB	DCM	1.95	0.98	0.49	0.49	0.49	0.98
		MeOH	3.91	3.91	1.95	-	-	-
T2	LV	DCM	3.91	1.95	1.95	0.98	0.49	0.24
		MeOH	7.81	3.91	1.95	-	-	-
	SB	DCM	0.49	0.98	0.98	0.24	0.12	0.49
		MeOH	3.91	1.95	0.98	-	-	-
T3	LV	DCM	1.95	1.95	0.98	1.95	1.95	0.98
		MeOH	-	-	-	-	-	-
	SB	DCM	1.95	0.98	0.98	-	-	-
		MeOH	3.91	1.95	0.98	-	-	-
T4	LV	DCM	7.81	3.91	3.91	3.91	1.95	0.49
		MeOH	15.63	7.81	3.91	-	-	-
	SB	DCM	1.95	0.98	0.49	-	-	-
		MeOH	1.95	0.98	0.49	3.91	3.91	0.98

Appendix 2: Cont'd

(c) Minimum inhibitory concentrations of the extracts from Kinale

Sample	**Plant part**	**Extract type**	**Antibacterial activity**			**Antifungal activity**		
			Staphylococcus aureus			***Candida albicans***		
			MIC (mg/ml)			**MIC (mg/ml)**		
T1	LV	DCM	7.81	3.91	1.95	7.81	1.95	0.98
		MeOH	7.81	3.91	1.95	-	-	-
	SB	DCM	1.95	0.49	0.98	0.03	0.12	0.06
		MeOH	3.91	3.91	1.95	3.91	1.95	0.49
T2	LV	DCM	15.63	7.81	7.81	-	-	-
		MeOH	15.63	7.81	3.91	7.81	1.95	3.91
	SB	DCM	0.49	0.98	0.49	0.06	0.24	0.49
		MeOH	3.91	1.95	0.98	7.81	3.91	3.91
T3	LV	DCM	3.91	0.98	0.98	-	-	-
		MeOH	7.81	3.91	0.98	-	-	-
	SB	DCM	0.49	0.98	0.98	1.95	0.49	0.12
		MeOH	-	-	-	-	-	-
T4	LV	DCM	-	-	-	-	-	-
		MeOH	1.95	0.98	0.49	-	-	-
	SB	DCM	3.91	1.95	0.49	1.95	0.98	0.24
		MeOH	-	-	-	15.63	3.91	0.98

(d) Minimum inhibitory concentrations of the extracts from Londiani

Sample	**Plant part**	**Extract type**	**Antibacterial activity**			**Antifungal activity**		
			Staphylococcus aureus			***Candida albicans***		
			MIC (mg/ml)			**MIC (mg/ml)**		
T1	LV	DCM	-	-	-	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	7.81	3.91	1.95	0.03	0.12	0.06
		MeOH	1.95	0.49	0.49	7.81	3.91	1.95
T2	LV	DCM	-	-	-	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	-	-	-	0.06	0.24	0.12
		MeOH	1.95	0.98	1.95	0.98	0.98	0.24
T3	LV	DCM	15.63	7.81	3.91	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	0.49	0.98	0.49	-	-	-
		MeOH	3.91	1.95	0.49	3.91	1.95	0.49
T4	LV	DCM	7.81	1.95	1.95	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	0.49	0.98	1.95	-	-	-
		MeOH	-	-	-	3.91	0.98	0.49

Appendix 2: Cont'd

(e) Minimum inhibitory concentrations of the extracts from Rumuruti

Sample	**Plant part**	**Extract type**	**Antibacterial activity**			**Antifungal activity**		
			Staphylococcus aureus			***Candida albicans***		
			MIC (mg/ml)			**MIC (mg/ml)**		
T1	LV	DCM	-	-	-	-	-	-
		MeOH	-	-	-	-	-	-
	SB	DCM	3.91	1.95	1.95	0.03	0.06	0.12
		MeOH	0.49	0.98	1.95	-	-	-
T2	LV	DCM	-	-	-	0.98	0.24	0.49
		MeOH	-	-	-	-	-	-
	SB	DCM	0.98	1.95	0.49	0.98	0.49	0.24
		MeOH	1.95	0.49	0.98	0.98	0.49	0.12
T3	LV	DCM	-	-	-	3.91	1.95	0.98
		MeOH	-	-	-	-	-	-
	SB	DCM	0.98	1.95	1.95	0.98	0.49	0.06
		MeOH	3.91	1.95	0.98	1.95	1.95	0.49
T4	LV	DCM	1.95	0.98	0.49	0.98	0.49	0.24
		MeOH	-	-	-	1.95	1.95	0.49
	SB	DCM	-	-	-	3.91	0.98	0.49
		MeOH	15.63	3.91	1.95	0.24	0.12	0.06

Appendix 3: Summary of chemical classes in *W. ugandensis* extracts

(a) Classes of compounds identified in the extracts from Karura

Class of compounds	**DCM extracts**		**MeOH extracts**	
	LV (%)	**SB (%)**	**LV (%)**	**SB (%)**
Monoterpenoids and related compounds	12 (10.91%)	9 (8.11%)	5 (4.81%)	2 (2.08%)
Sesquiterpenoids and related compounds	38 (34.55%)	63 (56.76%)	39 (37.50%)	46 (47.92%)
Diterpenoids	3 (2.73%)	-	2 (1.92%)	2 (2.08%)
Triterpenoids	1 (0.91%)	2 (1.80%)	3 (2.88%)	2 (2.08%)
Hydrocarbons	6 (5.45%)	3 (2.70%)	3 (2.88%)	1 (1.04%)
Fatty acid derivatives	21 (19.09%)	13 (11.71%)	15 (14.42%)	13 (13.54%)
Ketones and aldehydes	7 (6.36%)	8 (7.21%)	13 (12.50%)	6 (6.25%)
Phytosterols	6 (5.45%)	3 (2.70%)	5 (4.81%)	3 (3.13%)
Tocopherols	3 (2.73%)	-	4 (3.85%)	1 (1.04%)
Carbohydrate derivatives	1 (0.91%)	-	4 (3.85%)	3 (3.13%)
Phenols	2 (1.82%)	2 (1.80%)	5 (4.81%)	1 (1.04%)
Furans	1 (0.91%)	-	-	1 (1.04%)
Coumarins	1 (0.91%)	1 (0.90%)	2 (1.92%)	3 (3.13%)
Pyrans	-	-	-	1 (1.04%)
Benzene derivatives	1 (0.91%)	2 (1.80%)	3 (2.88%)	6 (6.25%)
Anthracenes/ phenanthracenes	1 (0.91%)	2 (1.80%)	1 (0.96%)	2 (2.08%)
Naphthalene derivatives	2 (1.82%)	2 (1.80%)	-	2 (2.08%)
Alkaloids	1 (0.91%)	-	-	-
Others	3 (2.73%)	1 (0.90%)	-	1 (1.04%)
Total	**110 (100%)**	**111 (100%)**	**104 (100%)**	**96 (100%)**

(b) Classes of compounds identified in the extracts from Kinale

Class of compounds	**DCM extracts**		**MeOH extracts**	
	LV (%)	**SB (%)**	**LV (%)**	**SB (%)**
Monoterpenoids and related compounds	10 (7.94%)	10 (9.52%)	7 (5.51%)	5 (4.42%)
Sesquiterpenoids and related compounds	61 (48.41%)	48 (45.71%)	46 (36.22%)	48 (42.48%)
Diterpenoids and related compounds	4 (3.17%)	-	2 (1.57%)	3 (2.65%)
Triterpenoids	1 (0.79%)	1 (0.95%)	3 (2.36%)	2 (1.77%)
Hydrocarbons	8 (6.35%)	11 (10.48%)	4 (3.15%)	1 (0.88%)
Fatty acid derivatives	17 (13.49%)	12 (11.43%)	15 (11.81%)	20 (17.70%)
Ketones and aldehydes	8 (6.35%)	11 (10.48%)	15 (11.81%)	7 (6.19%)
Phytosterols	5 (3.97%)	3 (2.86%)	5 (3.94%)	8 (7.08%)
Tocopherols	3 (2.38%)	-	3 (2.36%)	3 (2.65%)
Carbohydrate derivatives	-	-	5 (3.94%)	2 (1.77%)
Phenols	2 (1.59%)	3 (2.86%)	8 (6.30%)	3 (2.65%)
Coumarins	2 (1.59%)	1 (0.95%)	3 (2.36%)	-
Pyrans	-	-	1 (0.79%)	1 (0.88%)
Benzene derivatives	-	1 (0.95%)	5 (3.94%)	5 (4.42%)
Anthracenes/ phenanthracenes	4 (3.17%)	2 (1.90%)	3 (2.36%)	3 (2.65%)
Naphthalene derivatives	-	2 (1.90%)	-	1 (0.88%)
Alkaloids	1 (0.79%)	-	1 (0.79%)	1 (0.88%)
Others	-	-	1 (0.79%)	-
Total	**126 (100%)**	**105 (100%)**	**127 (100%)**	**113 (100%)**

Appendix 3: Cont'd

(c) Classes of compounds identified in the extracts from Kitale

Class of compounds	**DCM extracts**		**MeOH extracts**	
	LV (%)	**SB (%)**	**LV (%)**	**SB (%)**
Monoterpenoids	9 (8.04%)	5 (5.15%)	9 (8.41%)	8 (6.50%)
Sesquiterpenoids and related compounds	35 (31.25%)	43 (44.33%)	42 (39.25%)	46 (37.40%)
Diterpenoids	5 (4.46%)	2 (2.06%)	1 (0.93%)	2 (1.63%)
Triterpenoids	4 (3.57%)	2 (2.06%)	3 (2.80%)	2 (1.63%)
Hydrocarbons	13 (11.61%)	7 (7.22%)	4 (3.74%)	1 (0.81%)
Fatty acid derivatives	14 (12.50%)	15 (15.46%)	11 (10.28%)	21 (17.07%)
Ketones and aldehydes	7 (6.25%)	6 (6.19%)	12 (11.21%)	13 (10.57%)
Phytosterols	7 (6.25%)	6 (6.19%)	6 (5.61%)	4 (3.25%)
Tocopherols	4 (3.57%)	1 (1.03%)	2 (1.87%)	2 (1.63%)
Carbohydrate derivatives	-	-	4 (3.74%)	3 (2.44%)
Phenols	2 (1.79%)	1 (1.03%)	1 (0.93%)	7 (5.69%)
Furan	1 (0.89%)	1 (1.03%)	1 (0.93%)	1 (0.81%)
Coumarins	1 (0.89%)	-	-	1 (0.81%)
Pyrans	1 (0.89%)	-	1 (0.93%)	1 (0.81%)
Benzene derivatives	2 (1.79%)	3 (3.09%)	5 (4.67%)	6 (4.88%)
Anthracenes / phenanthracenes	1 (0.89%)	2 (2.06%)	1 (0.93%)	2 (1.63%)
Naphthalene derivatives	2 (1.79%)	3 (3.09%)	2 (1.87%)	1 (0.81%)
Alkaloids	1 (0.89%)	-	1 (0.93%)	1 (0.81%)
Flavonoids	-	-	1 (0.93%)	-
Others	3 (2.68%)	-	-	1 (0.81%)
Total	**112 (100%)**	**97 (100%)**	**107 (100%)**	**123 (100%)**

(d) Classes of compounds identified in the extracts from Londiani

Class of compounds	**DCM extracts**		**MeOH extracts**	
	LV (%)	**SB (%)**	**LV (%)**	**SB (%)**
Monoterpenoids and related compounds	5 (4.59%)	3 (2.86%)	6 (5.17%)	6 (5.13%)
Sesquiterpenoids and related compounds	45 (41.28%)	51 (48.57%)	46 (39.66%)	36 (30.77%)
Diterpenoids	4 (3.67%)	3 (2.86%)	4 (3.45%)	4 (3.42%)
Sesterpenoids	-	-	1 (0.86%)	-
Triterpenoids	1 (0.92%)	1 (0.95%)	2 (1.72%)	3 (2.56%)
Hydrocarbons	9 (8.26%)	12 (11.43%)	5 (4.31%)	5 (4.27%)
Fatty acid derivatives	17 (15.60%)	10 (9.52%)	11 (9.48%)	17 (14.53%)
Ketones and aldehydes	7 (6.42%)	10 (9.52%)	10 (8.62%)	13 (11.11%)
Phytosterols	5 (4.59%)	4 (3.81%)	5 (4.31%)	6 (5.13%)
Tocopherols	3 (2.75%)	-	2 (1.72%)	3 (2.56%)
Carbohydrate derivatives	1 (0.92%)	-	5 (4.31%)	7 (5.98%)
Phenols	1 (0.92%)	2 (1.90%)	4 (3.45%)	4 (3.42%)

Appendix 3: Cont'd

Class of compounds	DCM extracts		MeOH extracts	
	LV (%)	**SB (%)**	**LV (%)**	**SB (%)**
Furan	1 (0.92%)	1 (0.95%)	1 (0.86%)	1 (0.85%)
Coumarins	1 (0.92%)	1 (0.95%)	-	-
Pyrans	1 (0.92%)	-	1 (0.86%)	1 (0.85%)
Benzene derivatives	1 (0.92%)	1 (0.95%)	9 (7.76%)	6 (5.13%)
Anthracenes/ phenanthracenes	3 (2.75%)	2 (1.90%)	2 (1.72%)	2 (1.71%)
Naphthalene derivatives	2 (1.83%)	3 (2.86%)	-	1 (0.85%)
Alkaloids	-	-	1 (0.86%)	1 (0.85%)
Others	2 (1.83%)	1 (0.95%)	1 (0.86%)1	1 (0.85%)
Total	**109 (100%)**	**105 (100%)**	**116 (100%)**	**117 (100%)**

(e) Classes of compounds identified in the extracts from Rumuruti

Class of compounds	DCM extracts		MeOH extracts	
	LV (%)	**SB (%)**	**LV (%)**	**SB (%)**
Monoterpenoids and related compounds	8 (7.92%)	3 (3.41%)	8 (6.72%)	1 (0.83%)
Sesquiterpenoids and related compounds	45 (44.55%)	48 (54.55%)	36 (30.25%)	39 (32.50%)
Diterpenoids and related compounds	2 (1.98%)	1 (1.14%)	1 (0.84%)	3 (2.50%)
Triterpenoids	3 (2.97%)	1 (1.14%)	3 (2.52%)	3 (2.50%)
Hydrocarbons	7 (6.93%)	4 (4.55%)	7 (5.88%)	3 (2.50%)
Fatty acid derivatives	12 (11.88%)	9 (10.23%)	21 (17.65%)	27 (22.50%)
Ketones and aldehydes	8 (7.92%)	9 (10.23%)	19 (15.97%)	16 (13.33)
Phytosterols	4 (3.96%)	5 (5.68%)	3 (2.52%)	7 (5.83%)
Tocopherols	4 (3.96%)	-	1 (0.84%)	2 (1.67%)
Carbohydrate derivatives	-	-	6 (5.04%)	4 (3.33%)
Phenols	1 (0.99%)	2 (2.27%)	4 (3.36%)	4 (3.33%)
Furans	1 (0.99%)	-	1 (0.84%)	1 (0.83%)
Coumarins	-	-	1 (0.84%)	-
Pyrans	-	-	1 (0.84%)	3 (2.50%)
Benzene derivatives	1 (0.99%)	1 (1.14%)	4 (3.36%)	4 (3.33%)
Anthracenes/ phenanthracenes	-	2 (2.27%)	1 (0.84%)	2 (1.67%)
Naphthalene derivatives	2 (1.98%)	3 (3.41%)	-	-
Alkaloids	-	-	1 (0.84%)	1 (0.83%)
Others	3 (2.97%)	-	1 (0.84%)	-
Total	**101 (100%)**	**88 (100%)**	**119 (100%)**	**120 (100%)**

Appendix 4: Chemical profiles of Karura extracts

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Monoterpenoids and related compounds							
1	136	$C_{10}H_{16}$	Santolina triene			0.71	
2	136	$C_{10}H_{16}$	Camphene		0.09		
3	136	$C_{10}H_{16}$	α-Fenchene		0.22		
4	136	$C_{10}H_{16}$	Spiro[2.4]heptane, 1,5-dimethyl-6-methylene-	0.33			
5	176	$C_{13}H_{20}$	(+)-2-Carene, 2-isopropenyl-	0.11			
6	136	$C_{10}H_{16}$	Tricyclo[4.3.1.0(2,5)]decane	0.52		0.55	
7	154	$C_{10}H_{18}O$	α-Terpineol	0.35	0.08	1.03	0.11
8	162	$C_{10}H_{10}O_2$	1(3H)-Isobenzofuranone, 3,3-dimethyl-	0.11			
9	152	$C_{10}H_{16}O$	3a,6-Methano-3ah-inden-5-ol, octahydro-, (3a.alpha.,5.alpha.,6.alpha.,7a.beta.)-			0.91	
10	170	$C_{10}H_{18}O_2$	3,7-Octadiene-2,6-diol, 2,6-dimethyl-	0.36			
11	152	$C_{10}H_{16}O$	Isocarveol	0.26			
12	152	$C_{10}H_{16}O$	p-Mentha-1(7),8(10)-dien-9-ol	0.24			
13	156	$C_{10}H_{20}O$	2,3,6-Trimethylhept-3-en-1-ol	1.33	0.11		
14	182	$C_{10}H_{14}O_3$	1(3H)-Isobenzofuranone, 3a,4,5,7a-tetrahydro-4-hydroxy-3a,7a-dimethyl-, (3a.alpha.,4.beta., 7a.alpha.)-(.+/-.)-			0.55	
15	152	$C_{10}H_{16}O$	3-Cyclohexene-1-carboxaldehyde, 1,3,4-trimethyl-				0.35
16	150	$C_{10}H_{14}O$	Verbenone,(l)			0.37	
17	152	$C_{10}H_{16}O$	Sabinol		0.63		
18	156	$C_{10}H_{20}O$	Citronellol	0.74			
19	154	$C_{10}H_{18}O$	p-Menth-8(10)-en-9-ol		0.27		
20	154	$C_{10}H_{18}O$	Dihydrocarveol		0.26		
21	136	$C_{10}H_{16}O$	Carveol		**1.41**		
22	156	$C_{10}H_{20}O$	(1S,2R,5R)-(+)-Isomenthol	0.90			
23	152	$C_9H_{12}O_2$	4,7-Methanoisobenzofuran-1-ol, 1,3,3a,4,7,7a-hexahydro-	0.46			
24	196	$C_{12}H_{20}O_2$	Nerol acetate	**1.28**			
25	168	$C_{10}H_{16}O_2$	Bicyclo[2.2.1]heptan-2-one, 4-hydroxy-1,7,7-trimethyl-		0.29		
Sesquiterpenoids and related compounds							
1	204	$C_{15}H_{24}$	Selina-3,7(11)-diene				0.10
2	202	$C_{15}H_{22}$	Cadala-1(10),3,8-triene				0.15
3	204	$C_{15}H_{24}$	Copaene	0.90	0.38	0.45	1.01
4	204	$C_{15}H_{24}$	1,4-Methano-1H-indene, octahydro-1,7a-dimethyl-4-(1-methylethenyl)-, [1S-(1.alpha., 3a.beta.,4.alpha.,7a.beta.)]-				0.24
5	204	$C_{15}H_{24}$	α-Cubebene	1.86	1.35	1.14	0.31
6	204	$C_{15}H_{24}$	cis-Muurola-3,5-diene		0.08		
7	204	$C_{15}H_{24}$	α-Bergamotene	0.11	0.16	0.75	0.93
8	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	2.51	2.09	2.65	0.78
9	204	$C_{15}H_{24}$	Himachala-2,4-diene	0.44	0.89	0.14	0.19
10	204	$C_{15}H_{24}$	(+)-epi-Bicyclosesquiphellandrene		0.13		
11	204	$C_{15}H_{24}$	Cycloisolongifolene	0.88	1.79	2.12	0.58

Appendix 4: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
12	208	$C_{15}H_{28}$	Fukinane			**2.27**	
13	204	$C_{15}H_{24}$	α-Santalene		0.07		
14	204	$C_{15}H_{24}$	α-Gurjunene				**1.58**
15	204	$C_{15}H_{24}$	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z-	1.45	2.34	0.82	1.00
16	206	$C_{15}H_{26}$	(-)-Neoclovene-(II), dihydro-			0.40	
17	204	$C_{15}H_{24}$	7-epi-α-Cadinene		0.20		
18	204	$C_{15}H_{24}$	Caryophyllene	0.49	0.35	0.43	0.19
19	202	$C_{15}H_{22}$	Cadina-1(10),6,8-triene			0.31	0.27
20	204	$C_{15}H_{24}$	γ-Muurolene		0.17		
21	204	$C_{15}H_{24}$	Isocaryophillene		0.23		
22	204	$C_{15}H_{24}$	α-Muurolene		0.21		0.19
23	204	$C_{15}H_{24}$	1R,4R,7R,11R-1,3,4,7-Tetramethyltricyclo[5.3.1.0(4,11)]undec-2-ene	**2.22**			
24	204	$C_{15}H_{24}$	cis-Thujopsene	0.90		0.42	
25	200	$C_{15}H_{20}$	α-Calacorene		0.15	0.11	
26	202	$C_{15}H_{22}$	Aromadendrene, dehydro-				0.18
27	206	$C_{15}H_{26}$	Longipinane, (E)-				0.72
28	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-		0.56		
29	204	$C_{15}H_{24}$	2H-Cyclopentacyclooctene, 4,5,6,7,8,9-hexahydro-1,2,2,3-tetramethyl-	0.37			
30	198	$C_{15}H_{18}$	Cadalene			0.17	
31	204	$C_{15}H_{24}$	δ-Cadinene	0.16	**1.33**	0.71	0.57
32	204	$C_{15}H_{24}$	Guaia-1(10),11-diene			0.40	
33	204	$C_{15}H_{24}$	Acoradiene		0.31		
34	202	$C_{15}H_{22}$	Calamenene	0.12	0.16	0.87	1.56
	204	$C_{15}H_{24}$	(-)-Zingiberene	0.38	2.53	1.44	1.76
35	204	$C_{15}H_{24}$	Bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl-			0.18	
36	204	$C_{15}H_{24}$	1,1,4a-Trimethyl-5,6-dimethylenedecahydronaphthalene	0.29			
37	204	$C_{15}H_{24}$	Cadina-1(2),4-diene		0.36		
38	204	$C_{15}H_{24}$	Epizonarene	0.32	1.16	0.25	1.90
39	204	$C_{15}H_{24}$	β-Guaiene			**1.63**	**2.91**
40	210	$C_{15}H_{30}$	Germacrene B		0.11		
41	198	$C_{15}H_{18}$	6-Isopropyl-1,4-dimethylnaphthalene		0.14		
42	198	$C_{15}H_{18}$	Guaiazulene		0.13		
43	202	$C_{15}H_{22}$	1,4-Methanobenzocyclodecene, 1,2,3,4,4a,5,8,9, 12,12a-decahydro-		0.97		0.44
44	206	$C_{15}H_{26}$	2,4a,8,8-Tetramethyldecahydrocyclopropa[d]naphthalene	0.65	0.96		
45	206	$C_{15}H_{26}$	(1H-Cycloprop[e]azulene, decahydro-1,1,4,7-tetramethyl-, [1aR-(1a.alpha.,4.beta.,4a.beta., 7.beta.,7a.beta.,7b.alpha.)]-);Ledane	0.46			
46	204	$C_{15}H_{24}$	(-)-δ-Panasinsine	0.21	0.23	0.18	2.09
47	204	$C_{15}H_{24}$	α-Selinene	**1.14**			

Appendix 4: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
48	204	$C_{15}H_{24}$	1,2,4-Metheno-1H-indene, octahydro-1,7a-dimethyl-5-(1-methylethyl)-, [1S-(1.alpha.,2.alpha.,3a.beta. ,4.alpha.,5.alpha.,7a.beta.,8S*)]- ((+)-Cyclosativene)		0.19		
49	204	$C_{15}H_{24}$	(-)-α-Neoclovene		0.25		
50	206	$C_{15}H_{26}$	1,4-Dihydrothujopsene-(I1)		**1.87**		
51	204	$C_{15}H_{24}$	Caryophyllene-(I1)		**2.04**		
52	202	$C_{15}H_{22}$	4,4-Dimethyl-3-(3-methylbut-3-enylidene)-2-methylenebicyclo[4.1.0]heptane		**1.37**		
53	204	$C_{15}H_{24}$	Thujopsene-I3		**3.33**		
54	204	$C_{15}H_{24}$	β-Humulene	0.36	1.68	1.03	0.36
55	204	$C_{15}H_{24}$	γ-Himachalene	0.28	0.52	0.18	1.19
56	204	$C_{15}H_{24}$	7-epi-α-Selinene	0.97	1.48	1.73	1.24
57	208	$C_{15}H_{28}$	Muurolane	0.68			
58	204	$C_{15}H_{24}$	Berkheyaradulene	0.25			
59	204	$C_{15}H_{24}$	β-Cadinene	1.06	0.58	1.20	0.32
60	202	$C_{15}H_{22}$	Cycloisolongifolene, 8,9-dehydro-	0.30			
61	204	$C_{15}H_{24}$	1,2,4,8-Tetramethylbicyclo[6.3.0]undeca-2,4-diene		0.63		
62	202	$C_{15}H_{22}$	1,2,3,3a,4a,5,6,7,8,9,9a,9b-Dodecahydrocyclopenta[def]phenanthrene	**1.06**		0.71	
63	204	$C_{15}H_{24}$	1-Cycloheptene, 1,4-dimethyl-3-(2-methyl-1-propene-1-yl)-4-vinyl-	0.08			
64	200	$C_{15}H_{20}$	9-Methyl-S-octahydrophenanthrene	0.29		0.80	
65	204	$C_{15}H_{24}$	γ-Gurjunene	0.18			
66	218	$C_{15}H_{22}O$	Aristolone				0.83
67	238	$C_{15}H_{26}O_2$	Platambin				0.39
68	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol				0.18
69	222	$C_{15}H_{26}O$	Aristolan-9-ol			0.25	
70	250	$C_{15}H_{22}O_3$	(4s,4aR,7aS,8R)-1,3,4,4a,5,6,7,7a,8,9-decahydro-4-hydroxy-6,6,8-trimethyl-azuleno(5,6-c)furan-2-one				0.33
71	218	$C_{15}H_{22}O$	6-Isopropenyl-4,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-1H-naphthalen-2-one				0.18
74	234	$C_{15}H_{22}O_2$	Drimenin				0.53
75	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy-	**1.60**	**1.60**	0.72	0.50
72	234	$C_{15}H_{22}O_2$	7-(1,3-Dimethylbuta-1,3-dienyl)-1,6,6-trimethyl-3,8-dioxatricyclo[5.1.0.0(2,4)]octane				**5.39**
73	220	$C_{15}H_{24}O$	7R,8R-8-Hydroxy-4-isopropylidene-7-methylbicyclo[5.3.1]undec-1-ene				0.47
76	220	$C_{15}H_{24}O$	7-Oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)-	**1.64**	0.48	0.57	
77	222	$C_{15}H_{26}O$	Humulane-1,6-dien-3-ol				0.42
78	234	$C_{15}H_{22}O_2$	Bakkenolide A				**3.35**
79	228	$C_{15}H_{16}O_2$	Mansonone C			0.23	
80	238	$C_{15}H_{26}O_2$	Widdrol hydroxyether				0.41
81	222	$C_{15}H_{26}O$	Cubedol	0.17			
82	222	$C_{15}H_{26}O$	Widdrol	**1.04**			

Appendix 4: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
83	222	$C_{15}H_{26}O$	β-Dihydroagarofuran			0.32	
84	252	$C_{16}H_{28}O_2$	Sclaral (sclareolide lactol)				**5.07**
85	234	$C_{15}H_{22}O_2$	Davana ether				0.61
86	220	$C_{15}H_{24}O$	γ-Costol	0.54	0.84	0.29	0.41
87	222	$C_{15}H_{26}O$	α-Caryophyllene alcohol			0.20	
88	222	$C_{15}H_{26}O$	α-Bisabolol		0.39		
89	220	$C_{15}H_{24}O$	Spiro[4.5]dec-6-en-8-one, 1,7-dimethyl-4-(1-methylethyl)-		0.49		
90	222	$C_{15}H_{26}O$	Nerolidol 2	0.69	**1.26**	0.53	0.69
91	222	$C_{15}H_{26}O$	Farnesol		0.24		
92	236	$C_{15}H_{24}O_2$	Latia luciferin				
93	238	$C_{15}H_{26}O_2$	11,12-Dihydroxyseychellane	0.21		0.43	
94	218	$C_{15}H_{22}O$	2-Butyl-1-methyl-1,2,3,4-tetrahydronaphthalen-1-ol		0.26		
95	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a, 6,7,8,9,9a-decahydro-6,6,9a-trimethyl			**1.48**	0.92
96	220	$C_{15}H_{24}O$	Cyclopenta[c]pentalen-3(3aH)-one, octahydro-1,2,3a,6-tetramethyl-		0.64		
97	246	$C_{15}H_{18}O_3$	Achillicin			0.22	
98	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide	0.94	0.52	0.55	0.19
99	246	$C_{15}H_{18}O_3$	α-Santonin			0.31	0.33
100	220	$C_{15}H_{24}O$	Isolongifolene, 7,8-dehydro-8a-hydroxy-	0.29			
101	248	$C_{15}H_{20}O_3$	Confertin			0.69	
102	220	$C_{15}H_{24}O$	Longifolenaldehyde	0.69	0.31	0.49	0.40
103	220	$C_{15}H_{24}O$	Shyobunone	**1.01**			
104	220	$C_{15}H_{24}O$	9-Isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane		0.73		0.81
105	220	$C_{15}H_{24}O$	2-Cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)-	0.59	**1.27**		
106	222	$C_{15}H_{26}O$	(-)-Isolongifolol	3.51	2.14	0.47	0.38
107	222	$C_{15}H_{26}O$	Drimenol	**1.05**	**4.04**	**2.02**	**1.15**
108	230	$C_{15}H_{18}O_2$	2,4,6-Cycloheptatrien-1-one,2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)-;(Procerin)	0.96	0.93	1.03	0.29
109	222	$C_{15}H_{26}O$	1-Methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane	0.19	0.85		
110	220	$C_{15}H_{24}O$	Glaucyl alcohol		0.25		0.31
111	250	$C_{15}H_{22}O_3$	5,8-Dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone		**2.03**		
112	248	$C_{17}H_{28}O$	Podocarp-12-en-14-ol		0.10		0.44
113	240	$C_{15}H_{28}O_2$	Citronellyl iso-valerate	**1.22**			0.24
114	272	$C_{15}H_{12}O_5$	6H-Dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl-			0.16	
115	306	$C_{15}H_{14}O_7$	Fusarubin		0.20		
116	248	$C_{15}H_{20}O_3$	Hanphyllin		0.77	0.21	
117	220	$C_{15}H_{24}O$	Isolongifolene oxide		0.48		
118	282	$C_{15}H_{23}Br$	3a-Bromolongifolene			**1.34**	
	204	$C_{15}H_{24}$	β-Bisabolene	0.22	0.37	1.53	1.34

Appendix 4: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
119	222	$C_{15}H_{26}O$	2-Methyl-3-(3-methyl-but-2-enyl)-2-(4-methyl-pent-3-enyl)-oxetane		0.36		
120	248	$C_{15}H_{20}O_3$	1,3,4,4a.beta.,5,6,8,9-Octahydro-4a-hydroxy-6,6,8b-trimethylazuleno(5,6-c)furan-3-one	0.11			
121	208	$C_{14}H_{24}O$	2,5,5,8a-Tetramethyl-1,2,3,5,6,7,8,8a-octahydronaphthalen-1-ol	0.89	0.37		
122	210	$C_{13}H_{22}O_2$	2,6-Octadien-1-ol, 3,7-dimethyl-, propanoate, (Z)-		0.31		
123	332	$C_{22}H_{36}O_2$	2,6,10,14-Hexadecatetraen-1-ol, 3,7,11,15-tetramethyl-, acetate, (E,E,E)-	0.32	0.60		
124	204	$C_{14}H_{20}O$	Khusilol		**1.48**		
125	306	$C_{17}H_{22}O_5$	Azuleno[4,5-b]furan-2,9-dione, 9a-[(acetyloxy) methyl]decahydro-6-methyl-3-methylene-, [3as-(3a.alpha.,6.beta.,6a.alpha.,9a.beta.,9b.alpha.)]-				0.19
126	216	$C_{15}H_{20}O$	Cyclohexanone, 3,3,5-trimethyl-5-phenyl-		0.24		0.49
127	236	$C_{16}H_{28}O$	(-)-Isolongifolol, methyl ether	**1.34**		**4.33**	
128	254	$C_{16}H_{30}O_2$	4,8,12-Trimethyltridecan-4-olide			0.12	
129	264	$C_{17}H_{28}O_2$	Farnesol, acetate		0.45		
130	246	$C_{17}H_{31}B$	Isothujopsene-5,14-diylborane, B-ethyl-dihydro-		0.21		
Diterpenoids							
1	354	$C_{20}H_{18}O_6$	Asarinin				0.10
2	290	$C_{20}H_{34}O$	Geranyl Linalool	0.27	0.11	0.28	0.46
3	296	$C_{20}H_{40}O$	Phytol	0.51	0.03	1.90	1.04
4	290	$C_{20}H_{34}O$	Geranylgeraniol	0.33	0.08	0.24	0.59
5	290	$C_{20}H_{34}O$	Manool	0.45	0.28	0.55	0.58
Triterpenoids							
1	410	$C_{30}H_{50}$	C(14a)-Homo-27-norgammacer-14-ene			0.78	**1.61**
2	410	$C_{30}H_{50}$	Squalene	**1.18**	0.26	0.39	**3.35**
3	426	$C_{30}H_{50}O$	1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)-		0.61		
4	444	$C_{30}H_{52}O_2$	Cycloartane-3.beta.,25-diol			0.10	
Hydrocarbons							
1	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl-		0.17		
2	150	$C_{11}H_{18}$	Tricyclo[4.4.1.0(1,6)]undecane			**1.75**	
3	184	$C_{13}H_{28}$	Nonane, 3-methyl-5-propyl-		0.26		
4	164	$C_{12}H_{20}$	1,Z-5,E-7-Dodecatriene	1.57	3.50	0.24	0.08
5	452	$C_{33}H_{56}$	1,1,6-trimethyl-3-methylene-2-(3,6,9,13-tetramethyl-6-ethenye-10,14-dimethylene-pentadec-4-enyl) cyclohexane	0.46			
6	226	$C_{16}H_{34}$	Hexadecane	**6.37**	0.21		
7	248	$C_{18}H_{32}$	2,5,9-Tetradecatriene, 3,12-diethyl-			0.72	
8	296	$C_{21}H_{44}$	Heneicosane	**2.93**			
9	178	$C_{12}H_{18}O$	(7R,8S)-cis-anti-cis-7,8-Epoxytricyclo [7.3.0.0(2,6)]dodecane	**1.28**			
10	192	$C_{14}H_{24}$	Cyclohexane, 1,1-dimethyl-2,4-bis(1-methylethenyl)-, cis-	0.64			

Appendix 4: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Fatty acids and derivatives							
1	144	$C_8H_{16}O_2$	Octanoic acid	0.72		**1.41**	
2	172	$C_{10}H_{20}O_2$	n-Decanoic acid			**6.53**	
3	170	$C_{10}H_{18}O_2$	Butanoic acid, 3-hexenyl ester, (E)	0.55			
4	180	$C_{11}H_{16}O_2$	2-Propenoic acid, 5-methylene-6-heptenyl ester		0.08		
5	198	$C_{12}H_{22}O_2$	2-Propenoic acid, 2-methyl-, octyl ester	0.61			
6	226	$C_{14}H_{26}O_2$	Citronellyl isobutyrate			0.56	
7	214	$C_{13}H_{26}O_2$	Tridecanoic acid				**4.28**
8	282	$C_{18}H_{34}O_2$	Oleic Acid				0.97
9	206	$C_{13}H_{18}O_2$	2-Propenoic acid, 3-(6,6-dimethylbicyclo[3.1.1] hept-2-en-2-yl)-, methyl ester, (E)-				0.36
10	330	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester				0.47
11	326	$C_{18}H_{30}O_5$	Methyl (1R,2R,8aS)-2-(methoxycarbonyl)-2-hydroxy-5,5,8a-trimethyl-trans-decalin-1-acetate			**1.46**	
12	302	$C_{20}H_{30}O_2$	5,8,11,14,17-Eicosapentaenoic acid				0.61
13	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid (Z,Z)-, methyl ester				0.85
14	170	$C_{10}H_{18}O_2$	Cyclobutanecarboxylic acid, 2-methylbutyl ester	0.32			
15	344	$C_{23}H_{36}O_2$	n-Propyl 5,8,11,14,17-eicosapentaenoate				**1.04**
16	298	$C_{19}H_{38}O_2$	i-Propyl 14-methyl-pentadecanoate	0.32	0.26		
17	200	$C_{12}H_{24}O_2$	Dodecanoic acid	0.78		**1.01**	
18	272	$C_{18}H_{24}O_2$	5,8,11-Heptadecatriynoic acid, methyl ester			**2.00**	
19	256	$C_{16}H_{32}O_2$	n-Hexadecanoic acid	**4.37**	**1.79**	**2.37**	**1.55**
20	282	$C_{18}H_{34}O_2$	9-Octadecenoic acid, (E)-			0.97	
21	370	$C_{22}H_{42}O_4$	Hexanedioic acid, bis(2-ethylhexyl) ester	0.42			
22	304	$C_{20}H_{32}O_2$	Arachidonic acid		0.55		
23	350	$C_{19}H_{26}O_6$	Propanoic acid, 2-methyl-, (dodecahydro-6a-hydroxy-9a-methyl-3-methylene-2,9-dioxoazuleno[4,5-b]furan-6-yl)methyl ester, [3aS-(3a.alpha.,6.beta.,6a.alpha.,9a.beta.,9b.alpha.)]-			**1.30**	
24	178	$C_{10}H_{10}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-	**1.23**		**1.36**	
25	312	$C_{20}H_{40}O_2$	Hexadecanoic acid, 2-methylpropyl ester	0.10			
26	270	$C_{17}H_{34}O_2$	i-Propyl 12-methyl-tridecanoate		0.22		
27	228	$C_{14}H_{28}O_2$	Tetradecanoic acid	0.50		0.84	
28	204	$C_{12}H_{12}O_3$	3-Benzofurancarboxylic acid, 2-ethyl-, methyl ester		**1.56**		
29	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester	0.37	0.14	**1.31**	**1.24**
30	326	$C_{21}H_{42}O_2$	i-Propyl 16-methyl-heptadecanoate		0.50		
31	246	$C_{16}H_{22}O_2$	Cyclohexanecarboxylic acid, 3-phenylpropyl ester	0.38	**1.57**		
32	296	$C_{19}H_{36}O_2$	11-Octadecenoic acid, methyl ester	0.15			**1.29**
33	270	$C_{17}H_{34}O_2$	Heptadecanoic acid	0.15			
34	248	$C_{16}H_{24}O_2$	Cylobutanecarboxylic acid, 2,6-dimethylnon-1-en-3-yn-5-yl ester	**2.32**			
35	312	$C_{20}H_{40}O_2$	Hexadecanoic acid, 2-methylpropyl ester	0.91	0.08		
36	214	$C_{14}H_{30}O$	1-Tetradecanol				0.40
37	284	$C_{19}H_{40}O$	n-Nonadecanol-1	0.38			
38	228	$C_{15}H_{32}O$	n-Pentadecanol	0.52	0.37		

Appendix 4: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Fatty acids and derivative							
39	242	$C_{16}H_{34}O$	1-Decanol, 2-hexyl-	0.56	0.46	0.33	0.56
40	392	$C_{24}H_{40}O_4$	Hyodeoxycholic acid			**2.51**	
41	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester			**1.66**	**1.20**
42	284	$C_{18}H_{36}O_2$	Octadecanoic acid	0.45	0.31	0.36	0.33
Ketones and aldehydes							
1	126	$C_6H_6O_3$	5-Hydroxymethylfurfural			1.64	0.65
2	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)-			0.98	
3	208	$C_{13}H_{20}O_2$	1,3-Butanedione, 1-(2,6,6-trimethyl-1-cyclohexen-1-yl)-			**3.73**	
4	152	$C_8H_8O_3$	Vanillin		0.06		
5	208	$C_{14}H_{24}O$	1-Propanone, 2-methyl-1-(octahydro-3a-methyl-1H-inden-1-yl)-	**1.20**			
6	164	$C_{11}H_{16}O$	cis-Jasmone			0.99	
7	204	$C_{14}H_{20}O$	2,10,10-Trimethyltricyclo[7.1.1.0(2,7)]undec-6-en-8-one	0.52			
8	208	$C_{13}H_{20}O_2$	2,6-Naphthalenedione, octahydro-1,1,8a-trimethyl-, trans-			0.49	
9	190	$C_{13}H_{18}O$	Megastigmatrienone			0.54	
10	206	$C_{14}H_{22}O$	3-Ethyl-4,4-dimethyl-2-(2-methylpropenyl) cyclohex-2-enone			**1.78**	
11	216	$C_{14}H_{16}O_2$	2,3-Naphthalenedione, 1,4-dihydro-1,1,4,4-tetramethyl-		0.25		
12	250	$C_{16}H_{26}O_2$	3-Heptyn-2-one, 5-cyclopentyl-6-hydroxy-6-methyl-5-(1-methylethyl)-				**4.33**
13	206	$C_{13}H_{18}O_2$	3-Keto-β-ionone	0.28	0.20	0.40	0.37
14	124	$C_8H_{12}O$	2-Cyclopenten-1-one, 3,4,5-trimethyl-	**1.32**	**1.16**	0.52	0.46
15	192	$C_{13}H_{20}O$	2-Buten-1-one, 1-(2,6,6-trimethyl-1-cyclohexen-1-yl)-				**1.16**
16	218	$C_{15}H_{22}O$	p-Heptylacetophenone			**1.11**	
17	138	$C_9H_{14}O$	2-Cyclohexen-1-one, 3,4,4-trimethyl-	0.41			
18	222	$C_{13}H_{18}O_3$	Propan-2-one, 1-(4-isopropoxy-3-methoxyphenyl)-	0.13			
19	206	$C_{14}H_{22}O$	2-Butenal, 2-methyl-4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-	0.33			
20	164	$C_{11}H_{16}O$	4-Isopropyl-3,4-dimethylcyclohexa-2,5-dienone		**1.65**		
21	204	$C_{14}H_{20}O$	4-(2', 4', 4'-trimethyl-yciclo[4.1.0]hept-2'-en-3'-yl)-3-buten-2-one	0.64			
22	248	$C_{16}H_{24}O_2$	4,4,5',5'-Tetramethyl-bicyclohexyl-6-ene-2,3'-dione		0.92	0.81	**2.37**
23	206	$C_{14}H_{22}O$	2,4,4-Trimethyl-3-(3-methylbuta-1,3-dienyl)cyclohexanone		**4.76**		
24	206	$C_{13}H_{18}O_2$	Ethanone, 1-(3-butyl-2-hydroxy-5-methylphenyl)-			**1.61**	
25	208	$C_{13}H_{20}O_2$	2,10,10-Trimethyl-6-methylene-1-oxaspiro[4.5]decan-7-one			**1.08**	
26	124	$C_8H_{12}O$	Cyclopentanecarboxaldehyde, 2-methyl-3-methylene-		0.20		
Phytosterols							
1	414	$C_{29}H_{50}O$	ɣ-Sitosterol			**1.71**	
2	394	$C_{29}H_{46}$	Stigmastan-3,5,22-trien	0.33			

Appendix 4: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Phytosterols							
3	400	$C_{28}H_{48}O$	Pollinastanol	0.16			
4	412	$C_{29}H_{48}O$	Fucosterol	0.09			
5	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate	0.13	0.28	0.20	0.17
6	292	$C_{19}H_{32}O_2$	Androstane-3,17-diol, (3.beta.,5.alpha.,17.beta.)-		0.52		
7	410	$C_{29}H_{46}O$	Cycloprop[7,8]ergost-22-en-3-one, 3',7-dihydro-, (5.alpha.,7.beta.,8.alpha.,22E)-		0.38		
8	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol	2.58	1.95	4.05	0.27
9	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)- {Stigmasterol acetate}	0.21	0.58	0.68	0.48
10	414	$C_{29}H_{50}O$	Schottenol	2.31	1.40	2.36	1.38
Tocopherols							
1	416	$C_{28}H_{48}O_2$	β-Tocopherol	0.33	0.40	0.24	0.21
2	430	$C_{29}H_{50}O_2$	Vitamin E	0.50	0.35	0.44	0.07
3	444	$C_{30}H_{52}O_2$	(+)-.alpha.-Tocopherol, O-methyl-	0.21		0.09	
4	402	$C_{27}H_{46}O_2$	δ-Tocopherol			0.10	
Carbohydrates and derivatives							
1	162	$C_6H_{10}O_5$	3,4-Altrosan			**1.39**	
2	194	$C_7H_{14}O_6$	α-D-Galactopyranoside, methyl				0.90
3	164	$C_6H_{12}O_5$	β-l-Arabinopyranoside, methyl				0.98
4	162	$C_6H_{10}O_5$	β-D-Glucopyranose, 1,6-anhydro-			0.70	**1.12**
5	200	$C_{10}H_{16}O_4$	d-Ribo-tetrofuranose, 4-c-cyclopropyl-1,2-O-isopropylidene-, .alpha.-	0.20			
6	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside			**1.06**	
7	270	$C_{13}H_{18}O_6$	Benzyl .beta.-d-glucoside			**1.74**	
Phenols							
1	166	$C_{10}H_{14}O_2$	Cerulignol			0.38	
2	154	$C_8H_{10}O_3$	Phenol, 3,4-dimethoxy-				0.34
3	180	$C_{10}H_{12}O_3$	Coniferol			**2.63**	
4	210	$C_{15}H_{14}O$	3-Phenylbicyclo(3.2.2)nona-3,6-dien-2-one			0.88	
5	188	$C_{14}H_{20}$	Biphenylene, 1,2,3,6,7,8,8a,8b-octahydro-4,5-dimethyl-		0.85		
6	318	$C_{21}H_{34}O_2$	2-[(1R,3S)-3-Hydroxycyclohexyl]5-(2-methyloctan-2-yl)phenol			0.71	
7	234	$C_{17}H_{14}O$	1,4-Pentadien-3-one, 1,5-diphenyl	**8.40**			
8	124	$C_7H_8O_2$	Guaiacol	1.63	1.52	0.93	1.57
Furans and furanones							
1	124	$C_7H_8O_2$	2-Acetyl-5-methylfuran	0.22	0.28	0.95	0.71
Coumarins							
1	188	$C_{11}H_8O_3$	3-Acetylcoumarin	0.22		0.15	0.15
2	206	$C_{11}H_{10}O_4$	Scoparone			0.62	0.37
3	300	$C_{17}H_{16}O_5$	Phellopterin	0.09	0.26	1.22	0.14
Pyran							
1	144	$C_6H_8O_4$	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-				0.72

Appendix 4: Cont’d

No.	MWT	Formula	Name and class of compounds	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Benzene and derivatives							
1	126	$C_6H_6O_3$	1,3,5-Benzenetriol				2.00
2	274	$C_{20}H_{34}$	Benzene, 1,3-bis(2,2-dimethylpropyl)-2,4,5,6-tetramethyl-				0.90
3	262	$C_{17}H_{26}O_2$	11H-Benzo[a]cyclopenta[d]cycloocten-11-one, 4-acetyltetradecahydro-				**1.72**
4	192	$C_{11}H_{12}O_3$	4H-1-Benzopyran-4-one, 2,3-dihydro-7-hydroxy-2,2-dimethyl-		**2.54**		
5	230	$C_{14}H_{14}O_3$	4-(6-Methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one	0.28	0.14	0.87	0.70
6	282	$C_{20}H_{26}O$	Benzene, 1,1'-(oxydi-2,1-ethanediyl)bis[3-ethyl-				0.21
7	216	$C_{16}H_{24}$	Benzene, 2-(butenyl)-5-(1,1-dimethylethyl)-1,3-dimethyl-			0.29	
8	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl-			**2.10**	**2.90**
Anthracenes /phenathracenes and derivatives							
1	236	$C_{18}H_{20}$	Anthracene, 9-(1,1-dimethylethyl)-9,10-dihydro-	0.09			
2	308	$C_{18}H_{28}O_4$	1(2H)-Phenanthrenone, 7-(acetyloxy)dodecahydro-8a-hydroxy-2,4b-dimethyl-, [2S-(2.alpha.,4a.alpha., 4b.beta.,7.beta.,8a.alpha.,10a.beta.)]-				**4.03**
3	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl-		0.11	**1.53**	**1.52**
4	248	$C_{18}H_{16}O$	2-Acetyl-9,10-dimethylanthracene		**2.10**		
Naphthalenes and derivatives							
1	232	$C_{12}H_8O_5$	1,4-Naphthoquinone, 6-acetyl-2,5-dihydroxy-	0.17	0.15		0.53
2	248	$C_{12}H_8O_6$	1,4-Naphthoquinone, 6-acetyl-2,5,8-trihydroxy-		**3.13**		
3	188	$C_{12}H_{12}O_2$	1,4-Naphthoquinone, 2,3-dihydro-5,8-dimethyl-	0.21			0.16
Alkaloid							
1	202	$C_{12}H_{14}N_2O$	1,2-Dihydroharmaline	0.25			
Others							
1	182	$C_{11}H_{18}O_2$	2,6,8-Trimethylbicyclo[4.2.0]oct-2-ene-1,8-diol	0.70			
2	226	$C_{14}H_{26}O_2$	2,4,7,9-Tetramethyl-5-decyn-4,7-diol				**1.51**
3	258	$C_{16}H_{34}O_2$	1,16-Hexadecanediol	0.37			
4	406	$C_{23}H_{34}O_6$	Strophanthidol		0.50		
5	170	$C_{13}H_{14}$	1,2-Dehydro-as-hydrindacene	0.21			

Appendix 5: Chemical profiles of Kinale extracts

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Monoterpenoids and related compounds							
1	136	$C_{10}H_{16}$	Spiro[2.4]heptane, 1,5-dimethyl-6-methylene-		0.26		
2	136	$C_{10}H_{16}$	α-Fenchene		0.32		
3	136	$C_{10}H_{16}$	Santolina triene	0.29			
4	136	$C_{10}H_{16}$	Tricyclo[4.3.1.0(2,5)]decane	0.85		0.84	
5	136	$C_{10}H_{16}$	Isoterpinolene	0.23			
6	134	$C_{10}H_{14}$	4,7-Methano-1H-indene, 2,4,5,6,7,7a-hexahydro-	0.24			
7	154	$C_{10}H_{18}O$	Linalool		0.13		
8	154	$C_{10}H_{18}O$	Terpinen-4-ol		0.09		
9	154	$C_{10}H_{18}O$	endo-Borneol		0.13		
10	154	$C_{10}H_{18}O$	α-Terpineol	0.34	0.27	0.24	0.04
11	152	$C_{10}H_{16}O$	Citral				1.61
12	152	$C_{10}H_{16}O$	o-Mentha-1(7),8-dien-3-ol				0.35
13	150	$C_{10}H_{14}O$	Cinerone			0.76	
14	307	$C_{10}H_{14}Br_2O$	9,10-Dibromo-(+)-camphor				0.41
15	182	$C_{10}H_{14}O_3$	1(3H)-Isobenzofuranone, 3a,4,5,7a-tetrahydro-4-hydroxy-3a,7a-dimethyl-, (3a.alpha.,4.beta., 7a.alpha.)-(.+/-.)-				0.59
16	180	$C_{10}H_{12}O_3$	2,5-Dihydroxy-4-isopropyl-2,4,6-cycloheptatrien-1-one				0.43
17	152	$C_{10}H_{16}O$	2-Methoxy-4-methyl-bicyclo[3.2.1]oct-2-ene	0.15			
18	152	$C_{10}H_{16}O$	3,7-Dimethyl-2,3,3a,4,5,6-hexahydro-1-benzofuran		0.92		
19	150	$C_{10}H_{14}O$	5H-Inden-5-one, 1,2,3,3a,4,7a-hexahydro-7a-methyl-, trans-			0.23	
20	180	$C_{10}H_{12}O_3$	2,5-Dihydroxy-4-isopropyl-2,4,6-cycloheptatrien-1-one			1.32	
21	168	$C_{10}H_{16}O_2$	(2R,4R)-p-Mentha-6,8-diene, 2-hydroperoxide			0.37	
22	150	$C_{10}H_{14}O$	Safranal	0.34			
23	156	$C_{10}H_{20}O$	(1S,2R,5R)-(+)-Isomenthol	0.58			
24	152	$C_{10}H_{16}O$	2,3-Dehydro-1,8-cineole			0.35	
25	156	$C_{10}H_{20}O$	Citronellol	0.63			
26	152	$C_{10}H_{16}O$	trans-1,3,3-trimethylbicyclo[3.1.0]hexane-1-carboxaldehyde	0.09			
27	196	$C_{12}H_{20}O_2$	α-Terpinyl acetate			0.22	
28	186	$C_{14}H_{18}$	1H-Indene, 3-ethyl-1-(1-methylethyl)-		0.46		
29	184	$C_{11}H_{20}O_2$	Cyclohexanol, 3,3,5-trimethyl-, acetate, cis-		1.68		
30	196	$C_{12}H_{20}O_2$	Borneol, acetate, (1S,2R,4S)-(-)-		0.33		
31	178	$C_{12}H_{18}O$	(7R,8S)-cis-anti-cis-7,8-Epoxytricyclo [7.3.0.0(2,6)]dodecane	**1.04**			
Sesquiterpenoids and related compounds							
1	204	$C_{15}H_{24}$	α-Copaene	0.07	0.20	0.51	0.08
2	202	$C_{15}H_{22}$	Cadina-1(10),6,8-triene				
3	204	$C_{15}H_{24}$	α-Cubebene	0.07	0.20	0.51	0.08
4	204	$C_{15}H_{24}$	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethenyl)-, [S-(Z,E)]-		0.06		

Appendix 5: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
5	204	$C_{15}H_{24}$	Cadina-1(2),4-diene	0.16			
6	204	$C_{15}H_{24}$	α-Bergamotene	1.19	0.67	1.91	0.82
7	202	$C_{15}H_{22}$	Isolongifolene, 9,10-dehydro-	0.12			
8	204	$C_{15}H_{24}$	Himachala-2,4-diene	0.19	0.76	0.39	0.80
9	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	0.92	1.15	0.42	2.06
10	204	$C_{15}H_{24}$	α-Santalene		0.30		
11	204	$C_{15}H_{24}$	β-Bisabolene	0.76	0.37	0.56	1.33
12	202	$C_{15}H_{22}$	α-Curcumene		0.06		0.25
13	202	$C_{15}H_{22}$	Calamenene	0.09	2.28	0.22	1.50
14	204	$C_{15}H_{24}$	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z-	0.32	2.54	0.31	1.20
15	204	$C_{15}H_{24}$	7-epi-α-Selinene	0.86	0.08	1.12	0.47
16	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-				0.55
17	204	$C_{15}H_{24}$	Cycloisolongifolene	0.03	0.08	1.67	0.78
18	204	$C_{15}H_{24}$	cis-Muurola-3,5-diene	0.21			
19	208	$C_{15}H_{28}$	Muurolane				0.28
20	204	$C_{15}H_{24}$	(-)-Zingiberene	1.30	0.22	1.06	1.80
21	204	$C_{15}H_{24}$	Caryophyllene	1.44	1.84	1.09	1.79
22	204	$C_{15}H_{24}$	Epizonarene	0.23	1.37	1.23	2.01
	204	$C_{15}H_{24}$	γ-Himachalene	0.16	1.87	1.06	1.09
23	206	$C_{15}H_{26}$	1H-Cycloprop[e]azulene, decahydro-1,1,4,7-tetramethyl-, [1aR-(1a.alpha.,4.beta.,4a.beta.,7 .beta.,7a.beta.,7b.alpha.)]-;(Ledane)	**3.04**			
24	206	$C_{15}H_{26}$	2,4a,8,8-Tetramethyldecahydrocyclopropa[d]naphthalene	0.42	0.27		
25	204	$C_{15}H_{24}$	α-Selinene		0.25		
26	206	$C_{15}H_{26}$	7-Octylidenebicyclo[4.1.0]heptane		0.34		
27	204	$C_{15}H_{24}$	Ylangene				0.27
28	204	$C_{15}H_{24}$	δ-Cadinene	1.21	1.87	0.39	1.19
29	204	$C_{15}H_{24}$	γ-Gurjunene		0.56		
30	202	$C_{15}H_{22}$	Neoisolongifolene, 8,9-dehydro-		1.28		0.15
31	200	$C_{15}H_{20}$	α-Calacorene	0.11			
32	204	$C_{15}H_{24}$	1,2,4,8-Tetramethylbicyclo[6.3.0]undeca-2,4-diene				0.14
33	202	$C_{15}H_{22}$	Aromadendrene, dehydro-		2.92		
34	206	$C_{15}H_{26}$	6,10-Dimethyl-3-(1-methylethylidene)-1-cyclodecene	0.16			
35	204	$C_{15}H_{24}$	Guaia-1(10),11-diene	0.17	**1.48**		
36	202	$C_{15}H_{22}$	Cycloisolongifolene, 8,9-dehydro-	1.34			
37	204	$C_{15}H_{24}$	(-)-α-Panasinsen	0.54			
38	202	$C_{15}H_{22}$	1,4-Methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro-	**1.17**	**1.36**	0.70	0.56
39	204	$C_{15}H_{24}$	Bicyclo[5.3.0]decane, 2-methylene-5-(1-methylvinyl)-8-methyl-	0.40	1.48		

Appendix 5: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
40	202	$C_{15}H_{22}$	Cycloisolongifolene, 9,10-dehydro-	0.22	**1.34**		
41	204	$C_{15}H_{24}$	1H-Cyclopropa[a]naphthalene, decahydro-1,1,3a-trimethyl-7-methylene-, [1aS-(1a.alpha.,3a.alpha.,7a.beta.,7b.alpha.)]-	0.67			
42	204	$C_{15}H_{24}$	Alloaromadendrene		**3.53**		1.26
43	206	$C_{15}H_{26}$	1,4-Dihydrothujopsene-(I1)	0.47		0.23	
44	204	$C_{15}H_{24}$	δ-Neoclovene			0.28	
45	204	$C_{15}H_{24}$	(-)-β-Elemene			0.23	
46	204	$C_{15}H_{24}$	Bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl-	0.51	0.20		
47	204	$C_{15}H_{24}$	Isoledene			0.47	
48	204	$C_{15}H_{24}$	γ-Elemene	0.28			
49	204	$C_{15}H_{24}$	1R,4R,7R,11R-1,3,4,7-Tetramethyltricyclo[5.3.1.0(4,11)]undec-2-ene			0.10	
50	204	$C_{15}H_{24}$	Isocaryophyllene		0.46		0.98
51	200	$C_{15}H_{20}$	Benzene, 1-(1,2-dimethyl-3-methylenecyclopentyl)-4-methyl-, cis-; (Laurene)	0.76			
52	204	$C_{15}H_{24}$	(-)-α-Neoclovene	0.17	0.19		
53	204	$C_{15}H_{24}$	δ-Selinene		**1.06**		
54	204	$C_{15}H_{24}$	1,1,4a-Trimethyl-5,6-dimethylenedecahydro naphthalene	0.24			
55	204	$C_{15}H_{24}$	β-Humulene	0.39	1.44	0.41	0.92
56	204	$C_{15}H_{24}$	Berkheyaradulene			1.10	
57	204	$C_{15}H_{24}$	α-Patchoulene	0.45			
58	204	$C_{15}H_{24}$	γ-Patchoulene	0.76			0.19
59	204	$C_{15}H_{24}$	1-Cycloheptene, 1,4-dimethyl-3-(2-methyl-1-propene-1-yl)-4-vinyl-			0.13	
60	200	$C_{15}H_{20}$	Isolongifolene, 4,5,9,10-dehydro-	0.25			
61	204	$C_{15}H_{24}$	β-Cadinene	0.43	1.53	0.12	1.11
62	212	$C_{15}H_{32}$	Farnesane	0.47			
63	202	$C_{15}H_{22}$	Aromadendrene, dehydro-	1.86			
64	210	$C_{15}H_{30}$	Germacrene B	0.32			
65	204	$C_{15}H_{24}$	β-Guaiene			2.64	**4.63**
66	204	$C_{15}H_{24}$	(-)-δ-Panasinsine	0.27	0.18	0.57	1.22
67	218	$C_{15}H_{22}O$	Aristolone	**1.20**			
68	212	$C_{15}H_{32}$	Dodecane, 2,7,10-trimethyl-		0.14		
69	238	$C_{15}H_{26}O_2$	α-Terpinyl isovalerate		0.10		
70	220	$C_{15}H_{20}O$	γ-Costol	0.74	1.21	1.82	0.25
71	220	$C_{15}H_{24}O$	Humulene epoxide 2				0.17
72	222	$C_{15}H_{26}O$	1,3,3-Trimethyl-2-hydroxymethyl-3,3-dimethyl-4-(3-methylbut-2-enyl)-cyclohexene			0.36	
73	218	$C_{15}H_{22}O$	6-Isopropenyl-4,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-1H-naphthalen-2-one				1.19
74	218	$C_{15}H_{22}O$	9H-Cycloisolongifolene, 8-oxo-				0.40
75	220	$C_{15}H_{24}O$	Bergamotol, Z-α-trans-				0.28

Appendix 5: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
76	220	$C_{15}H_{24}O$	Spiro[4.5]dec-6-en-8-one, 1,7-dimethyl-4-(1-methylethyl)-		**1.19**		
77	218	$C_{15}H_{22}O$	Africanone				0.06
78	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy-	1.44	1.79	1.15	0.96
79	246	$C_{15}H_{18}O_3$	Achillicin				0.17
80	216	$C_{15}H_{20}O$	Cyclohexanone, 3,3,5-trimethyl-5-phenyl-		0.95		0.71
81	222	$C_{15}H_{26}O$	Cedrol				1.70
82	283	$C_{15}H_{23}Br$	Neoisolongifolene, 8-bromo-		**1.18**		
83	236	$C_{16}H_{28}O$	(-)-Isolongifolol, methyl ether			0.44	
84	222	$C_{15}H_{26}O$	Cubedol	0.30			
85	220	$C_{15}H_{24}O$	Bicyclo[6.3.0]undec-1(8)-en-3-one, 2,2,5,5-tetramethyl-				0.76
86	276	$C_{16}H_{20}O_4$	Sericealactone, deoxy-				0.74
87	222	$C_{15}H_{26}O$	Nerolidol 2	1.17	1.36	0.84	0.83
88	220	$C_{15}H_{24}O$	5.alpha.-Hydroxy-4.alpha.,8,10,11-tetramethyltricyclo[6.3.0.0(2,4)]undec-10-ene				0.22
89	220	$C_{15}H_{24}O$	cis-α-Copaene-8-ol	0.18			
90	222	$C_{15}H_{26}O$	(-)-Isolongifolol	1.31	0.35	0.70	0.65
91	220	$C_{15}H_{24}O$	Longifolenaldehyde	1.31	0.94	3.15	1.11
92	218	$C_{15}H_{22}O$	trans-Nuciferol		0.23		
93	238	$C_{15}H_{26}O_2$	3.alpha.,9.beta.-Dihydroxy-3,5.alpha.,8-trimethyltricyclo[6.3.1.0(1,5)]dodecane				0.49
94	250	$C_{15}H_{22}O_3$	5-Ethoxy-8,8-dimethyl-3,3a,4,5,6,7,8,8b-octahydroindeno[1,2-b]furan-2-one				0.54
95	252	$C_{16}H_{28}O_2$	Sclaral (sclareolide lactol)				0.82
96	214	$C_{15}H_{18}O$	5,7,7-Trimethyl-4,5,7,8-tetrahydroazuleno[4,5-c]furan		0.45		
97	222	$C_{15}H_{26}O$	Bicyclo[6.3.0]undec-1(8)-en-3-ol, 2,2,5,5-tetramethyl-			0.35	
98	220	$C_{15}H_{24}O$	2-Cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)-	**2.34**	0.79	0.52	
99	218	$C_{15}H_{22}O$	α-Sinensal		0.20		
100	218	$C_{15}H_{22}O$	1,2,3,4,5,6-Hexahydro-1,1,5,5-tetramethyl-2,4a-methanonaphthalen-7(4aH)-one; (Isolongifolen-9-one)		0.49		0.14
101	220	$C_{15}H_{24}O$	β-Santalol	**1.32**		1.00	
102	234	$C_{15}H_{22}O_2$	6-Isopropyl-1,2-dimethyl-4-oxo-bicyclo[3.3.1]non-2-ene-9-carboxaldehyde	0.49		0.28	
103	222	$C_{15}H_{26}O$	Drimenol	0.59	1.03	2.35	1.65
104	230	$C_{15}H_{18}O_2$	2,4,6-Cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (Procerin)	0.37	2.39	1.02	0.35
105	220	$C_{15}H_{24}O$	7R,8R-8-Hydroxy-4-isopropylidene-7-methylbicyclo[5.3.1]undec-1-ene	0.29			
106	218	$C_{15}H_{22}O$	9H-Cycloisolongifolene, 8-oxo-			0.46	
107	278	$C_{17}H_{26}O_3$	Isolongifolene, 5-acetoxy-3-hydroxy-			0.44	

Appendix 5: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
108	218	$C_{15}H_{22}O$	8-Isopropenyl-1,3,3,7-tetramethyl-bicyclo[5.1.0]oct-5-en-2-one	0.46			
109	248	$C_{15}H_{20}O_3$	Azuleno[6,5-b]furan-2,5-dione, decahydro-4a,8-dimethyl-3-methylene-, [3aR-(3a.alpha.,4a.beta.,7a.alpha.,8.beta.,9a.alpha.)]-(Confertin)		0.61		
110	220	$C_{15}H_{24}O$	9-Isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane	0.51		1.82	1.29
111	222	$C_{15}H_{26}O$	1,3a-Ethano(1H)inden-4-ol, octahydro-2,2,4,7a-tetramethyl-			0.18	0.24
112	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a,6,7,8,9,9a-decahydro-6,6,9a-trimethyl	0.09		0.26	0.34
113	218	$C_{15}H_{22}O$	α-Cyperone			0.23	
114	222	$C_{15}H_{26}O$	1-Methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane	0.36			
115	250	$C_{15}H_{22}O_3$	4.Xi.-Germacr-9-en-12-oic acid, 6.alpha.-hydroxy-1-oxo-, .gamma.-lactone			1.01	
116	228	$C_{15}H_{16}O_2$	Chloranthalactone A	0.24			
117	220	$C_{15}H_{24}O$	Bicyclo[6.3.0]undec-1(8)-en-3-one, 2,2,5,5-tetramethyl-			0.59	
118	236	$C_{15}H_{24}O_2$	Latia luciferin			0.54	
119	290	$C_{17}H_{22}O_4$	4.Xi.,5.xi.,7.xi.-Guaia-1(10),11(13)-dien-12-oic acid, 4,8-dihydroxy-, .gamma.-lactone, acetate			0.94	
120	250	$C_{15}H_{22}O_3$	5,8-Dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone	0.86	**4.56**	0.30	
121	262	$C_{15}H_{18}O_4$	Austricin	0.31		0.59	
122	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide	1.22	1.77	1.35	2.78
123	248	$C_{15}H_{20}O_3$	2-(4a,8-Dimethyl-7-oxo-1,2,3,4,4a,7-hexahydronaphthalen-2-yl)-propionic acid	0.60			
124	234	$C_{15}H_{22}O_2$	Bakkenolide A			1.54	1.34
125	234	$C_{15}H_{22}O_2$	Nootkaton-11,12-epoxide	0.39			
126	228	$C_{15}H_{16}O_2$	7-Hydroxycadalenal	0.60			
127	288	$C_{14}H_{24}O_6$	D-Galactono-1,4-lactone, 5,6-O-octylidene-		0.06		
128	247	$C_{15}H_{18}O_3$	α-Santonin			0.83	
129	238	$C_{15}H_{26}O_2$	7-Isopropenyl-4,4,8,8-tetramethylbicyclo[4.2.0]octane-1,5-diol			1.24	
130	272	$C_{15}H_{12}O_5$	6H-Dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl-			0.16	0.04
131	248	$C_{17}H_{28}O$	Podocarp-13-en-12-ol		0.46		
132	348	$C_{19}H_{24}O_6$	Naphtho[2,3-b]furan-2(3H)-one, 4,8-bis(acetyloxy)decahydro-8a-methyl-3,5-bis(methylene)-, [3aS-(3a.alpha.,4.alpha.,4a.alpha.,8.beta.,8a.beta.,9a.beta.)]-	0.12			
133	234	$C_{15}H_{22}O_2$	4,8a-Dimethyl-6-(2-methyl-oxiran-2-yl)-4a,5,6,7,8,8a-hexahydro-1H-naphthalen-2-one	0.30			

Appendix 5: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
134	206	$C_{14}H_{22}O$	4-(6,6-Dimethyl-2-methylenecyclohex-3-enylidene)pentan-2-ol	0.75			
135	278	$C_{17}H_{26}O_3$	2-Naphthalenemethanol, 1-ethyl-1,2,3,4-tetrahydro-2,3-dihydroxy-.alpha.,1,4,4-tetramethyl-		**3.74**		
136	216	$C_{14}H_{16}O_2$	3-Isobutylidene-6,7-dimethyl-3H-isobenzofuran-1-one		**1.62**		
137	236	$C_{16}H_{28}O$	3-Hexen-1-ol, 6-(2,6,6-trimethyl-1-cyclohexenyl)-4-methyl-, (E)-				0.55
138	252	$C_{15}H_{24}O_3$	Spiro[tricyclo[4.4.0.0(5,9)]decane-10,2'-oxirane], 1-methyl-4-isopropyl-7,8-dihydroxy-, (8S)-			1.20	
Diterpenoids and related compounds							
1	324	$C_{21}H_{40}O_2$	4,8,12,16-Tetramethylheptadecan-4-olide			0.15	
2	272	$C_{20}H_{32}$	(+)-Beyerene	**2.45**			
3	290	$C_{20}H_{34}O$	Manool	0.37	1.98	1.44	0.55
	290	$C_{20}H_{34}O$	Geranyl Linalool	0.12	2.03	0.38	0.60
4	296	$C_{20}H_{40}O$	Phytol	0.98	0.39	2.78	2.34
5	290	$C_{20}H_{34}O$	trans-Geranylgeraniol	0.50	1.04	0.43	0.15
6	318	$C_{20}H_{30}O_3$	15-Oxatricyclo[9.3.2.1(4,8)]heptadec-11-en-16-one, 2-hydroxy-1,7,8-trimethyl-17-methylene-, [1R-(1R*,2S*,4R*,7S*,8R*)]- (Cleomeolide)	0.33			
7	290	$C_{20}H_{34}O$	Grindelene				0.94
Triterpenoids							
1	410	$C_{30}H_{50}$	Squalene	0.87	0.39	0.10	0.34
2	410	$C_{30}H_{50}$	C(14a)-Homo-27-norgammacer-14-ene			0.27	0.53
3	444	$C_{30}H_{52}O_2$	Cycloartane-3.beta.,25-diol	0.08		0.15	
Hydrocarbons							
1	224	$C_{16}H_{32}$	Cyclohexane, 1,2-dimethyl-3-pentyl-4-propyl-		0.06		
2	184	$C_{13}H_{28}$	Nonane, 3-methyl-5-propyl-	0.48	0.13		
3	192	$C_{14}H_{24}$	Cyclohexane, 1,2-dimethyl-3,5-bis(1-methylethenyl)-, (1.alpha.,2.beta.,3.beta.,5.beta.)-		0.68		
4	164	$C_{12}H_{20}$	Cyclohexane, 1,5-diethenyl-2,3-dimethyl-, (1.alpha.,2.alpha.,3.alpha.,5.beta.)-	0.60	0.59		
5	226	$C_{16}H_{34}$	Hexadecane	**5.16**	0.44		
6	164	$C_{12}H_{20}$	Bicyclo[2.2.2]oct-2-ene, 1,2,3,6-tetramethyl-		0.85		
7	188	$C_{14}H_{20}$	Pentacyclo[7.5.0.0(2,8).0(5,14).0(7,11)]tetradecane		0.43		
8	128	C_9H_{20}	Hexane, 2,4,4-trimethyl-			**1.37**	
9	234	$C_{17}H_{30}$	3-Heptadecen-5-yne, (Z)-			**1.93**	
10	190	$C_{14}H_{22}$	1,5,5-Trimethyl-6-(3-methyl-buta-1,3-dienyl)-cyclohexene		**1.23**		
11	188	$C_{14}H_{20}$	Bicyclo[4.2.0]oct-1-ene, exo-7-(1-cyclohexen-1-yl)-	0.41			
12	164	$C_{12}H_{20}$	Cyclohexane, 1,1,4,4-tetramethyl-2,5-dimethylene-			0.39	
13	188	$C_{14}H_{20}$	Bicyclo[2.2.1]heptane, 7-bicyclo[2.2.1]hept-7-ylidene-	0.54			

Appendix 5: Cont’d

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Hydrocarbons							
14	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl-	0.61	0.17		
15	296	$C_{21}H_{44}$	Heneicosane	**1.73**			
16	164	$C_{12}H_{20}$	1,Z-5,E-7-Dodecatriene	0.36	1.85	0.35	0.57
17	266	$C_{19}H_{38}$	1-Nonadecene	0.38			
18	162	$C_{12}H_{18}$	6,7-Dimethyl-1,2,3,5,8,8a-hexahydronaphthalene		0.50		
19	188	$C_{14}H_{20}$	1,3-Cyclohexadiene, 2,6,6-trimethyl-1-(3-methyl-1,3-butadienyl)-		**1.63**		
Fatty acids and derivatives							
1	170	$C_{10}H_{18}O_2$	Butanoic acid, 3-hexenyl ester, (E)-	0.22			
2	172	$C_{10}H_{20}O_2$	Pentanoic acid, 1,1-dimethylpropyl ester				0.34
3	196	$C_{12}H_{20}O_2$	Nerol acetate	**1.13**			
4	224	$C_{13}H_{20}O_3$	(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)methyl ethyl carbonate		0.73		
5	170	$C_{10}H_{18}O_2$	Cyclobutanecarboxylic acid, 2-methylbutyl ester	0.34			
6	230	$C_{15}H_{18}O_2$	2,3-Hexadienoic acid, 2-methyl-4-phenyl-, ethyl ester				1.22
7	206	$C_{11}H_{10}O_4$	6-Methoxy-3-methyl-2-benzofurancarboxylic acid				0.30
8	356	$C_{20}H_{20}O_6$	5-Methoxy-2-(4-methoxy-phenoxymethyl)-benzofuran-3-carboxylic acid ethyl ester				0.73
9	188	$C_{14}H_{20}$	Biphenylene, 1,2,3,6,7,8,8a,8b-octahydro-4,5-dimethyl-		**1.64**		1.06
10	168	$C_{10}H_{16}O_2$	1,5-Dimethyl-bicyclo[3.2.0]heptane-6-carboxylic acid				1.11
11	216	$C_{14}H_{16}O_2$	2,3-Hexadienoic acid, 2-methyl-4-phenyl-, methyl ester		0.84		
12	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid (Z,Z)-, methyl ester				0.83
13	272	$C_{18}H_{24}O_2$	5,8,11-Heptadecatriynoic acid, methyl ester				**1.92**
14	354	$C_{23}H_{46}O_2$	Docosanoic acid, methyl ester				0.17
15	200	$C_{12}H_{24}O_2$	Dodecanoic acid			0.75	
16	328	$C_{19}H_{36}O_4$	Adipic acid, 2,4-dimethylpent-3-yl hexyl ester			2.33	
17	326	$C_{21}H_{42}O_2$	Eicosanoic acid, methyl ester				0.19
18	296	$C_{19}H_{36}O_2$	8-Octadecenoic acid, methyl ester, (E)-				0.74
19	238	$C_{15}H_{26}O_2$	Citronellyl tiglate			0.70	
20	344	$C_{23}H_{36}O_2$	i-Propyl 5,8,11,14,17-eicosapentaenoate		0.40		
21	240	$C_{15}H_{28}O_2$	Citronellyl iso-valerate	0.79			
22	480	$C_{32}H_{64}O_2$	Hexadecanoic acid, hexadecyl ester		0.09		
23	282	$C_{17}H_{30}O_3$	3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate	0.34			
24	330	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester				0.46
25	290	$C_{15}H_{14}O_6$	2-Naphthoic acid, 6-hydroxy-5,7-dimethoxy-, acetate		**1.83**		
26	228	$C_{14}H_{28}O_2$	Tetradecanoic acid	0.33			
27	326	$C_{21}H_{42}O_2$	i-Propyl 16-methyl-heptadecanoate		0.38		
28	226	$C_{12}H_{18}O_4$	2,4-Hexadienedioic acid, 3-methyl-4-propyl-, dimethyl ester, (E,Z)-			1.53	

Appendix 5: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Fatty acids and derivatives							
29	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester	0.23	1.48	1.25	1.86
30	652	$C_{38}H_{68}O_8$	l-(+)-Ascorbic acid 2,6-dihexadecanoate	**3.02**			
31	298	$C_{19}H_{38}O_2$	i-Propyl 14-methyl-pentadecanoate	0.33	0.14		
32	256	$C_{16}H_{32}O_2$	n-Hexadecanoic acid	3.24	1.58	2.92	2.86
33	284	$C_{18}H_{36}O_2$	Octadecanoic acid	0.45	0.58	0.52	0.29
34	232	$C_{13}H_{12}O_4$	Methyl 5-hydroxy-8-methoxy-1-naphthalenecarboxylate			1.13	
35	296	$C_{19}H_{36}O_2$	9-Octadecenoic acid, methyl ester, (E)-			1.16	
36	354	$C_{22}H_{26}O_4$	Succinic acid, di(2-propylphenyl) ester			**2.41**	
37	504	$C_{30}H_{48}O_6$	Sericic acid	0.48			
38	280	$C_{18}H_{32}O_2$	9,12-Octadecadienoic acid (Z,Z)- (Linoleic acid)			0.44	0.51
39	290	$C_{19}H_{30}O_2$	9,12-Octadecadiynoic acid, methyl ester	**2.53**			
40	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester			**2.77**	**5.03**
41	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester			0.10	0.24
42	214	$C_{14}H_{30}O$	1-Tetradecanol		0.74		0.38
43	238	$C_{16}H_{30}O$	11-Hexadecyn-1-ol	0.92			
44	200	$C_{13}H_{28}O$	n-Tridecan-1-ol	0.40			
45	242	$C_{16}H_{34}O$	1-Decanol, 2-hexyl-	0.51	0.20	0.46	0.75
46	284	$C_{19}H_{40}O$	n-Nonadecanol-1		0.82		
47	228	$C_{15}H_{32}O$	n-Pentadecanol	0.67	0.68	**1.00**	
Ketones and aldehydes							
1	126	$C_6H_6O_3$	5-Hydroxymethylfurfural			**1.21**	
2	122	$C_7H_6O_2$	Benzaldehyde, 4-hydroxy-			**1.59**	
3	152	$C_8H_8O_3$	Vanillin		0.08		
4	192	$C_{13}H_{20}O$	Tricyclo[6.3.0.0(1,5)]undecan-4-one, 5,9-dimethyl-			1.26	1.49
5	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)-			1.01	0.57
6	206	$C_{13}H_{18}O_2$	Ethanone, 1-(3-butyl-2-hydroxy-5-methylphenyl)-			1.55	1.18
7	232	$C_{16}H_{24}O$	Allyl ionone 4				0.85
8	206	$C_{13}H_{18}O_2$	3-Keto-β-ionone	0.33	0.52	1.73	1.27
9	190	$C_{13}H_{18}O$	Megastigmatrienone			1.46	
9	190	$C_{13}H_{18}O$	Megastigmatrienone			1.46	
10	164	$C_{11}H_{16}O$	4-Isopropyl-3,4-dimethylcyclohexa-2,5-dienone	**3.23**			
11	124	$C_7H_8O_2$	2-Acetyl-5-methylfuran	0.39	0.22		
12	226	$C_{15}H_{30}O$	Pentadecanal	0.92		1.24	
13	208	$C_{13}H_{20}O_2$	2,10,10-Trimethyl-6-methylene-1-oxaspiro[4.5]decan-7-one			1.19	2.55
14	204	$C_{14}H_{20}O$	2-(3-Isopropyl-4-methyl-pent-3-en-1-ynyl)-2-methyl-cyclobutanone		0.76		
15	216	$C_{14}H_{16}O_2$	2,3-Naphthalenedione, 1,4-dihydro-1,1,4,4-tetramethyl-		0.18		
16	196	$C_{10}H_{12}O_4$	2-Propanone, 1-hydroxy-3-(4-hydroxy-3-methoxyphenyl)-			0.70	

Appendix 5: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Ketones and aldehydes							
17	238	$C_{16}H_{30}O$	cis-9-Hexadecenal		0.87		
18	124	$C_8H_{12}O$	2-Cyclopenten-1-one, 2,3,4-trimethyl-		**1.60**		
19	164	$C_{11}H_{16}O$	(3aS,6aS)-3,3-dimethyl-3,4,5,6-tetrahydro-3a,6a-methanopentalen-1(2H)-one		0.11		
20	206	$C_{14}H_{22}O$	2,4,4-Trimethyl-3-(3-methylbuta-1,3-dienyl) cyclohexanone		1.23		
21	192	$C_{13}H_{20}O$	α-Ionone	0.16			
22	206	$C_{14}H_{22}O$	4-Camphenylbutan-2-one			1.93	
23	202	$C_{14}H_{18}O$	11-Isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one	**1.22**	0.84	1.28	
24	208	$C_{11}H_{12}O_4$	Sinapinaldehyde			0.14	
25	248	$C_{16}H_{24}O_2$	4,4,5',5'-Tetramethyl-bicyclohexyl-6-ene-2,3'-dione		**1.34**		0.90
26	164	$C_{11}H_{16}O$	(R)-(-)-4,4a,5,6,7,8-Hexahydro-4a-methyl-2(3H)-naphthalenone			0.46	
27	230	$C_{14}H_{14}O_3$	1-Methoxy-5-methyl-5-phenyl-7-oxabicyclo[4.1.0]hept-3-en-2-one	0.09			
28	206	$C_{14}H_{22}O$	α-Irone	0.17			
29	182	$C_9H_{10}O_4$	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-			0.21	
Phytosterols							
1	492	$C_{31}H_{53}ClO_2$	Stigmastan-3-ol, 5-chloro-, acetate, (3.beta.,5.alpha.)-				**3.89**
2	414	$C_{29}H_{50}O$	ɣ-Sitosterol				1.78
3	260	$C_{19}H_{32}$	Androstane, (5.alpha.)-				1.02
4	318	$C_{21}H_{34}O_2$	Androstan-17-one, 3-ethyl-3-hydroxy-, (5.alpha.)-				0.31
5	412	$C_{29}H_{48}O$	Stigmasterol				0.12
6	336	$C_{20}H_{32}O_4$	17.beta.-Hydroxy-6-oxo-4,5-secoandrostan-4-oic acid methyl ester		**1.26**		
7	394	$C_{29}H_{46}$	Stigmastan-3,5,22-trien	0.18			
8	414	$C_{29}H_{50}O$	Schottenol	1.77	0.40	1.99	1.61
9	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate	0.08	1.04	0.06	1.76
10	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol	2.89	1.22	2.05	3.41
11	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)-{Stigmasterol acetate}	0.22	0.38	0.38	1.04
12	426	$C_{30}H_{50}O$	9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, (3.beta.,4.alpha.,5.alpha.)-			0.09	
13	414	$C_{28}H_{46}O_2$	3Beta,5-epoxy-a-homo-5beta-cholest-4-en-3alpha-ol	**1.37**			
Tocopherols							
1	416	$C_{28}H_{48}O_2$	β-Tocopherol	0.26	1.89	0.18	0.14
2	444	$C_{30}H_{52}O_2$	(+)-α-Tocopherol, O-methyl-	0.09			
3	430	$C_{29}H_{50}O_2$	Vitamin E	0.74	0.79	0.42	0.16

Appendix 5: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Carbohydrate and derivatives							
1	160	$C_7H_{12}O_4$	1-Deoxy-2,4:3,5-dimethylene-d-xylitol				2.20
2	150	$C_5H_{10}O_5$	Xylose			1.51	
3	162	$C_6H_{10}O_5$	.beta.-D-Glucopyranose, 1,6-anhydro-			0.97	
4	182	$C_6H_{14}O_6$	D-Mannitol			2.10	
5	182	$C_6H_{14}O_6$	Galactitol				1.31
6	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside			1.47	0.19
7	240	$C_{12}H_{16}O_5$	2-O-Benzyl-d-arabinose			0.90	
Phenols							
1	180	$C_{10}H_{12}O_3$	Coniferol			1.45	
2	110	$C_6H_6O_2$	Catechol			1.39	
3	150	$C_{10}H_{14}O$	Durenol				1.36
4	166	$C_{10}H_{14}O_2$	Cerulignol			0.32	
5	178	$C_{10}H_{10}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-			0.55	
6	248	$C_{15}H_{20}O_3$	Phenol, 2-(2-hydroxy-1,2-dimethylcyclopentyl)-, 1-acetate, trans-		0.58		
7	124	$C_7H_8O_2$	Guaiacol	0.24	1.28	1.26	1.33
8	230	$C_{16}H_{22}O$	Phenol, 2-(3,7-dimethylocta-2,6-dienyl)-	0.26	0.27		
9	210	$C_{15}H_{14}O$	3-Phenylbicyclo(3.2.2)nona-3,6-dien-2-one			1.20	
10	154	$C_8H_{10}O_3$	Phenol, 2,6-dimethoxy-				0.63
11	234	$C_{16}H_{26}O$	Phenol, 2,6-bis(1,1-dimethylethyl)-4-ethyl-			1.01	
12	318	$C_{21}H_{34}O_2$	2-[(1R,3S)-3-Hydroxycyclohexyl]5-(2-methyloctan-2-yl)phenol			0.38	
Furans							
	124	$C_7H_8O_2$	2-Acetyl-5-methylfuran	0.39	0.22	1.80	1.39
Coumarins							
1	190	$C_{12}H_{14}O_2$	Coumarin, 3,4-dihydro-4,5,7-trimethyl-			0.36	
2	218	$C_{14}H_{18}O_2$	Dihydrocoumarin, 4,4,5,7,8-pentamethyl	**1.20**		0.81	
3	300	$C_{17}H_{16}O_5$	Phellopterin	0.98	0.18	0.45	0.67
4	210	$C_{11}H_{14}O_4$	Comarin, 3,4,4a,5,6,8a-hexahydro-6,8a-epidioxy-4a,6-dimethyl-			0.13	
5	176	$C_{11}H_{12}O_2$	3,4-Dihydrocoumarin, 7,8-dimethyl-	0.17			
Pyrans							
1	144	$C_6H_8O_4$	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-				0.91
2	228	$C_{14}H_{12}O_3$	2-Isopropenyl-2,3-dihydrofuro[3,2-g]chromen-7-one			0.76	
Benzene derivatives							
1	126	$C_6H_6O_3$	1,2,3-Benzenetriol			2.06	2.27
2	120	C_8H_8O	Benzofuran, 2,3-dihydro-			0.94	
3	230	$C_{14}H_{14}O_3$	4-(6-Methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one		**1.49**	0.41	0.37
4	228	$C_{14}H_{12}O_3$	2H,8H-Benzo[1,2-b:5,4-b']dipyran-2-one, 8,8-dimethyl-			0.27	0.34
5	188	$C_{14}H_{20}$	1,4-Dimethyl-2-cyclohexylbenzene				0.17
6	246	$C_{18}H_{30}$	Benzene, hexaethyl-			2.47	1.95

Appendix 5: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Anthracenes /phenathracenes and derivatives							
1	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl-	0.23	**1.64**	1.14	0.86
2	248	$C_{18}H_{16}O$	2-Acetyl-9,10-dimethylanthracene		0.36		
3	200	$C_{15}H_{20}$	9-Methyl-S-octahydroanthracene	**3.30**		0.77	0.71
4	228	$C_{16}H_{20}O$	9-Acetyl-S-octahydrophenanthrene	0.40		0.13	
5	214	$C_{15}H_{18}O$	1(2H)Phenanthrenone, 3,4,4a,9,10,10a-hexahydro-4a-methyl-				0.14
6	212	$C_{15}H_{16}O$	2(3H)-Phenanthrenone, 4,4a,9,10-tetrahydro-4a-methyl-	0.17			
Alkaloids							
1	143	$C_8H_{17}NO$	Conhydrin			0.11	
2	295	$C_{18}H_{17}NO_3$	(+)-Mecambroline				0.05
3	202	$C_{12}H_{14}N_2O$	1,2-Dihydroharmaline	0.25			
Naphthalenes and derivatives							
1	248	$C_{12}H_8O_6$	1,4-Naphthoquinone, 6-acetyl-2,5,8-trihydroxy-		0.98		
2	188	$C_{13}H_{16}O$	1(2H)-Naphthalenone, 3,4-dihydro-4,5,6-trimethyl-				0.85
3	232	$C_{12}H_8O_5$	1,4-Naphthoquinone, 6-acetyl-2,5-dihydroxy-		0.46		
Others							
1	202	$C_{14}H_{18}O$	Bis[bicyclo[3.2.0]hept-2-en-4-yl]ether			1.41	

Appendix 6: Chemical profiles of Kitale extracts

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Monoterpenoids and related compounds							
1	136	$C_{10}H_{16}$	α-Fenchene		0.18		
2	136	$C_{10}H_{16}$	Artemisia triene			0.05	
3	136	$C_{10}H_{16}$	β-Ocimene			0.60	
4	140	$C_{10}H_{20}$	1R,2c,3t,4t-Tetramethyl-cyclohexane	0.10			
5	136	$C_{10}H_{16}$	α-Terpinene		0.25		
6	134	$C_{10}H_{14}$	3a,6-Methano-3aH-indene, 2,3,4,5,6,7-hexahydro-	0.78			
7	136	$C_{10}H_{16}$	Tricyclo[4.3.1.0(2,5)]decane				1.01
8	154	$C_{10}H_{18}O$	α-Terpineol	1.09	0.05	0.95	1.06
9	152	$C_{10}H_{16}O$	Teresantalol	0.15			
10	152	$C_{10}H_{16}O$	3-Pinanone, cis				0.37
11	152	$C_{10}H_{16}O_2$	Citral				1.02
12	162	$C_{10}H_{10}O_2$	1(3H)-Isobenzofuranone, 3,3-dimethyl-				0.12
13	154	$C_{10}H_{18}O$	p-Menth-3-en-9-ol			0.60	
14	152	$C_{10}H_{16}O$	3,6-Dimethyl-2,3,3a,4,5,7a-hexahydrobenzofuran				0.40
15	152	$C_{10}H_{16}O$	Sabinol			0.81	
16	154	$C_{10}H_{18}O$	Thujanol		0.13		
17	152	$C_{10}H_{16}O$	3a,6-Methano-3ah-inden-5-ol, octahydro-, (3a.alpha.,5.alpha.,6.alpha.,7a.beta.)-			0.58	
18	150	$C_{10}H_{14}O$	2H-Inden-2-one, 1,4,5,6,7,7a-hexahydro-7a-methyl-, (S)-			2.11	
19	152	$C_{10}H_{16}O$	p-Menth-8-en-3-one, trans	0.25			
20	180	$C_{10}H_{12}O_3$	2,5-Dihydroxy-4-isopropyl-2,4,6-cycloheptatrien-1-one			0.86	
21	136	$C_{10}H_{16}$	Bicyclo[4.3.0]nonane, 2-methylene-, cis-			0.48	
22	156	$C_{10}H_{20}O$	(1S,2R,5R)-(+)-Isomenthol	0.64			
23	168	$C_{11}H_{20}O$	4a(2H)-Naphthalenemethanol, octahydro-		0.07		
24	182	$C_{11}H_{18}O_2$	1-Hydroxymethyladamantan-2-ol				0.71
25	168	$C_{11}H_{20}O$	Cyclopentanol, 3-methyl-2-(2-pentenyl)-	2.62			
26	178	$C_{12}H_{18}O$	9-Methyl-10-methylenetricyclo[4.2.1.1(2,5)]decan-9-ol	0.61			
27	182	$C_{12}H_{22}O$	2-(2-Ethyl-1,3-dimethyl-cyclopent-2-enyl)-propan-2-ol			1.05	1.48
28	152	$C_{10}H_{16}O$	trans-1,3,3-trimethylbicyclo[3.1.0]hexane-1-carboxaldehyde	0.30			
29	178	$C_{12}H_{18}O$	(7R,8S)-cis-anti-cis-7,8-Epoxytricyclo[7.3.0.0(2,6)]dodecane	1.92			
Sesquiterpenoids and related compounds							
1	204	$C_{15}H_{24}$	Copaene	2.23	1.37	0.93	0.08
2	204	$C_{15}H_{24}$	α-Santalene		0.30		
3	204	$C_{15}H_{24}$	α-Cubebene	0.81	0.14	0.15	0.41
4	202	$C_{15}H_{22}$	α-Curcumene		0.18		
5	204	$C_{15}H_{24}$	α-Muurolene		0.12		
6	204	$C_{15}H_{24}$	Epizonarene	1.42	1.89	1.18	0.43
7	204	$C_{15}H_{24}$	α-Cedrene		0.45		
8	204	$C_{15}H_{24}$	Isoledene				0.46

Appendix 6: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
9	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	0.93	1.70	0.69	0.83
10	204	$C_{15}H_{24}$	Caryophyllene	1.95	2.20	0.42	0.49
11	204	$C_{15}H_{24}$	β-Bisabolene	0.84	0.43	0.36	0.18
12	202	$C_{15}H_{22}$	Calamenene	1.34	0.10	1.01	0.42
13	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-				1.13
14	204	$C_{15}H_{24}$	(-)-Zingiberene	0.33	1.22	0.49	0.86
15	204	$C_{15}H_{24}$	γ-Gurjunene	0.19	0.58		
16	208	$C_{15}H_{28}$	10.alpha.-Eremophilane				0.84
17	204	$C_{15}H_{24}$	7-epi-α-Selinene	0.17	0.98	0.51	2.21
18	200	$C_{15}H_{20}$	α-Calacorene		0.10		
19	206	$C_{15}H_{26}$	(-)-Neoclovene-(II), dihydro-	0.11			
20	208	$C_{15}H_{28}$	1H-Indene, octahydro-2,3a,4-trimethyl-2-(1-methylethyl)-, (2.alpha.,3a.beta.,4.beta.,7a.beta.)-(+)-			**2.99**	
21	204	$C_{15}H_{24}$	δ-Selinene		0.71		
22	204	$C_{15}H_{24}$	Selina-3,7(11)-diene	0.18			
23	204	$C_{15}H_{24}$	α-Guaiene		0.12		
24	204	$C_{15}H_{24}$	Bergamotene	0.32	1.23	0.33	0.67
25	204	$C_{15}H_{24}$	β-Cadinene	0.28	1.14	0.92	2.06
26	204	$C_{15}H_{24}$	cis-Muurola-3,5-diene			0.44	
27	204	$C_{15}H_{24}$	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z-	0.93	1.13	0.62	0.71
28	204	$C_{15}H_{24}$	cis-Thujopsene	0.59			
29	204	$C_{15}H_{24}$	β-Patchoulene	**3.24**			
30	204	$C_{15}H_{24}$	(-)-δ-Panasinsine	1.98	0.94	0.11	0.70
31	204	$C_{15}H_{24}$	(-)-Aristolene		1.92		
32	204	$C_{15}H_{24}$	Isocaryophillene			0.19	0.60
33	204	$C_{15}H_{24}$	Cycloisolongifolene	0.07	0.29	1.57	0.06
34	202	$C_{15}H_{22}$	Isolongifolene, 9,10-dehydro-		0.29		
35	204	$C_{15}H_{24}$	1,2,4,8-Tetramethylbicyclo[6.3.0]undeca-2,4-diene		0.52		
36	204	$C_{15}H_{24}$	Thujopsene-(I2)		1.61	0.22	
37	204	$C_{15}H_{24}$	Cascarilladiene				0.53
38	204	$C_{15}H_{24}$	Himachala-2,4-diene	1.71	2.02	0.42	1.42
39	204	$C_{15}H_{24}$	β-Cedrene			0.40	
40	204	$C_{15}H_{24}$	α-Selinene		0.73		
41	202	$C_{15}H_{22}$	1,4-Methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro-	0.10	1.62		0.32
42	204	$C_{15}H_{24}$	δ-Cadinene	2.13	0.56	0.59	0.94
43	206	$C_{15}H_{26}$	1H-Cycloprop[e]azulene, decahydro-1,1,4,7-tetramethyl-, [1aR-(1a.alpha.,4.beta.,4a.beta.,7.beta., 7a.beta.,7b.alpha.)]-;(Ledane)			0.43	
44	204	$C_{15}H_{24}$	Caryophyleine-(I3)		1.26		
45	206	$C_{15}H_{26}$	Patchoulane	0.41			
46	204	$C_{15}H_{24}$	γ-Himachalene	2.20	0.11	2.76	1.98
47	208	$C_{15}H_{28}$	Fukinane			0.66	

Appendix 6: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
48	204	$C_{15}H_{24}$	Bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl-	0.42			
49	204	$C_{15}H_{24}$	Thujopsene-I3	2.52			
50	204	$C_{15}H_{24}$	γ-Elemene			0.28	
51	202	$C_{15}H_{22}$	1,2,3,3a,4a,5,6,7,8,9,9a,9b-Dodecahydrocyclopenta[def]phenanthrene			0.64	0.48
52	202	$C_{15}H_{22}$	Cadina-1(10),6,8-triene			0.13	
53	204	$C_{15}H_{24}$	β-Humulene	0.37	1.10	1.29	0.52
54	204	$C_{15}H_{24}$	(-)-β-Elemene			0.81	
55	204	$C_{15}H_{24}$	1R,4S,7S,11R-2,2,4,8-Tetramethyltricyclo[5.3.1.0(4,11)]undec-8-ene			0.67	
56	204	$C_{15}H_{24}$	Berkheyaradulene			0.68	
57	206	$C_{15}H_{26}$	2,4a,8,8-Tetramethyldecahydrocyclopropa[d]naphthalene		1.37	0.48	0.57
58	202	$C_{15}H_{22}$	Cycloisolongifolene, 8,9-dehydro-	0.33			
59	204	$C_{15}H_{24}$	β-Cadinene		1.14	0.92	
60	222	$C_{15}H_{26}O$	Nerolidol 1	2.40	1.42	0.98	0.92
61	220	$C_{15}H_{24}O$	Bergamotol, Z-.alpha.-trans-				0.21
62	220	$C_{15}H_{24}O$	Cyclopenta[c]pentalen-3(3aH)-one, octahydro-1,2,3a,6-tetramethyl-				0.49
63	218	$C_{15}H_{22}O$	Aristolone				0.36
64	283	$C_{15}H_{23}Br$	3a-Bromolongifolene				1.87
65	212	$C_{15}H_{16}O$	Naphthalene, 6-methoxy-2-(1-buten-3-yl)-				0.26
66	234	$C_{15}H_{22}O_2$	Isodrimenin				0.64
67	222	$C_{15}H_{26}O$	α-Bisabolol		0.79		
68	220	$C_{15}H_{24}O$	Longifolenaldehyde	2.18	0.30	0.77	0.42
69	296	$C_{15}H_{20}O_6$	Deoxynivalenol				0.89
70	222	$C_{15}H_{26}O$	2,4,4-Trimethyl-3-hydroxymethyl-5a-(3-methyl-but-2-enyl)-cyclohexene		0.18		
71	222	$C_{15}H_{26}O$	Cedrol			0.42	
72	250	$C_{15}H_{22}O_3$	5,8-Dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone		1.17		
73	222	$C_{15}H_{26}O$	α-Caryophyllene alcohol	1.51			
74	246	$C_{15}H_{18}O_3$	α-Santonin				0.23
75	222	$C_{15}H_{26}O$	epi-10-γ-Eudesmol		0.33		
76	220	$C_{15}H_{24}O$	5.alpha.-Hydroxy-4.alpha.,8,10,11-tetramethyltricyclo[6.3.0.0(2,4)]undec-10-ene				0.20
77	264	$C_{15}H_{20}O_4$	Naphtho[1,2-b]furan-2-one, 2,3,3a,4,5,5a,6,7,9a,9b-decahydro-3,5a,9-trimethyl-7,9a-peroxy-				0.21
78	218	$C_{15}H_{22}O$	2-Butyl-1-methyl-1,2,3,4-tetrahydronaphthalen-1-ol				0.66
79	234	$C_{15}H_{22}O_2$	Bakkenolide A				2.16
80	234	$C_{15}H_{22}O_2$	Dihydrocostunolide				0.26
81	230	$C_{15}H_{18}O_2$	2,4,6-Cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (Procerin)	0.34	0.81	1.09	0.65
82	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol	0.24	0.30		

Appendix 6: Cont’d

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
83	220	$C_{15}H_{24}O$	γ-Gurjunenepoxide-(2)				0.26
84	238	$C_{15}H_{26}O_2$	7-Isopropenyl-4,4,8,8-tetramethylbicyclo[4.2.0]octane-1,5-diol				0.45
85	222	$C_{15}H_{26}O$	(-)-Isolongifolol	1.34	1.14	1.19	0.79
86	218	$C_{15}H_{22}O$	Germacrone		0.18		
87	220	$C_{15}H_{24}O$	7-Oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)-	1.74	1.10	0.98	
88	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy-	1.74	1.11	0.91	0.37
89	222	$C_{15}H_{26}O$	Drimenol	1.65	0.98	2.47	2.50
90	236	$C_{16}H_{28}O$	(-)-Isolongifolol, methyl ether	0.83			0.93
91	222	$C_{15}H_{26}O$	1-Methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane	0.15		0.20	
92	218	$C_{15}H_{22}O$	6-Isopropenyl-4,8a-dimethyl-4a,5,6,7,8,8a-hexahydro-1H-naphthalen-2-one		0.58	0.70	
93	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide	0.33	0.83	0.67	0.61
94	220	$C_{15}H_{24}O$	Bicyclo[6.3.0]undec-1(8)-en-3-one, 2,2,5,5-tetramethyl-			0.20	0.44
95	220	$C_{15}H_{24}O$	γ-Costol	0.91	0.75	0.57	0.96
96	234	$C_{15}H_{22}O_2$	Drimenin	1.14	1.61		
97	232	$C_{15}H_{20}O_2$	Furan, 2-[(2-ethoxy-3,4-dimethyl-2-cyclohexen-1-ylidene)methyl]-			0.62	
98	246	$C_{17}H_{31}B$	Isothujopsene-5,14-diylborane, B-ethyl-dihydro-	0.45			
99	290	$C_{16}H_{18}O_5$	6,8,9-Trimethoxy-2-methyl-2,3-dihydronaphtho[1,2-b]furan-2-ol				0.58
100	220	$C_{15}H_{24}O$	2-Cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)-	1.24		0.28	
101	220	$C_{15}H_{24}O$	1-Formyl-2,2,6-trimethyl-3-cis-(3-methylbut-2-enyl)-5-cyclohexene	0.10			
102	218	$C_{15}H_{22}O$	Sesquirosefuran			0.36	
103	218	$C_{15}H_{22}O$	1,2,3,4,5,6-Hexahydro-1,1,5,5-tetramethyl-2,4a-methanonaphthalen-7(4aH)-one; (Isolongifolen-9-one)			0.20	
104	228	$C_{15}H_{32}O$	Nerolidol, hexahydro-			1.84	
105	272	$C_{15}H_{12}O_5$	6H-Dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl-			0.09	0.12
106	220	$C_{15}H_{24}O$	9-Isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane			0.31	1.47
107	236	$C_{16}H_{28}O$	1-Hydroxymethyl-5,8,9-endo-10-exo-tetramethyltricyclo[6.3.0.0(5,11)]undecane		0.21		
108	236	$C_{16}H_{28}O$	1-Hydroxymethyl-3,3,7,11-tetramethyltricyclo[5.4.0.0(4,11)]undecane	0.13			
Diterpenoids							
1	272	$C_{20}H_{32}$	8-(2,6-Dimethyl-hepta-1,5-dienyl)-3,7,7-trimethyl-bicyclo[4.2.0]oct-2-ene	0.38			
2	274	$C_{20}H_{34}$	2-(Fench-2-yl)fenchane	0.25			

Appendix 6: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Diterpenoids							
	290	$C_{20}H_{34}O$	Geranyl Linalool	1.05	0.08	0.47	2.52
	290	$C_{20}H_{34}O$	Geranylgeraniol	0.60	0.10	0.03	0.34
3	290	$C_{20}H_{34}O$	Manool	2.20	0.59	0.29	0.52
4	320	$C_{20}H_{32}O_3$	Tetracyclo[5.4.3.0(7,11)]tetradecane-2.alpha.-5.beta .diol-10-one, 1,4.alpha.,6,14-tetramethyl-4-vinyl-		1.44		
5	290	$C_{20}H_{34}O$	trans-Geranylgeraniol	0.60	0.10		
6	296	$C_{20}H_{40}O$	Phytol	0.54	1.65	2.01	2.11
7	292	$C_{20}H_{36}O$	2,3-Dimethyl-5-(2,6,10-trimethylundecyl) furan	0.60			
Triterpenoids and related compounds							
1	410	$C_{30}H_{50}$	Squalene	0.64	1.68	0.16	1.32
2	410	$C_{30}H_{50}$	C(14a)-Homo-27-norgammacer-14-ene			1.33	0.99
3	410	$C_{30}H_{50}$	Supraene	0.43			
4	406	$C_{29}H_{42}O$	3-Oxatricyclo[20.8.0.0(7,16)]triaconta-1(22),7(16),9,13,23,29-hexaene		0.40		
5	426	$C_{30}H_{50}O$	1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)-			0.08	
6	424	$C_{30}H_{48}O$	Lup-20(29)-en-3-one	0.18			
7	444	$C_{30}H_{52}O_2$	Cycloartane-3.beta.,25-diol	0.09			
Hydrocarbons							
1	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl-			0.18	
2	150	$C_{11}H_{18}$	1,3-Cyclopentadiene, 1,3-bis(1-methylethyl)-	0.07			
3	180	$C_{13}H_{24}$	1,1,6,6-Tetramethylspiro[4.4]nonane			1.25	
4	180	$C_{13}H_{24}$	cis,cis-1,9-Dimethylspiro[5.5]undecane	0.52			
5	176	$C_{13}H_{20}$	5,9-Undecadien-1-yne, 6,10-dimethyl-			1.20	
6	184	$C_{13}H_{28}$	Nonane, 5-methyl-5-propyl-	0.21	0.05		
7	342	$C_{25}H_{42}$	2,6,10,14,18-Pentamethyl-2,6,10,14,18-eicosapentaene	0.32			
8	204	$C_{14}H_{24}$	Cyclohexane, 1,2-dimethyl-3,5-bis(1-methylethenyl)-, (1.alpha.,2.beta.,3.beta.,5.beta.)-		0.08		
9	150	$C_{11}H_{18}$	Tricyclo[4.4.1.0(1,6)]undecane			1.89	
10	164	$C_{12}H_{20}$	1,Z-5,E-7-Dodecatriene	1.15	1.04	0.05	1.22
11	164	$C_{12}H_{20}$	Bicyclo[2.2.2]oct-2-ene, 1,2,3,6-tetramethyl-		1.02		
12	248	$C_{18}H_{32}$	2,5,9-Tetradecatriene, 3,12-diethyl-				1.09
13	266	$C_{19}H_{38}$	1-Nonadecene	0.46	0.99		
14	176	$C_{13}H_{20}$	Bicyclo[6.3.0]undeca-1(8),9-diene, 11,11-dimethyl-		1.46		
15	176	$C_{13}H_{20}$	Cyclohexane, 1,2-diethenyl-4-(1-methylethylidene)-, cis-	1.98			
16	176	$C_{13}H_{20}$	Bicyclo[2.2.1]heptane, 2-cyclopropylidene-1,7,7-trimethyl-	2.47			
17	124	C_9H_{16}	6,6-Dimethylhepta-2,4-diene			1.81	
18	192	$C_{14}H_{24}$	Cyclohexane, 1,1-dimethyl-2,4-bis(1-methylethenyl)-, cis-	0.98			
19	252	$C_{18}H_{36}$	Cyclohexane, 1,2,3,5-tetraisopropyl-	0.86			
20	226	$C_{16}H_{34}$	Hexadecane	**5.27**	0.28		
21	190	$C_{14}H_{22}$	Cycloocta-1,3,6-triene, 2,3,5,5,8,8-hexamethyl-	0.23			
22	176	$C_{13}H_{20}$	1,3,5-Cycloheptatriene, 2,4-diethyl-7,7-dimethyl-	1.67			
23	296	$C_{21}H_{44}$	Heneicosane	1.37			

Appendix 6: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Fatty acids and derivatives							
1	210	$C_{13}H_{22}O_2$	Neryl propionate		0.35		
2	170	$C_{10}H_{18}O_2$	Cyclobutanecarboxylic acid, 2-methylbutyl ester	0.12			
3	178	$C_{10}H_{10}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-				1.39
4	278	$C_{16}H_{22}O_4$	2-Cyclohexene-1-carboxylic acid, 1-(2-methyl-3-cyclohexenecarbonyl)-, methyl ester		0.06		
5	220	$C_{13}H_{16}O_3$	Bicyclo[2.2.1]hept-2-ene-5,6-dicarboxylic anhydride, 3,4,7,7-tetramethyl, endo-				0.77
6	330	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester				0.94
7	232	$C_{13}H_{12}O_4$	Methyl 5-hydroxy-8-methoxy-1-naphthalenecarboxylate				0.73
8	280	$C_{18}H_{32}O_2$	9,12-Octadecadienoic acid (Z,Z)- (Linoleic acid)				1.73
9	172	$C_{10}H_{20}O_2$	n-Decanoic acid		1.24		**6.12**
10	214	$C_{13}H_{26}O_2$	Tridecanoic acid				**4.79**
11	284	$C_{18}H_{36}O_2$	Heptadecanoic acid, methyl ester				0.36
12	280	$C_{17}H_{28}O_3$	2,6,10-Dodecatriene, 12-acetoxy-6-hydroxymethyl-2,10-dimethyl-, (E,E)-				0.63
13	288	$C_{17}H_{20}O_4$	Bicyclo[2.2.2]oct-5-ene-2,3-dicarboxylic anhydride, 1-(3-oxo-1-butenyl)-6,7,7-trimethyl-		**3.23**		
14	344	$C_{23}H_{36}O_2$	i-Propyl 5,8,11,14,17-eicosapentaenoate		0.47		
15	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid, methyl ester				1.55
16	296	$C_{19}H_{36}O_2$	9-Octadecenoic acid (Z)-, methyl ester				0.66
17	240	$C_{15}H_{28}O_2$	Citronellyl iso-valerate	1.67			
18	298	$C_{19}H_{38}O_2$	Methyl stearate				1.02
19	370	$C_{22}H_{42}O_4$	Hexanedioic acid, bis(2-ethylhexyl) ester		0.10		
20	168	$C_{10}H_{16}O_2$	Cyclopentanecarboxylic acid, 2,4-dimethyl-3-methylene-, methyl ester	0.29			
21	258	$C_{14}H_{26}O_4$	Hexanedioic acid, mono(2-ethylhexyl)ester		0.13		
22	332	$C_{22}H_{36}O_2$	Ethyl 5,8,11,14-eicosatetraenoate		0.68		
23	480	$C_{32}H_{64}O_2$	Hexadecanoic acid, hexadecyl ester		0.16		
24	290	$C_{15}H_{14}O_6$	2-Naphthoic acid, 6-hydroxy-5,7-dimethoxy-, acetate-		0.95		
25	290	$C_{18}H_{26}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-, 2-ethylhexyl ester		0.06		
26	264	$C_{16}H_{24}O_3$	2,5,5,8a-Tetramethyl-3-oxo-3,4,4a,5,6,7,8,8a-octahydronaphthalene-1-carboxylic acid, methyl ester			0.58	
27	282	$C_{17}H_{30}O_3$	3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate	0.27			
28	242	$C_{15}H_{30}O_2$	Pentadecanoic acid	0.07			
29	248	$C_{15}H_{20}O_3$	3-Cyclopentylpropionic acid, 4-methoxyphenyl ester			0.80	
30	326	$C_{21}H_{42}O_2$	i-Propyl 16-methyl-heptadecanoate	0.65			
20	370	$C_{22}H_{42}O_4$	Hexanedioic acid, bis(2-ethylhexyl) ester		0.10		
21	258	$C_{14}H_{26}O_4$	Hexanedioic acid, mono(2-ethylhexyl)ester		0.13		
22	332	$C_{22}H_{36}O_2$	Ethyl 5,8,11,14-eicosatetraenoate		0.68		
23	480	$C_{32}H_{64}O_2$	Hexadecanoic acid, hexadecyl ester		0.16		
24	242	$C_{15}H_{30}O_2$	Pentadecanoic acid	0.07			

Appendix 6: Cont’d

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Fatty acids and derivatives							
25	290	$C_{15}H_{14}O_6$	2-Naphthoic acid, 6-hydroxy-5,7-dimethoxy-, acetate-		0.95		
26	290	$C_{18}H_{26}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-, 2-ethylhexyl ester		0.06		
28	282	$C_{17}H_{30}O_3$	3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate	0.27			
29	248	$C_{15}H_{20}O_3$	3-Cyclopentylpropionic acid, 4-methoxyphenyl ester			0.80	
30	326	$C_{21}H_{42}O_2$	i-Propyl 16-methyl-heptadecanoate	0.65			
31	270	$C_{17}H_{34}O_2$	Tetradecanoic acid, 10,13-dimethyl-, methyl ester	0.10			
32	354	$C_{21}H_{38}O_4$	Fumaric acid, decyl 3-heptyl ester			1.84	1.44
33	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester	0.26	0.98	0.37	2.29
34	256	$C_{16}H_{32}O_2$	n-Hexadecanoic acid	2.00	1.59	1.43	3.20
35	312	$C_{20}H_{40}O_2$	Hexadecanoic acid, 2-methylpropyl ester	0.09			
36	292	$C_{19}H_{32}O_2$	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-			0.75	
37	256	$C_{16}H_{16}O_3$	Guaiacyl-β-phenylpropionate	0.09			
38	284	$C_{18}H_{36}O_2$	Hexadecanoic acid, 15-methyl-, methyl ester			0.20	
39	282	$C_{18}H_{34}O_2$	9-Octadecenoic acid, (E)-			0.90	
40	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid, methyl ester			1.20	
41	296	$C_{19}H_{36}O_2$	9-Octadecenoic acid, methyl ester, (E)-			1.04	
42	284	$C_{18}H_{36}O_2$	Octadecanoic acid	1.18	0.31	0.61	0.40
43	354	$C_{22}H_{26}O_4$	Succinic acid, di(2-propylphenyl) ester			1.49	**2.91**
44	214	$C_{14}H_{30}O$	1-Tetradecanol				0.94
45	350	$C_{19}H_{26}O_6$	Propanoic acid, 2-methyl-, (dodecahydro-6a-hydroxy-9a-methyl-3-methylene-2,9-dioxoazuleno[4,5-b]furan-6-yl)methyl ester, [3aS-(3a.alpha.,6.beta.,6a.alpha.,9a.beta.,9b.alpha.)]-				0.68
46	242	$C_{16}H_{34}O$	1-Decanol, 2-hexyl-	0.20	0.09	1.22	1.98
47	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester	0.31	1.02		0.95
48	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester			0.10	0.10
Ketones and aldehydes							
1	126	$C_6H_6O_3$	5-Hydroxymethylfurfural				0.90
2	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)-			1.31	1.54
3	164	$C_{11}H_{16}O$	cis-Jasmone			0.97	
4	192	$C_{13}H_{20}O$	2-(1-Cyclopent-1-enyl-1-methylethyl)cyclopentanone		0.09		
5	206	$C_{13}H_{18}O_2$	3-Keto-β-ionone	1.39	0.98	0.14	0.86
6	166	$C_{11}H_{18}O$	Cyclohexanone, 2,5-dimethyl-2-(1-methylethenyl)-				0.87
7	124	$C_8H_{12}O$	2-Cyclopenten-1-one, 3,4,5-trimethyl-	1.84	1.18		
8	216	$C_{15}H_{20}O$	Cyclohexanone, 3,3,5-trimethyl-5-phenyl-		0.35		0.52
9	192	$C_{13}H_{20}O$	Tricyclo[6.3.0.0(1,5)]undecan-4-one, 5,9-dimethyl-				0.70
10	164	$C_{10}H_{12}O_2$	Hajos-Parrish ketone				0.20
11	194	$C_{13}H_{22}O$	α,β-Dihydro-β-ionone				0.54
12	208	$C_{13}H_{20}O_2$	1,3-Butanedione, 1-(2,6,6-trimethyl-1-cyclohexen-1-yl)-				0.98

Appendix 6: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Ketones and aldehydes							
13	208	$C_{13}H_{20}O_2$	2,10,10-Trimethyl-6-methylene-1-oxaspiro[4.5]decan-7-one			**2.89**	
14	232	$C_{16}H_{24}O$	Allyl ionone 4				0.58
15	190	$C_{13}H_{18}O$	Megastigmatrienone			0.28	
16	220	$C_{14}H_{20}O_2$	Tricyclo[5.1.0.0(3,5)]octane-2,6-dione, 1,3,4,5,7,8-hexamethyl-, stereoisomer			0.66	
17	220	$C_{15}H_{24}O$	Dimethylionone		0.87		
18	206	$C_{13}H_{18}O_2$	Ethanone, 1-(3-butyl-2-hydroxy-5-methylphenyl)-			1.79	1.77
19	202	$C_{14}H_{18}O$	11-Isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one	0.74		0.57	0.99
20	238	$C_{16}H_{30}O$	cis-9-Hexadecenal	1.01			
21	196	$C_{10}H_{12}O_4$	2-Propanone, 1-hydroxy-3-(4-hydroxy-3-methoxyphenyl)-			0.41	
22	220	$C_{14}H_{20}O_2$	p-Methoxyheptanophenone			1.93	
23	180	$C_{12}H_{20}O$	5,6,7,7-Tetramethyl-octa-3,5-dien-2-one			1.09	
24	248	$C_{16}H_{24}O_2$	4,4,5',5'-Tetramethyl-bicyclohexyl-6-ene-2,3'-dione		0.50	0.91	0.69
30	206	$C_{14}H_{22}O$	2,4,4-Trimethyl-3-(3-methylbuta-1,3-dienyl)cyclohexanone	**3.91**			
31	226	$C_{15}H_{30}O$	Pentadecanal	0.23			
32	166	$C_{10}H_{14}O_2$	Elsholtzia ketone			0.21	
33	204	$C_{14}H_{20}O$	4-(2', 4', 4'-trimethyl-yciclo[4.1.0]hept-2'-en-3'-yl)-3-buten-2-one	0.86	**3.70**		
34	284	$C_{20}H_{28}O$	Retinal	0.64			
Phytosterols							
1	472	$C_{30}H_{48}O_4$	Methyl (25rs)-3.beta.-acetoxy-5-cholesten-26-oate		0.29		
2	400	$C_{27}H_{44}O_2$	Cholesta-20,24-diene-3,6-diol, (3.beta.,5.alpha.,6.alpha.)-	0.16			
3	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)-			0.18	0.37
4	412	$C_{29}H_{48}O$	Ergosta-5,22-dien-3-ol, 24-methyl-, (3.beta.,22E)-	0.15			
5	412	$C_{29}H_{48}O$	Chondrillasterol		0.15		
6	492	$C_{31}H_{53}ClO_2$	Stigmastan-3-ol, 5-chloro-, acetate, (3.beta.,5.alpha.)-			**2.55**	
7	290	$C_{19}H_{30}O_2$	.delta.4-Androstene-3.beta.,17.beta.-diol				0.43
8	246	$C_{18}H_{30}$	d-Norandrostane (5.alpha.,14.alpha.)			0.58	
9	400	$C_{28}H_{48}O$	Cholestan-3-ol, 2-methylene-, (3.beta.,5.alpha.)-	0.65			
10	400	$C_{28}H_{48}O$	Pollinastanol	0.16	0.12		
11	414	$C_{29}H_{50}O$	Schottenol	2.12	0.06	2.08	1.24
12	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol	1.94	2.30	2.76	1.02
	454	$C_{31}H_{50}O_2$	Stigmasterol acetate	1.58	0.04	0.18	0.37
13	412	$C_{29}H_{48}O$	Stigmasta-4,22-dien-3.beta.-ol			0.09	
14	412	$C_{29}H_{48}O$	Stigmasterol	0.17	0.13		
15	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate	0.47	0.13	0.59	0.95
Tocopherols							
1	402	$C_{27}H_{46}O_2$	δ-Tocopherol	0.17	1.22	0.16	0.11
2	416	$C_{28}H_{48}O_2$	β-Tocopherol	0.17		0.16	0.11
3	430	$C_{29}H_{50}O_2$	Vitamin E	0.52	0.08	0.28	0.28

Appendix 6: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Tocopherols							
4	444	$C_{30}H_{52}O_2$	(+)-α-Tocopherol, O-methyl-	0.08			
Carbohydrate and derivatives							
1	146	$C_6H_{10}O_4$	Dianhydromannitol			1.69	1.17
2	162	$C_6H_{10}O_5$	3,4-Altrosan				0.59
3	162	$C_6H_{10}O_5$	.beta.-D-Glucopyranose, 1,6-anhydro-			0.47	
4	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside				1.42
5	270	$C_{13}H_{18}O_6$	Benzyl .beta.-d-glucoside			1.01	
6	182	$C_6H_{14}O_6$	D-Mannitol			**4.26**	
Phenols							
1	154	$C_8H_{10}O_3$	Phenol, 2,6-dimethoxy-			0.77	0.52
2	180	$C_{10}H_{12}O_3$	Coniferol				**4.96**
3	196	$C_{10}H_{12}O_4$	Phenol, 2,6-dimethoxy-, acetate				0.32
4	234	$C_{18}H_{18}$	2,5-Diphenyl-2,4-hexadiene				1.03
5	206	$C_{14}H_{22}O$	Phenol, 3,5-bis(1,1-dimethylethyl)-	0.12			
6	210	$C_{15}H_{14}O$	3-Phenylbicyclo(3.2.2)nona-3,6-dien-2-one				1.72
7	318	$C_{21}H_{34}O_2$	2-[(1R,3S)-3-Hydroxycyclohexyl]5-(2-methyloctan-2-yl)phenol				0.38
8	124	$C_7H_8O_2$	Guaiacol	3.92	1.54	1.49	1.85
Furans							
1	124	$C_7H_8O_2$	2-Acetyl-5-methylfuran	0.37	0.28	0.36	0.38
Coumarin							
1	300	$C_{17}H_{16}O_5$	Phellopterin	0.38	1.46	1.74	0.14
Pyrans							
1	144	$C_6H_8O_4$	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-			0.70	0.82
2	208	$C_{14}H_{24}O$	4H-Chromene, 4a,5,6,7,8,8a-hexahydro-2,3,5,5,8a-pentamethyl	0.31			
Benzene derivatives							
1	110	$C_6H_6O_2$	Catechol				1.11
2	228	$C_{14}H_{12}O_3$	2H,8H-Benzo[1,2-b:5,4-b']dipyran-2-one, 8,8-dimethyl-				0.15
3	206	$C_{11}H_{10}O_4$	2H-1-Benzopyran-2-one, 7-hydroxy-6-methoxy-4-methyl-		0.85		
4	192	$C_{11}H_{12}O_3$	4H-1-Benzopyran-4-one, 2,3-dihydro-7-hydroxy-2,2-dimethyl-		1.67		
5	162	$C_{12}H_{18}$	Benzene, 1-(1,1-dimethylethyl)-3-ethyl-	0.77			0.13
6	126	$C_6H_6O_3$	1,2,3-Benzenetriol			**4.60**	**2.77**
7	230	$C_{14}H_{14}O_3$	4-(6-Methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one	0.29	0.34	0.28	
8	246	$C_{18}H_{30}$	Benzene, hexaethyl-				0.97
9	220	$C_{14}H_{20}O_2$	Methyl-3-n-hexylbenzoate			1.03	
10	190	$C_{14}H_{22}$	Benzene, 1,4-bis(1,1-dimethylethyl)-			0.73	
11	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl-			2.18	**3.30**

Appendix 6: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Anthracenes /phenathracenes and derivatives							
1	200	$C_{15}H_{20}$	9-Methyl-S-octahydroanthracene				0.98
2	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl-		0.57		0.83
3	228	$C_{16}H_{20}O$	9-Acetyl-S-octahydrophenanthrene			0.11	
4	248	$C_{18}H_{16}O$	2-Acetyl-9,10-dimethylanthracene	0.10	0.99		
Alkaloids							
1	186	$C_{12}H_{14}N_2$	Tetrahydroharman	0.61			
2	295	$C_{18}H_{17}NO_3$	(+)-Mecambroline			0.33	0.10
Flavonoid							
1	252	$C_{16}H_{12}O_3$	3-Methoxyflavone				
Naphthalene and derivatives							
1	206	$C_{14}H_{22}O$	1-Naphthalenone, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl				0.51
2	216	$C_{14}H_{16}O_2$	2,3-Naphthalenedione, 1,4-dihydro-1,1,4,4-tetramethyl-	0.15	1.40		
3	248	$C_{12}H_8O_6$	1,4-Naphthalenedione, 3-acetyl-2,5,7-trihydroxy-		1.19		
4	208	$C_{13}H_{20}O_2$	2,6-Naphthalenedione, octahydro-1,1,8a-trimethyl-, trans-			0.95	
5	150	$C_{10}H_{14}O$	2(1H)-Naphthalenone, 3,4,5,6,7,8-hexahydro-		0.65		
6	248	$C_{12}H_8O_6$	1,4-Naphthoquinone, 6-acetyl-2,5,8-trihydroxy-	0.09		0.27	
Others							
1	222	$C_{15}H_{26}O$	2-Methyl-3-(3-methyl-but-2-enyl)-2-(4-methyl-pent-3-enyl)-oxetane	0.19			0.43
2	118	$C_6H_{14}O_2$	2,3-Butanediol, 2,3-dimethyl-	0.25			
3	258	$C_{16}H_{34}O_2$	1,16-Hexadecanediol	0.32			

Appendix 7: Chemical profiles of Londiani extracts

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Monoterpenoids and related compounds							
1	136	$C_{10}H_{16}$	Camphene		0.11		
2	138	$C_{10}H_{18}$	Pinane	0.28			
3	138	$C_{10}H_{18}$	Decahydroazulene, cis-				0.34
4	136	$C_{10}H_{16}$	7-Propylidene-bicyclo[4.1.0]heptane	2.58			
5	138	$C_{10}H_{18}$	Cyclopentene, 1,2,3,4,5-pentamethyl-			1.15	
6	154	$C_{10}H_{18}O$	α-Terpineol	0.26	0.03	0.36	0.98
7	152	$C_{10}H_{16}O$	Isocarveol	0.29			
8	152	$C_{10}H_{16}O$	α-Phellandrene-8-ol			0.22	
9	152	$C_{10}H_{16}O$	Pseudo-cyclocitral				0.79
10	152	$C_{10}H_{16}O$	Photocitral B			0.36	
11	164	$C_{10}H_{12}O_2$	ɣ-Thujaplicin			0.16	
12	160	$C_{12}H_{16}$	1H-Indene, 2,3-dihydro-1,1,3-trimethyl-			0.59	
13	142	$C_8H_{14}O_2$	3-Hexen-1-ol, 5-methyl-, formate, (Z)-			1.54	
14	182	$C_{11}H_{18}O_2$	1-Hydroxymethyladamantan-2-ol				0.73
15	180	$C_{12}H_{20}O$	(7R)-cis-anti-cis-Tricyclo[7.3.0.0(2,6)]dodecan-7-ol		0.14		
16	184	$C_{11}H_{20}O_2$	Cyclohexanol, 3,3,5-trimethyl-, acetate, cis-				0.23
17	144	$C_9H_{20}O$	(S)-(+)-6-Methyl-1-octanol				1.68
18	156	$C_{10}H_{20}O$	(1S,2R,5R)-(+)-Isomenthol	0.91			1.07
19	156	$C_{10}H_{20}O$	2,3,6-Trimethylhept-3-en-1-ol	1.08			
Sesquiterpenoids and related compounds							
1	204	$C_{15}H_{24}$	(-)-Zingiberene	1.67	0.14	1.37	1.23
2	204	$C_{15}H_{24}$	Isocaryophyllene				1.05
3	204	$C_{15}H_{24}$	Bergamotene	0.44	0.28	0.14	0.12
4	204	$C_{15}H_{24}$	Ylangene		0.18		
5	204	$C_{15}H_{24}$	cis-Muurola-3,5-diene	0.30	0.10		
6	204	$C_{15}H_{24}$	α-Cadinene		0.07		
7	204	$C_{15}H_{24}$	γ-Muurolene		0.86		
8	204	$C_{15}H_{24}$	7-epi-α-Cadinene		0.10		
	204	$C_{15}H_{24}$	7-epi-α-Selinene	0.26	1.80	0.59	1.01
9	204	$C_{15}H_{24}$	δ-Cadinene	0.33	0.96	0.05	0.16
10	204	$C_{15}H_{24}$	β-Bisabolene	1.49	0.20	0.99	1.82
11	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	2.07	1.42	0.98	2.12
12	204	$C_{15}H_{24}$	Cadina-1(2),4-diene		0.26		
13	202	$C_{15}H_{22}$	Cadina-1(10),6,8-triene				0.12
14	204	$C_{15}H_{24}$	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z-	0.40	0.93	0.32	0.75
15	204	$C_{15}H_{24}$	Isoledene		0.51		
16	204	$C_{15}H_{24}$	α-Cubebene	1.79	0.18	1.89	0.04
17	206	$C_{15}H_{26}$	1,4-Dihydrothujopsene-(I1)				0.48
18	204	$C_{15}H_{24}$	α-Guaiene		0.79		1.73
19	204	$C_{15}H_{24}$	Bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl-	0.29			
20	204	$C_{15}H_{24}$	Himachala-2,4-diene	2.49	0.56	1.30	0.91
21	204	$C_{15}H_{24}$	Epizonarene	0.21	0.29	1.56	0.25
22	204	$C_{15}H_{24}$	Caryophyllene	0.54	4.29	1.36	1.25

Appendix 7: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
23	204	$C_{15}H_{24}$	6S-2,3,8,8-Tetramethyltricyclo[5.2.2.0(1,6)]undec-2-ene	0.94			
24	204	$C_{15}H_{24}$	Caryophyllene-(I1)				0.50
25	200	$C_{15}H_{20}$	α-Calacorene		0.15	0.13	
26	204	$C_{15}H_{24}$	Copaene	0.47	2.42	0.38	0.34
27	204	$C_{15}H_{24}$	(+)-epi-Bicyclosesquiphellandrene		1.13		
28	206	$C_{15}H_{26}$	2,4a,8,8-Tetramethyldecahydrocyclopropa[d]naphthalene	0.83	1.02		
29	204	$C_{15}H_{24}$	γ-Elemene				0.28
30	204	$C_{15}H_{24}$	Bicyclo[5.3.0]decane, 2-methylene-5-(1-methylvinyl)-8-methyl-	0.98			
31	204	$C_{15}H_{24}$	cis-Thujopsene	0.47		1.27	
32	204	$C_{15}H_{24}$	Cycloisolongifolene	0.24	0.19	0.14	1.10
33	204	$C_{15}H_{24}$	α-Selinene		0.61	0.42	
34	204	$C_{15}H_{24}$	Berkheyaradulene	0.19			
35	204	$C_{15}H_{24}$	Caryophyleine-(I3)		1.34		
36	204	$C_{15}H_{24}$	Alloaromadendrene		1.87	0.30	
37	202	$C_{15}H_{22}$	Neoisolongifolene, 8,9-dehydro-		1.09		
38	204	$C_{15}H_{24}$	(-)-α-Panasinsen	0.93		0.47	
39	204	$C_{15}H_{24}$	β-Guaiene	0.97		**3.10**	2.34
40	204	$C_{15}H_{24}$	1R,4R,7R,11R-1,3,4,7-Tetramethyltricyclo[5.3.1.0(4,11)]undec-2-ene	0.86			
41	204	$C_{15}H_{24}$	β-Cadinene	1.49	1.66	1.09	2.91
42	202	$C_{15}H_{22}$	Calamenene	0.48	1.06	1.39	1.96
43	204	$C_{15}H_{24}$	(-)-β-Elemene			0.68	
44	202	$C_{15}H_{22}$	1,4-Methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro-	0.54	0.29		
45	204	$C_{15}H_{24}$	δ-Selinene		0.67		
46	204	$C_{15}H_{24}$	γ-Patchoulene	1.32		0.17	
47	202	$C_{15}H_{22}$	Cycloisolongifolene, 8,9-dehydro-	1.25			
48	204	$C_{15}H_{24}$	α-Chamigrene			0.18	
49	204	$C_{15}H_{24}$	β-Humulene	1.20	1.46	1.05	0.73
50	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-	0.88	0.95	0.76	0.82
51	204	$C_{15}H_{24}$	γ-Himachalene	4.88	1.09	0.12	0.68
52	204	$C_{15}H_{24}$	α-Patchoulene			0.49	
53	204	$C_{15}H_{24}$	(-)-δ-Panasinsine	1.01	0.04	1.87	0.28
54	200	$C_{15}H_{20}$	Isolongifolene, 4,5,9,10-dehydro-	0.50			
55	204	$C_{15}H_{24}$	1,2,4,8-Tetramethylbicyclo[6.3.0]undeca-2,4-diene	0.71		0.58	
56	206	$C_{15}H_{26}$	7-Octylidenebicyclo[4.1.0]heptane		0.38		
57	222	$C_{15}H_{26}O$	1,3,3-Trimethyl-2-hydroxymethyl-3,3-dimethyl-4-(3-methylbut-2-enyl)-cyclohexene		0.10		
58	222	$C_{15}H_{26}O$	(7a-Isopropenyl-4,5-dimethyloctahydroinden-4-yl)methanol				0.44
59	222	$C_{15}H_{26}O$	Cubedol	0.55			

Appendix 7: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
60	220	$C_{15}H_{24}O$	Bicyclo[6.3.0]undec-1(8)-en-3-one, 2,2,5,5-tetramethyl-				0.35
61	220	$C_{15}H_{24}O$	Cyclopenta[c]pentalen-3(3aH)-one, octahydro-1,2,3a,6-tetramethyl-				0.53
62	220	$C_{15}H_{24}O$	9-Isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane	1.38	**3.15**	1.64	1.52
63	220	$C_{15}H_{24}O$	7-Oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)-		0.47		0.54
64	222	$C_{15}H_{26}O$	Nerolidol 2	0.01	0.82	0.32	1.03
65	228	$C_{15}H_{16}O_2$	Mansonone C		0.14		
66	282	$C_{15}H_{23}Br$	Neoisolongifolene, 8-bromo-	1.37			
67	222	$C_{15}H_{26}O$	Humulane-1,6-dien-3-ol				0.43
68	216	$C_{15}H_{20}O$	1H-Inden-1-one, 5-(1,1-dimethylethyl)-2,3-dihydro-3,3-dimethyl-		0.90		
69	220	$C_{15}H_{24}O$	Spiro[4.5]dec-6-en-8-one, 1,7-dimethyl-4-(1-methylethyl)-	0.46			
70	220	$C_{15}H_{24}O$	Copaen-15-ol		**9.83**		
71	234	$C_{15}H_{22}O_2$	Cyclodeca[b]furan-2(3H)-one, 3a,4,5,8,9,11a-hexahydro-3,6,10-trimethyl-, [3S-(3R*,3aR*,6E,10E,11aR*)]-(Dihydrocostunolide)				0.22
72	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy-	2.21	1.00	0.04	1.91
73	220	$C_{15}H_{24}O$	γ-Costol	0.34	0.09	1.14	0.10
74	222	$C_{15}H_{26}O$	1,3a-Ethano(1H)inden-4-ol, octahydro-2,2,4,7a-tetramethyl-				0.35
75	202	$C_{15}H_{22}$	4,4-Dimethyl-3-(3-methylbut-3-enylidene)-2-methylenebicyclo[4.1.0]heptane		0.50		
76	232	$C_{15}H_{20}O_2$	Furan, 2-[(2-ethoxy-3,4-dimethyl-2-cyclohexen-1-ylidene)methyl]-			0.90	
77	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol	0.10		0.30	0.23
78	220	$C_{15}H_{24}O$	β-Santalol	0.83	0.10	0.98	
79	204	$C_{15}H_{24}O$	(-)-Aristolene		1.57		
80	218	$C_{15}H_{22}O$	9H-Cycloisolongifolene, 8-oxo-	1.44			
81	214	$C_{15}H_{18}O$	3a,9b-Dimethyl-1,2,3a,4,5,9b-hexahydrocyclopenta[a]naphthalen-3-one			0.70	
82	220	$C_{15}H_{24}O$	Longifolenaldehyde	1.37	1.03	1.94	0.6
83	220	$C_{15}H_{24}O$	γ-Gurjunene poxide (2)	0.78			
84	218	$C_{15}H_{22}O$	Neoisolongifolene, 8-oxo-			0.66	
85	222	$C_{15}H_{26}O$	trans-Farnesol			0.17	
86	218	$C_{15}H_{22}O$	1s,4R,7R,11R-1,3,4,7-Tetramethyltricyclo[5.3.1.0(4,11)]undec-2-en-8-one			0.82	
87	222	$C_{15}H_{24}O$	Drimenol	2.08	0.34	0.06	1.85
88	222	$C_{15}H_{26}O$	Germacrene D-4-ol			0.42	
89	218	$C_{15}H_{22}O$	β-Elemenone	0.31			
90	264	$C_{17}H_{28}O_2$	Farnesol, acetate	0.63			
91	248	$C_{15}H_{20}O_3$	Confertin		0.20	0.81	
92	222	$C_{15}H_{26}O$	(-)-Isolongifolol	1.31	0.18	1.30	1.09

Appendix 7: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
93	250	$C_{15}H_{22}O_3$	5,8-Dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone	2.90	1.24		0.21
94	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a,6,7,8,9,9a-decahydro-6,6,9a-trimethyl			1.95	0.88
95	230	$C_{15}H_{18}O_2$	2,4,6-Cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (Procerin)	1.49	1.56	1.37	1.91
96	218	$C_{15}H_{22}O$	6-(1,3-Dimethyl-buta-1,3-dienyl)-1,5,5-trimethyl-7-oxa-bicyclo[4.1.0]hept-2-ene			0.67	
97	222	$C_{15}H_{26}O$	1-Methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane	0.24			
98	234	$C_{15}H_{22}O_2$	Bakkenolide A			1.05	
99	246	$C_{15}H_{18}O_3$	α-Santonin	0.48		0.17	
100	248	$C_{15}H_{20}O_3$	1,3,4,4a.beta.,5,6,8,9-Octahydro-4a-hydroxy-6,6,8b-trimethylazuleno(5,6-c)furan-3-one		0.25	0.18	
101	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide	0.16	0.69	2.80	1.75
102	220	$C_{15}H_{24}O$	5.alpha.-Hydroxy-4.alpha.,8,10,11-tetramethyltricyclo[6.3.0.0(2,4)]undec-10-ene			0.84	0.19
103	214	$C_{15}H_{18}O$	5,7,7-Trimethyl-4,5,7,8-tetrahydroazuleno[4,5-c]furan		0.19	0.05	0.04
104	264	$C_{16}H_{24}O_3$	Bicyclo[4.1.0]heptan-2-ol, 1.beta.-(3-methyl-1,3-butadienyl)-2.alpha.,6.beta.-dimethyl-3.beta.-acetoxy-			0.72	
105	248	$C_{18}H_{32}$	1H-Indene, 1-(1,5-dimethyl-2-hexenyl)octahydro-7a-methyl-, [1R-[1.alpha.(1R*,2Z),3a.beta.,7a.alpha.]]-	1.21			
106	228	$C_{16}H_{20}O$	As-Indacen-1(2H)-one, 3,6,7,8-tetrahydro-3,3,6,6-tetramethyl-				0.23
107	272	$C_{15}H_{12}O_5$	6H-Dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl-			0.06	0.10
108	308	$C_{18}H_{28}O_4$	1(2H)-Phenanthrenone, 7-(acetyloxy)dodecahydro-8a-hydroxy-2,4b-dimethyl-, [2S-(2.alpha.,4a.alpha.,4b.beta.,7.beta.,8a.alpha.,10a.beta.)]-				1.86
109	234	$C_{15}H_{22}O_2$	7-(1,3-Dimethylbuta-1,3-dienyl)-1,6,6-trimethyl-3,8-dioxatricyclo[5.1.0.0(2,4)]octane			0.18	
110	248	$C_{17}H_{28}O$	Podocarp-13-en-12-ol		1.11		
Diterpenoids							
1	272	$C_{20}H_{32}$	(+)-Beyerene	2.58			
2	272	$C_{20}H_{32}$	2,6,11,15-Tetramethyl-hexadeca-2,6,8,10,14-pentaene			0.54	0.26
3	308	$C_{20}H_{36}O_2$	Z,E-3,13-Octadecadien-1-ol acetate				0.42
4	290	$C_{20}H_{34}O$	Geranylgeraniol	0.91	0.92	1.32	1.33
5	290	$C_{20}H_{34}O$	Grindelene		2.33		
6	292	$C_{20}H_{36}O$	1-Naphthalenepropanol, .alpha.-ethyldecahydro-.alpha.,5,5,8a-tetramethyl-2-methylene-, [1S-[1.alpha.(S*),4a.beta.,8a.alpha.]]- (Dihydro-manool)		0.12		

Appendix 7: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Diterpenoids							
7	296	$C_{20}H_{40}O$	Phytol	1.25	1.04	0.06	0.96
8	290	$C_{20}H_{34}O$	Manool	0.47	1.04	2.04	2.24
9	290	$C_{20}H_{34}O$	Geranyl linalool	0.39	1.35	0.70	0.95
Sesterpenoid							
1	366	$C_{25}H_{34}O_2$	3-(7-Hydroxy-4b-methyl-2-methylenetetradecahydrophenanthren-1-yl)-1-phenylpropan-1-one			0.39	
Triterpenoids							
1	410	$C_{30}H_{50}$	C(14a)-Homo-27-norgammacer-14-ene				1.59
2	410	$C_{30}H_{50}$	Squalene	1.04	0.14	0.09	0.76
3	426	$C_{30}H_{50}O$	1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)-			0.25	0.20
4	444	$C_{30}H_{52}O_2$	Cycloartane-3.beta.,25-diol	0.07			
Hydrocarbons							
1	162	$C_{12}H_{18}$	cis-syn-trans-Tricyclo[7.3.0.0(2,6)]dodec-7-ene				0.41
2	192	$C_{14}H_{24}$	Cyclohexane, 1,2-dimethyl-3,5-bis(1-methylethenyl)-, (1.alpha.,2.beta.,3.beta.,5.beta.)-	0.45	0.13	1.68	1.16
3	164	$C_{12}H_{20}$	Bicyclo[2.2.2]oct-2-ene, 1,2,3,6-tetramethyl-		0.82		
4	176	$C_{13}H_{20}$	Cyclohexane, 1,2-diethenyl-4-(1-methylethylidene)-, cis-			2.61	
5	184	$C_{14}H_{16}$	3-Methyl-7-phenylhepta-1,3,4-triene		1.27		
6	178	$C_{12}H_{18}O$	7,8-Epoxy-trans-syn-cis-tricyclo[7.3.0.0(2,6)]dodecane, (+-) (7S,8R)-		0.32		
7	178	$C_{12}H_{18}O$	1-Methyl-6-(3-methylbuta-1,3-dienyl)-7-oxabicyclo[4.1.0]heptane		0.19		
8	190	$C_{14}H_{22}$	Tetracyclo[7.3.1.0(2,7).1(7,11)]tetradecane	1.11			
9	162	$C_{12}H_{18}$	Bicyclo[2.2.2]octa-2,5-diene, 1,2,3,6-tetramethyl-			0.88	
10	176	$C_{13}H_{20}$	Bicyclo[6.3.0]undeca-1(8),9-diene, 11,11-dimethyl-		0.51		
11	150	$C_{11}H_{18}$	Cis-8-methyl-exo-tricyclo[5.2.1.0(2.6)]decane				1.51
12	386	$C_{28}H_{50}$	13,15-Octacosadiyne				1.30
13	124	C_9H_{16}	6,6-Dimethylhepta-2,4-diene		1.63		
14	176	$C_{13}H_{20}$	Cyclohexene, 1,3-diisopropenyl-6-methyl-	0.47			
15	196	$C_{14}H_{28}$	Cyclohexane, 1,2,4,5-tetraethyl-, (1.alpha.,2.alpha.,4.alpha.,5.alpha.)-		0.83		
16	188	$C_{14}H_{20}$	1,3-Cyclohexadiene, 2,6,6-trimethyl-1-(3-methyl-1,3-butadienyl)-	0.27			
17	188	$C_{14}H_{20}$	Pentacyclo[7.5.0.0(2,8).0(5,14).0(7,11)]tetradecane	1.05	1.16		
18	266	$C_{19}H_{38}$	1-Nonadecene		0.34	1.02	
19	188	$C_{14}H_{20}$	Cyclopentane-3'-spirotricyclo[3.1.0.0(2,4)]hexane-6'-spirocyclopentane	0.74			
20	226	$C_{16}H_{34}$	Hexadecane	**3.05**	0.84		0.29
21	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl-	0.15	0.29		
22	296	$C_{21}H_{44}$	Heneicosane	1.60			
23	234	$C_{17}H_{30}$	3-Heptadecen-5-yne, (Z)-			1.52	
	164	$C_{12}H_{20}$	1,Z-5,E-7-Dodecatriene	2.07	1.42	0.98	0.97

Appendix 7: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Fatty acids and derivatives							
1	238	$C_{15}H_{26}O_2$	Neryl (S)-2-methylbutanoate	0.17			
2	196	$C_{12}H_{20}O_2$	Nerol acetate	1.25			
3	172	$C_{10}H_{20}O_2$	n-Decanoic acid	0.13			1.01
4	198	$C_{12}H_{22}O_2$	2-Propenoic acid, 2-methyl-, octyl ester	0.48			
5	214	$C_{14}H_{30}O$	1-Tetradecanol		0.66		0.53
6	242	$C_{16}H_{34}O$	1-Decanol, 2-hexyl-	0.77	0.34	0.89	0.94
7	170	$C_{10}H_{18}O_2$	Cyclobutanecarboxylic acid, 2-methylbutyl ester	0.22			
8	218	$C_{14}H_{18}O_2$	1H-Indene-4-carboxylic acid, 2,3-dihydro-1,1-dimethyl-, ethyl ester				0.56
9	292	$C_{19}H_{32}O_2$	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-				1.15
10	212	$C_{13}H_{24}O_2$	Citronellyl propionate				0.50
11	290	$C_{19}H_{30}O_2$	9,12-Octadecadiynoic acid, methyl ester	**3.37**			
12	230	$C_{15}H_{18}O_2$	2,3-Pentadienoic acid, 2-ethyl-4-phenyl-, ethyl ester		2.32		
13	330	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester				1.43
14	354	$C_{23}H_{46}O_2$	Docosanoic acid, methyl ester				0.13
15	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid (Z,Z)-, methyl ester				0.80
16	282	$C_{17}H_{30}O_3$	3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate	0.19		1.24	
17	298	$C_{19}H_{38}O_2$	Methyl stearate				0.37
18	280	$C_{18}H_{32}O_2$	9,12-Octadecadienoic acid (Z,Z)- (Linoleic acid)				0.68
19	270	$C_{17}H_{34}O_2$	i-Propyl 12-methyl-tridecanoate		0.24		
20	168	$C_{10}H_{16}O_2$	2-Butenoic acid, 3-hexenyl ester, (E,Z)-		0.47		
21	332	$C_{22}H_{36}O_2$	2,6,10,14-Hexadecatetraen-1-ol, 3,7,11,15-tetramethyl-, acetate, (E,E,E)-	0.47			
22	240	$C_{15}H_{28}O_2$	Citronellyl iso-valerate	1.01		1.07	
23	480	$C_{32}H_{64}O_2$	Hexadecanoic acid, hexadecyl ester		0.20		
24	302	$C_{20}H_{30}O_2$	5,8,11,14,17-Eicosapentaenoic acid	0.32			
25	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester	0.29	0.09	1.03	0.58
26	270	$C_{17}H_{34}O_2$	Tetradecanoic acid, 10,13-dimethyl-, methyl ester	0.08			
27	256	$C_{16}H_{32}O_2$	n-Hexadecanoic acid	0.97	1.44	1.94	0.47
28	250	$C_{16}H_{26}O_2$	Acetate, (2,4a,5,8a-tetramethyl-1,2,3,4,4a,7,8,8a-octahydro-1-naphthalenyl) ester			0.77	
29	298	$C_{19}H_{38}O_2$	i-Propyl 14-methyl-pentadecanoate	0.16	0.22		
30	284	$C_{18}H_{36}O_2$	Octadecanoic acid	0.14	0.02	1.52	1.59
31	354	$C_{21}H_{38}O_4$	Fumaric acid, decyl 3-heptyl ester			1.40	1.42
32	354	$C_{23}H_{46}O_2$	Methyl 20-methyl-heneicosanoate			0.06	
33	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester			0.19	0.16
34	230	$C_{15}H_{18}O_2$	2,3-Hexadienoic acid, 2-methyl-4-phenyl-, ethyl ester			2.08	
35	206	$C_{11}H_{10}O_4$	6-Methoxy-3-methyl-2-benzofurancarboxylic acid				0.28
36	296	$C_{22}H_{32}$	Cyclodecacyclotetradecene, 14,15-didehydro-1,4,5,8,9,10,11,12,13,16,17,18,19,20-tetradecahydro-	2.14			
37	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester		2.24	2.37	**5.27**

Appendix 7: Cont’d

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Fatty acids and derivatives							
38	330	$C_{22}H_{34}O_2$	Ethyl 5,8,11,14,17-icosapentaenoate	0.45			
Ketones and aldehydes							
1	126	$C_6H_6O_3$	5-Hydroxymethylfurfural			1.22	0.94
2	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)-			0.64	0.83
3	226	$C_{15}H_{30}O$	Pentadecanal	0.30			
4	170	$C_{12}H_{10}O$	2-Naphthyl methyl ketone				1.01
5	178	$C_{12}H_{18}O$	2-Propanone, 1-(3,5,5-trimethyl-2-cyclohexen-1-ylidene)-, (E)-				0.49
6	164	$C_{11}H_{16}O$	cis-Jasmone			1.58	
7	206	$C_{13}H_{18}O_2$	4,4-Dimethyltricyclo(6.3.0.0(1,7))undecane-2,6-dione		0.17		
8	216	$C_{15}H_{20}O$	Cyclohexanone, 3,3,5-trimethyl-5-phenyl-		0.53		0.45
9	190	$C_{13}H_{18}O$	Megastigmatrienone				0.73
10	164	$C_{11}H_{16}O$	Tricyclo[7.1.0.0[1,3]]decane-2-carbaldehyde		0.94		
11	166	$C_{11}H_{18}O$	Cyclohexanone, 2,5-dimethyl-2-(1-methylethenyl)-				1.23
12	206	$C_{14}H_{22}O$	4-Camphenylbutan-2-one				1.95
13	208	$C_{13}H_{20}O_2$	1,3-Butanedione, 1-(2,6,6-trimethyl-1-cyclohexen-1-yl)-			2.79	
14	272	$C_{20}H_{16}O$	2-Methyl-2-p-tolyl-1-acenaphthenone				0.18
15	230	$C_{14}H_{14}O_3$	1-Methoxy-5-methyl-5-phenyl-7-oxabicyclo[4.1.0]hept-3-en-2-one		1.30		
16	196	$C_{12}H_{20}O_2$	4-Hydroxy-4-(4,6-dimethylcyclohex-3-enyl)butan-2-one			1.21	
17	206	$C_{13}H_{18}O_2$	3-Keto-β-ionone	0.39	0.26	0.52	1.06
18	124	$C_8H_{12}O$	2-Cyclopenten-1-one, 2,3,4-trimethyl-		0.74	0.37	0.63
19	248	$C_{16}H_{24}O_2$	4,4,5',5'-Tetramethyl-bicyclohexyl-6-ene-2,3'-dione		0.63		0.73
20	202	$C_{14}H_{18}O$	Cinnamaldehyde, .alpha.-pentyl-	0.22			
21	164	$C_{11}H_{16}O$	4-Isopropyl-3,4-dimethylcyclohexa-2,5-dienone	2.76			
22	192	$C_{13}H_{20}O$	Tricyclo[6.3.0.0(1,5)]undecan-4-one, 5,9-dimethyl-			0.69	0.78
23	202	$C_{14}H_{18}O$	11-Isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one	2.89	0.88		
24	204	$C_{14}H_{20}O$	4-(2,7,7-Trimethylbicyclo[3.2.0]hept-2-en-1-yl)but-3-en-2-one		1.64		
25	206	$C_{14}H_{22}O$	3-Ethyl-4,4-dimethyl-2-(2-methylpropenyl)cyclohex-2-enone			1.67	
26	206	$C_{13}H_{18}O_2$	Ethanone, 1-(3-butyl-2-hydroxy-5-methylphenyl)-			1.39	
27	206	$C_{14}H_{22}O$	2,4,4-Trimethyl-3-(3-methylbuta-1,3-dienyl)cyclohexanone	2.01	1.63		
28	204	$C_{14}H_{20}O$	3-Isopropyl-tricyclo[4.3.1.1(2,5)]undec-3-en-10-one	**3.06**			
Phytosterols							
1	404	$C_{24}H_{36}O_5$	Pregnan-20-one, 3-(acetyloxy)-5,6-epoxy-17-hydroxy-16-methyl-, (3.beta.,5.alpha.,6.alpha.,16.alpha.)-		0.37		
2	410	$C_{29}H_{46}O$	Cycloprop[7,8]ergost-22-en-3-one, 3',7-dihydro-, (5.alpha.,7.beta.,8.alpha.,22E)-		0.45		

Appendix 7: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Phytosterols							
3	414	$C_{29}H_{50}O$	Schottenol	0.05	0.39	1.79	0.59
4	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)-			0.35	0.33
	454	$C_{31}H_{50}O_2$	Stigmasterol acetate	0.39	0.67	0.48	0.28
5	318	$C_{21}H_{34}O_2$	Androstan-17-one, 3-ethyl-3-hydroxy-, (5.alpha.)-	1.17			0.40
6	288	$C_{20}H_{32}O$	5-.alpha.-Androst-2-en-17-.beta.-ol, 17-methyl-				0.20
7	400	$C_{28}H_{48}O$	α-Ergostenol				0.07
8	440	$C_{31}H_{52}O$	9,19-Cyclolanostan-3-ol, 24-methylene-, (3.beta.)-	0.21			
9	272	$C_{19}H_{28}O$	Androst-1-en-3-one, (5.alpha.)-	2.35			
10	394	$C_{29}H_{46}$	Stigmastan-3,5,22-trien	0.25			
11	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol	1.09	0.98	3.11	0.49
12	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate	1.04	2.03	1.08	0.01
13	290	$C_{19}H_{30}O_2$	Androstenediol			0.27	
Tocopherols							
1	416	$C_{28}H_{48}O_2$	β-Tocopherol	0.08	0.48	0.97	1.40
2	430	$C_{29}H_{50}O_2$	dl-.alpha.-Tocopherol				0.24
3	430	$C_{29}H_{50}O_2$	Vitamin E	0.45	0.10	0.47	0.59
4	444	$C_{30}H_{52}O_2$	(+)-.alpha.-Tocopherol, O-methyl-	0.04			
Carbohydrate and derivatives							
1	162	$C_6H_{10}O_5$	1,6-Anhydro-.beta.-d-talopyranose				0.74
2	146	$C_6H_{10}O_4$	Dianhydromannitol			1.14	1.53
3	122	$C_4H_{10}O_4$	dl-Threitol				1.32
4	200	$C_{10}H_{16}O_4$	d-Ribo-tetrofuranose, 4-c-cyclopropyl-1,2-O-isopropylidene-, .alpha.-	0.23			
5	166	$C_6H_{14}O_5$	6-Desoxy-l-altritol				3.02
6	162	$C_6H_{10}O_5$	3,4-Altrosan				0.58
7	162	$C_6H_{10}O_5$	.beta.-D-Glucopyranose, 1,6-anhydro-			0.98	1.27
8	182	$C_6H_{14}O_6$	D-Mannitol			1.25	
9	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside			0.60	0.22
10	270	$C_{13}H_{18}O_6$	Benzyl .beta.-d-glucoside			0.56	
Phenols							
1	154	$C_8H_{10}O_3$	Phenol, 3,4-dimethoxy-				0.57
2	188	$C_{14}H_{20}$	Biphenylene, 1,2,3,6,7,8,8a,8b-octahydro-4,5-dimethyl-		1.06		0.44
3	124	$C_7H_8O_2$	Guaiacol	0.23	0.58	1.48	2.05
4	180	$C_{10}H_{12}O_3$	Coniferol			1.03	
5	318	$C_{21}H_{34}O_2$	2-[(1R,3S)-3-Hydroxycyclohexyl]5-(2-methyloctan-2-yl)phenol			0.64	0.68
6	210	$C_{15}H_{14}O$	3-Phenylbicyclo(3.2.2)nona-3,6-dien-2-one			1.14	
Furan							
1	124	$C_7H_8O_2$	2-Acetyl-5-methylfuran	1.40	0.78	1.09	2.99
Coumarins							
1	300	$C_{17}H_{16}O_5$	Phellopterin	0.40	0.93	0.32	0.75
2	204	$C_{13}H_{16}O_2$	4,4,5,8-Tetramethyl-chroman-2-one		2.69		
Pyrans							
1	144	$C_6H_8O_4$	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-			0.88	1.14

Appendix 7: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Pyrans							
2	212	$C_{13}H_{24}O_2$	2H-Pyran-2-one, tetrahydro-6-octyl-	0.24			
Benzene derivatives							
1	160	$C_{12}H_{16}$	Benzene, 1,3,5-trimethyl-2-(1-methylethenyl)-			0.73	
2	122	$C_7H_6O_2$	1,3-Benzodioxole			1.44	
3	126	$C_6H_6O_3$	1,2,3-Benzenetriol			1.28	**4.07**
4	230	$C_{14}H_{14}O_3$	4-(6-Methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one		1.41	0.13	0.25
5	220	$C_{14}H_{20}O_2$	Methyl-3-n-hexylbenzoate			1.62	
6	246	$C_{18}H_{30}$	Benzene, hexaethyl-			2.66	1.77
7	372	$C_{22}H_{28}O_5$	2,4a-Epidioxy-4a,5,6,7,8,8a-hexahydro-2-[2-benzoyloxypropyl]-5,5,8a-trimethylbenzopyrane				1.27
8	192	$C_{11}H_{12}O_3$	4H-1-Benzopyran-4-one, 2,3-dihydro-7-hydroxy-2,2-dimethyl-				0.53
9	228	$C_{14}H_{12}O_3$	2H,8H-Benzo[1,2-b:5,4-b']dipyran-2-one, 8,8-dimethyl-			0.43	
10	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl-			1.27	2.26
11	226	$C_{15}H_{14}O_2$	Benzeneacetic acid, .alpha.-phenyl-, methyl ester			0.22	
12	202	$C_{15}H_{22}$	1,3.4-Trimethyl-6-cyclohexylbenzene	0.76			
Anthracenes /phenathracenes and derivatives							
1	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl-	0.16	1.12	0.75	1.13
2	248	$C_{18}H_{16}O$	2-Acetyl-9,10-dimethylanthracene		1.05		
3	200	$C_{15}H_{20}$	9-Methyl-S-octahydrophenanthrene	1.33		0.83	1.10
4	228	$C_{16}H_{20}O$	9-Acetyl-S-octahydrophenanthrene	0.19			
Alkaloids and flavonoids							
1	212	$C_{13}H_{12}N_2O$	Harmine			0.12	
2	295	$C_{18}H_{17}NO_3$	(+)-Mecambroline				0.05
Naphthalene and derivatives							
1	216	$C_{14}H_{16}O_2$	2,3-Naphthalenedione, 1,4-dihydro-1,1,4,4-tetramethyl-		0.28		
2	232	$C_{12}H_8O_5$	1,4-Naphthoquinone, 6-acetyl-2,5-dihydroxy-		0.33		
3	162	$C_{12}H_{18}$	6,7-Dimethyl-1,2,3,5,8,8a-hexahydronaphthalene	0.64			
4	190	$C_{12}H_{14}O_2$	1,4-Naphthalenedione, 1,4,4a,5,8,8a-hexahydro-2,8a-dimethyl				1.16
5	248	$C_{12}H_8O_6$	1,4-Naphthoquinone, 6-acetyl-2,5,8-trihydroxy-		1.03		
6	188	$C_{14}H_{20}$	Naphthalene, 1,2,3,4-tetrahydro-1-methyl-8-(1-methylethyl)-	0.16			
Others							
1	144	$C_6H_8O_4$	Cyclobuta[1,2-d:3,4-d']bis[1,3]dioxole, tetrahydro-, (3a.alpha.,3b.alpha.,6a.alpha.,6b.alpha.)-	0.26			
2	192	$C_8H_{16}O_5$	2-[2-[2-Methoxyethoxy]ethoxy-1,3-dioxalane			1.43	
3	226	$C_{14}H_{26}O_2$	2,4,7,9-Tetramethyl-5-decyn-4,7-diol				1.27
4	192	$C_{13}H_{20}O$	(2S,6R,7S,8E)-(+)-2,7-Epoxy-4,8-megastigmadiene		0.32		
5	258	$C_{16}H_{34}O_2$	1,16-Hexadecanediol	0.31			

Appendix 8: Chemical profiles of Rumuruti extracts

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Monoterpenoids and related compounds							
1	136	$C_{10}H_{16}$	Tricyclo[4.3.1.0(2,5)]decane			1.18	
2	138	$C_{10}H_{18}$	Bicyclo[2.2.1]heptane, 1,3,3-trimethyl-			0.39	
3	154	$C_{10}H_{18}O$	α-Terpineol	0.12	1.25	0.84	0.09
4	150	$C_{10}H_{14}O$	Pinocarvone	0.13			
5	152	$C_{10}H_{16}O$	Carveol		0.24		
6	162	$C_{10}H_{10}O_2$	1(3H)-Isobenzofuranone, 3,3-dimethyl-	0.22			
7	150	$C_{10}H_{14}O$	Cinerone			2.17	
8	196	$C_{12}H_{20}O_2$	α-Terpinyl acetate		0.13		
9	154	$C_{10}H_{18}O$	Rose oxide	1.11			
10	166	$C_{11}H_{18}O$	β-Homocyclocitral			0.37	
11	182	$C_{10}H_{14}O_3$	1(3H)-Isobenzofuranone, 3a,4,5,7a-tetrahydro-4-hydroxy-3a,7a-dimethyl-, (3a.alpha.,4.beta.,7a.alpha.)-(.+/-.)-				0.29
12	156	$C_{10}H_{20}O$	Cyclohexanol, 3-methyl-2-(1-methylethyl)-, (1.alpha.,2.alpha.,3.alpha.)-	1.01			
13	152	$C_{10}H_{16}O$	Teresantalol			0.56	
14	152	$C_{10}H_{16}O$	p-Mentha-1(7),8-dien-2-ol			0.62	
15	158	$C_{10}H_{22}O$	Tetrahydrolavandulol	0.17			
16	168	$C_{11}H_{20}O$	Cyclopentanol, 3-methyl-2-(2-pentenyl)-	2.70			
17	152	$C_{10}H_{16}O$	3-Cyclohexene-1-carboxaldehyde, 1,3,4-trimethyl-	1.73			
18	184	$C_{11}H_{20}O_2$	Cyclohexanol, 3,3,5-trimethyl-, acetate, cis-			0.53	
19	156	$C_{10}H_{20}O$	(1S,2R,5R)-(+)-Isomenthol	1.04		0.61	
Sesquiterpenoids and related compounds							
1	204	$C_{15}H_{24}$	α-Cubebene	0.76	1.07	2.01	1.03
2	204	$C_{15}H_{24}$	(-)-Zingiberene	1.94	1.76	0.36	0.16
3	204	$C_{15}H_{24}$	Clovene		0.10		
4	204	$C_{15}H_{24}$	Bicyclo[4.3.0]nonane, 7-methylene-2,4,4-trimethyl-2-vinyl-	0.32			
5	204	$C_{15}H_{24}$	Guaia-1(10),11-diene		0.25		
6	204	$C_{15}H_{24}$	β-Bisabolene	0.22	1.03	0.39	1.00
7	204	$C_{15}H_{24}$	α-Bergamotene	0.97	2.39	3.42	1.57
8	202	$C_{15}H_{22}$	Cadina-1(10),6,8-triene				0.09
9	204	$C_{15}H_{24}$	δ-Cadinene	0.52	1.33	1.71	1.97
10	204	$C_{15}H_{24}$	α-Copaene	1.12	0.37	0.39	0.42
11	204	$C_{15}H_{24}$	α-Guaiene		0.10		
12	204	$C_{15}H_{24}$	Caryophyllene	0.99	0.48	1.11	0.42
13	204	$C_{15}H_{24}$	Cadina-1(2),4-diene	0.12			
14	204	$C_{15}H_{24}$	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-		0.58		
15	208	$C_{15}H_{28}$	1H-Indene, octahydro-2,2,4,4,7,7-hexamethyl-, trans-		0.54		
16	204	$C_{15}H_{24}$	7-epi-α-Selinene	1.21	0.95	1.89	0.90
17	202	$C_{15}H_{22}$	Isolongifolene, 9,10-dehydro-	0.10			
18	204	$C_{15}H_{24}$	Acoradiene			0.69	
19	204	$C_{15}H_{24}$	α-Cadinene	0.26			
20	204	$C_{12}H_{24}$	α-Chamigrene		0.32		

Appendix 8: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Sesquiterpenoids and related compounds							
21	204	$C_{15}H_{24}$	Bicyclo[5.2.0]nonane, 2-methylene-4,8,8-trimethyl-4-vinyl-	1.19	0.46	0.29	0.27
22	204	$C_{15}H_{24}$	α-Muurolene	0.06			
23	204	$C_{15}H_{24}$	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl-, Z,Z,Z-	0.89	2.49	0.37	1.45
24	204	$C_{15}H_{24}$	Isoledene	0.22			
25	204	$C_{15}H_{24}$	β-Cadinene	0.04	1.78	019	2.82
26	198	$C_{15}H_{18}$	Cadalene	0.07			
27	204	$C_{15}H_{22}$	Calamenene	0.29	1.45	0.92	1.02
28	202	$C_{15}H_{22}$	Neoisolongifolene, 8,9-dehydro-		1.47		
29	204	$C_{15}H_{24}$	α-Selinene		0.33		
30	204	$C_{15}H_{24}$	Alloaromadendrene		**9.69**		0.57
31	204	$C_{15}H_{24}$	(-)-α-Neoclovene	2.99			
32	204	$C_{15}H_{24}$	cis-Thujopsene	1.27		0.14	0.55
33	200	$C_{15}H_{20}$	α-Calacorene	0.12			
34	204	$C_{15}H_{24}$	β-Selinene		1.97		
35	206	$C_{15}H_{26}$	2,4a,8,8-Tetramethyldecahydrocyclopropa[d]naphthalene	0.87	1.37		
36	204	$C_{15}H_{24}$	1,2,4,8-Tetramethylbicyclo[6.3.0]undeca-2,4-diene		0.70		
37	202	$C_{15}H_{22}$	Aromadendrene, dehydro-		1.73		0.33
38	206	$C_{15}H_{26}$	1H-Cycloprop[e]azulene, decahydro-1,1,4,7-tetramethyl-, [1aR-(1a.alpha.,4.beta.,4a.beta.,7.beta., 7a.beta.,7b.alpha.)]-; (Ledane)		**4.06**		
39	212	$C_{15}H_{32}$	Farnesane	0.28			
40	204	$C_{15}H_{24}$	γ-Elemene		2.44	1.05	
41	208	$C_{15}H_{28}$	Fukinane			2.72	
42	210	$C_{15}H_{30}$	Germacrene B			0.95	
43	204	$C_{15}H_{24}$	Cycloisolongifolene	1.07	0.27	3.02	0.27
44	204	$C_{15}H_{24}$	Isocaryophillene	0.25			
45	202	$C_{15}H_{22}$	1,4-Methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro-	0.92			0.45
46	204	$C_{15}H_{24}$	β-Patchoulene	**3.50**			
47	202	$C_{15}H_{22}$	Cycloisolongifolene, 8,9-dehydro-	0.36			
48	204	$C_{15}H_{24}$	Caryophyleine-(I3)	0.49			
49	204	$C_{15}H_{24}$	Himachala-2,4-diene	0.99	1.75	0.77	1.96
50	204	$C_{15}H_{24}$	β-Humulene	1.04	1.19	1.01	0.87
51	204	$C_{15}H_{24}$	(-)-δ-Panasinsine	1.07	0.56	1.69	0.92
52	206	$C_{15}H_{26}$	Longipinane, (E)-			0.33	
53	204	$C_{15}H_{24}$	Berkheyaradulene	1.54			
54	204	$C_{15}H_{24}$	Selina-3,7(11)-diene			0.41	
55	204	$C_{15}H_{24}$	1R,4S,7S,11R-2,2,4,8-Tetramethyltricyclo[5.3.1.0(4,11)]undec-8-ene	0.18			
56	208	$C_{15}H_{28}$	Muurolane	2.59			
57	202	$C_{15}H_{22}$	1,2,3,3a,4a,5,6,7,8,9,9a,9b-Dodecahydrocyclopenta[def]phenanthrene			0.22	0.35
58	204	$C_{15}H_{24}$	Epizonarene	1.91	2.40	1.81	9.42

Appendix 8: Cont’d

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
59	218	$C_{15}H_{22}O$	Germacrone				0.49
60	222	$C_{15}H_{26}O$	Cubedol		0.10		
61	222	$C_{15}H_{26}O$	Bicyclo[6.3.0]undec-1(8)-en-3-ol, 2,2,5,5-tetramethyl-				
62	212	$C_{15}H_{16}O$	Naphthalene, 6-methoxy-2-(1-buten-3-yl)-				
63	238	$C_{15}H_{26}O_2$	3.alpha.,9.beta.-Dihydroxy-3,5.alpha.,8-trimethyltricyclo[6.3.1.0(1,5)]dodecane				
64	218	$C_{15}H_{22}O$	Dihydrokaranone				
65	220	$C_{15}H_{24}O$	β-Santalol				
66	220	$C_{15}H_{24}O$	Glaucyl alcohol				
67	222	$C_{15}H_{26}O$	α-Bisabolol			0.79	
68	222	$C_{15}H_{26}O$	1-Methylene-2b-hydroxymethyl-3,3-dimethyl-4b-(3-methylbut-2-enyl)-cyclohexane		0.66		
69	224	$C_{15}H_{28}O$	6,10-Dodecadien-3-ol, 3,7,11-trimethyl-		1.22		
70	282	$C_{15}H_{23}Br$	3a-Bromolongifolene				
71	220	$C_{15}H_{20}O_2$	5.alpha.-Hydroxy-4.alpha.,8,10,11-tetramethyltricyclo[6.3.0.0(2,4)]undec-10-ene				
72	218	$C_{15}H_{28}O$	9H-Cycloisolongifolene, 8-oxo-		0.36		
73	232	$C_{15}H_{20}O_2$	trans-Dihydrophymaspermone		0.15		
74	248	$C_{15}H_{20}O_3$	Confertin		0.98		
75	218	$C_{15}H_{22}O$	β-Elemenone			0.89	
76	222	$C_{15}H_{26}O$	Nerolidol 2	0.46	1.07	0.79	1.38
77	238	$C_{15}H_{26}O_2$	Widdrol hydroxyether				
78	220	$C_{15}H_{24}O$	Isolongifolene oxide		**3.91**		
79	218	$C_{15}H_{22}O$	Ar-himachalen-2-ol	0.11	0.39		
80	248	$C_{15}H_{20}O_3$	1,3,4,4a.beta.,5,6,8,9-Octahydro-4a-hydroxy-6,6,8b-trimethylazuleno(5,6-c)furan-3-one		0.30		
81	218	$C_{15}H_{22}O$	2-(4a,8-Dimethyl-2,3,4,4a,5,6-hexahydro-naphthalen-2-yl)-prop-2-en-1-ol				
82	220	$C_{15}H_{24}O$	γ-Gurjunenepoxide-(2)	1.47			
83	232	$C_{15}H_{20}O_2$	Eudesma-5,11(13)-dien-8,12-olide	.52	1.42	1.53	0.07
84	214	$C_{15}H_{18}O$	5,7,7-Trimethyl-4,5,7,8-tetrahydroazuleno[4,5-c]furan			0.18	
85	222	$C_{15}H_{26}O$	(-)-Isolongifolol	0.41	0.81	1.01	1.65
86	220	$C_{15}H_{24}O$	7-Oxabicyclo[4.1.0]heptane, 1-(1,3-dimethyl-1,3-butadienyl)-2,2,6-trimethyl-, (E)-	2.45	0.84		
87	220	$C_{15}H_{24}O$	Isolongifolene, 9-hydroxy-	1.42	1.55	1.80	1.93
88	220	$C_{15}H_{24}O$	Cyclopenta[c]pentalen-3(3aH)-one, octahydro-1,2,3a,6-tetramethyl-			0.42	
89	232	$C_{15}H_{20}O_2$	Furan, 2-[(2-ethoxy-3,4-dimethyl-2-cyclohexen-1-ylidene)methyl]-	0.76	0.22		
90	218	$C_{15}H_{22}O$	Isolongifolen-9-one	0.29			
91	222	$C_{15}H_{26}O$	Drimenol	1.40	0.22	0.04	0.01
92	250	$C_{15}H_{22}O_3$	5,8-Dihydroxy-4a-methyl-4,4a,4b,5,6,7,8,8a,9,10-decahydro-2(3H)-phenanthrenone			0.22	
93	220	$C_{15}H_{24}O$	2-Cyclohexene-1-carboxaldehyde, 2,6-dimethyl-6-(4-methyl-3-pentenyl)-		0.09	2.32	

Appendix 8: Cont’d

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Sesquiterpenoids and related compounds							
94	222	$C_{15}H_{26}O$	Humulane-1,6-dien-3-ol			0.43	
95	220	$C_{15}H_{24}O$	Longifolenaldehyde	0.37	0.86	0.23	0.51
96	220	$C_{15}H_{24}O$	α-Cedrene epoxide			0.69	
97	308	$C_{18}H_{28}O_4$	1(2H)-Phenanthrenone, 7-(acetyloxy)dodecahydro-8a-hydroxy-2,4b-dimethyl-, [2S-(2.alpha.,4a.alpha.,4b.beta.,7.beta.,8a.alpha.,10a.beta.)]-			2.97	
98	248	$C_{15}H_{20}O_3$	Benzo[e]isobenzofuran-1,4-dione,1,3,4,5,5a,6,7,8,9,9a-decahydro-6,6,9a-trimethyl	1.14		0.99	
99	250	$C_{15}H_{22}O_3$	6,6,9a-Trimethyl-decahydronaphtho[1,2-c]furan-1,4-dione	0.81			
100	252	$C_{16}H_{28}O_2$	Sclaral (sclareolide lactol)			2.94	
101	234	$C_{15}H_{22}O_2$	Davana ether			0.44	
102	220	$C_{15}H_{24}O$	γ-Costol	0.07	0.37	3.82	0.57
	204	$C_{15}H_{24}$	γ-Himachalene	2.03	1.08	1.50	0.93
103	230	$C_{15}H_{18}O_2$	2,4,6-Cycloheptatrien-1-one, 2-hydroxy-5-(3-methyl-2-butenyl)-4-(1-methylethenyl)- (Procerin)	0.09	1.05	0.57	2.96
104	280	$C_{15}H_{20}O_5$	Anobin			0.21	
105	222	$C_{15}H_{26}O$	Gleenol			0.51	
106	236	$C_{16}H_{28}O$	(-)-Isolongifolol, methyl ether	**3.08**			
107	264	$C_{17}H_{28}O_2$	Farnesol, acetate	0.19			
108	238	$C_{15}H_{26}O_2$	Geranyl iso-valerate	0.38			
109	208	$C_{14}H_{24}O$	Luciferin aldehyde (Latia)			0.77	
110	248	$C_{17}H_{28}O$	Podocarp-12-en-14-ol		2.35		
111	220	$C_{15}H_{24}O$	Copaen-15-ol			1.27	
112	236	$C_{16}H_{28}O$	1-Hydroxymethyl-3,3,7,11-tetramethyltricyclo[5.4.0.0(4,11)]undecane	1.09			
113	208	$C_{14}H_{24}O$	7.beta.-Ethyl-8.beta.-hydroxy-2,6-dimethylbicyclo[4.4.0]dec-1-ene			0.24	
114	236	$C_{16}H_{28}O$	1-Hydroxymethyl-5,8,9-endo-10-exo-tetramethyltricyclo[6.3.0.0(5,11)]undecane		0.09		
115	272	$C_{15}H_{12}O_5$	6H-Dibenzo[b,d]pyran-6-one, 7,9-dihydroxy-3-methoxy-1-methyl-			0.10	0.03
Diterpenoids and related compounds							
1	290	$C_{20}H_{34}O$	Manool				0.65
2	290	$C_{20}H_{34}O$	Geranyl Linalool	1.34	0.41	1.69	2.65
3	290	$C_{20}H_{34}O$	trans-Geranylgeraniol	0.43	0.07	0.59	0.38
4	296	$C_{20}H_{40}O$	Phytol	1.12	1.05	1.85	1.03
	290	$C_{20}H_{34}O$	Manool /	1.7	0.92	0.47	0.59
5	332	$C_{22}H_{36}O_2$	2,6,10,14-Hexadecatetraen-1-ol, 3,7,11,15-tetramethyl-, acetate, (E,E,E)-	0.37			
Triterpenoids							
1	410	$C_{30}H_{50}$	C(14a)-Homo-27-norgammacer-14-ene				1.01
2	410	$C_{30}H_{50}$	Squalene	2.01	1.90	0.85	0.27
3	426	$C_{30}H_{50}O$	1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)-			0.10	
4	442	$C_{30}H_{50}O_2$	9,19-Cyclolanost-23-ene-3,25-diol, (3.beta.,23E)-	0.11			
5	444	$C_{30}H_{52}O_2$	Cycloartane-3.beta.,25-diol	0.11		0.09	0.13

Appendix 8: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Hydrocarbons							
1	236	$C_{17}H_{32}$	1,1-Dicyclohexylpentane				1.09
2	176	$C_{13}H_{20}$	Cyclohexane, 1,2-diethenyl-4-(1-methylethylidene)-, cis-				**3.72**
3	150	$C_{11}H_{18}$	p-Menth-8-ene, 3-methylene-		0.11		
4	124	C_9H_{16}	6,6-Dimethylhepta-2,4-diene			1.01	
5	164	$C_{12}H_{20}$	1,Z-5,E-7-Dodecatriene	0.22	1.68	0.34	0.29
6	162	$C_{12}H_{18}$	Bicyclo[2.2.2]octa-2,5-diene, 1,2,3,6-tetramethyl-				1.21
7	108	C_8H_{12}	Bicyclo[4.1.0]heptane, 7-methylene-		**6.57**		
8	266	$C_{19}H_{38}$	1-Nonadecene		0.27		
9	234	$C_{17}H_{30}$	3-Heptadecen-5-yne, (Z)-			2.58	
10	248	$C_{18}H_{32}$	2,5,9-Tetradecatriene, 3,12-diethyl-			1.30	
11	136	$C_{10}H_{16}$	Adamantane			0.70	
12	176	$C_{13}H_{20}$	Cyclohexene, 1,3-diisopropenyl-6-methyl-	**3.04**			
13	176	$C_{13}H_{20}$	1,3,5-Cycloheptatriene, 2,4-diethyl-7,7-dimethyl-			0.58	
14	170	$C_{12}H_{26}$	Decane, 3,8-dimethyl-	0.51			
15	124	C_9H_{16}	1,3-Hexadiene, 3-ethyl-2-methyl-, (Z)-	1.01			
16	140	$C_{10}H_{20}$	3-Hexene, 3-ethyl-2,5-dimethyl-	1.03			
17	226	$C_{16}H_{34}$	Hexadecane	**5.67**	0.30		
18	150	$C_{11}H_{18}$	Cis-8-methyl-exo-tricyclo[5.2.1.0(2.6)]decane			0.72	
19	296	$C_{21}H_{44}$	Heneicosane	1.97			
Fatty acid derivatives							
1	172	$C_{10}H_{20}O_2$	n-Decanoic acid	1.69	1.64	**5.70**	1.51
2	206	$C_{11}H_{10}O_4$	6-Methoxy-3-methyl-2-benzofurancarboxylic acid				0.64
3	210	$C_{13}H_{22}O_2$	2-Propenoic acid, 2-methyl-, 3,3,5-trimethylcyclohexyl ester	0.77			
4	214	$C_{13}H_{26}O_2$	Tridecanoic acid				**5.65**
5	242	$C_{15}H_{30}O_2$	Methyl tetradecanoate				0.42
6	284	$C_{18}H_{36}O_2$	Heptadecanoic acid, methyl ester				0.11
7	282	$C_{18}H_{34}O_2$	Oleic Acid				1.30
8	224	$C_{12}H_{16}O_4$	5-Acetoxymethylbicyclo[2.2.1]hept-2-ene-1-carboxylic acid, methyl ester			1.07	
9	296	$C_{19}H_{36}O_2$	9-Octadecenoic acid, methyl ester, (E)-				1.11
10	194	$C_{12}H_{18}O_2$	3-(2,2,4-Trimethylcyclohex-3-enyl)prop-2-enoic acid				0.99
11	316	$C_{21}H_{32}O_2$	5,8,11,14,17-Eicosapentaenoic acid, methyl ester, (all-Z)-				0.19
12	212	$C_{13}H_{24}O_2$	Citronellyl propionate	0.66		0.48	
13	278	$C_{18}H_{30}O_2$	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-		0.21		
14	312	$C_{20}H_{40}O_2$	Hexadecanoic acid, 2-methylpropyl ester		0.12		
15	326	$C_{21}H_{42}O_2$	Eicosanoic acid, methyl ester				0.13
16	308	$C_{20}H_{36}O_2$	Linoleic acid ethyl ester				0.26
17	292	$C_{19}H_{32}O_2$	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-				0.59
18	282	$C_{17}H_{30}O_3$	3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate		0.17		
19	354	$C_{21}H_{38}O_4$	Fumaric acid, decyl 3-heptyl ester				1.59

Appendix 8: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Fatty acid derivatives							
20	168	$C_{10}H_{16}O_2$	Cyclopentanecarboxylic acid, 2,4-dimethyl-3-methylene-, methyl ester	0.64			
21	382	$C_{25}H_{50}O_2$	Tetracosanoic acid, methyl ester				0.16
22	340	$C_{22}H_{44}O_2$	Octadecanoic acid, 2-methylpropyl ester		0.19		
23	326	$C_{21}H_{42}O_2$	i-Propyl 16-methyl-heptadecanoate	0.44			
24	240	$C_{15}H_{28}O_2$	Citronellyl iso-valerate	1.13			
25	210	$C_{13}H_{22}O_2$	Acetic acid, 4a-methyldecahydronaphthalen-1-yl ester			0.54	
26	480	$C_{32}H_{64}O_2$	Hexadecanoic acid, hexadecyl ester		0.15		
27	178	$C_{10}H_{10}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-			0.65	
28	326	$C_{21}H_{42}O_2$	i-Propyl 16-methyl-heptadecanoate			0.81	
29	298	$C_{19}H_{38}O_2$	i-Propyl 14-methyl-pentadecanoate	0.32			
30	242	$C_{15}H_{30}O_2$	Pentadecanoic acid	0.15			
31	170	$C_9H_{14}O_3$	Cyclopentanecarboxylic acid, 3,3-dimethyl-4-oxo-, methyl ester			0.93	
32	270	$C_{17}H_{34}O_2$	Hexadecanoic acid, methyl ester	0.40	1.29	0.38	0.73
33	218	$C_{14}H_{18}O_2$	1H-Indene-4-carboxylic acid, 2,3-dihydro-1,1-dimethyl-, ethyl ester			0.17	
34	256	$C_{16}H_{32}O_2$	n-Hexadecanoic acid	0.28	2.87	1.07	0.06
35	294	$C_{19}H_{34}O_2$	9,12-Octadecadienoic acid, methyl ester			0.35	0.98
36	292	$C_{19}H_{32}O_2$	Methyl 3-cis,9-cis,12-cis-octadecatrienoate	2.33			
37	226	$C_{12}H_{18}O_4$	2,4-Hexadienedioic acid, 3-methyl-4-propyl-, dimethyl ester, (E,Z)-			0.89	
38	296	$C_{19}H_{36}O_2$	11-Octadecenoic acid, methyl ester			0.79	
39	266	$C_{17}H_{30}O_2$	3,7,11,Trimethyl-8,10-dodecedienylacetate	0.79			
40	298	$C_{19}H_{38}O_2$	Methyl stearate			0.19	0.43
41	282	$C_{18}H_{34}O_2$	9-Octadecenoic acid, (E)-			1.05	1.03
42	284	$C_{18}H_{36}O_2$	Octadecanoic acid	0.64	0.34	0.15	1.01
43	180	$C_{12}H_{20}O$	1-Methylverbenol, methyl ether				2.14
44	294	$C_{19}H_{34}O_2$	Methyl 9-cis,11-trans-octadecadienoate				0.57
45	280	$C_{18}H_{32}O_2$	9,12-Octadecadienoic acid (Z,Z)- (Linoleic acid)			0.52	0.58
46	246	$C_{16}H_{22}O_2$	3-Cyclopentylpropionic acid, 3,5-dimethylphenyl ester			1.39	
47	330	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester			1.01	
48	200	$C_{12}H_{24}O_2$	Dodecanoic acid			0.90	
49	326	$C_{18}H_{30}O_5$	Methyl (1R,2R,8aS)-2-(methoxycarbonyl)-2-hydroxy-5,5,8a-trimethyl-trans-decalin-1-acetate			0.62	
50	214	$C_{14}H_{30}O$	1-Tetradecanol				0.35
51	228	$C_{15}H_{32}O$	n-Pentadecanol	0.57			0.27
52	354	$C_{24}H_{50}O$	n-Tetracosanol-1		0.33		
53	242	$C_{16}H_{34}O$	1-Decanol, 2-hexyl-	1.29	0.70	0.20	0.94
Ketones and aldehydes							
1	150	$C_9H_{10}O_2$	Ethanone, 1-(2-hydroxy-5-methylphenyl)-			1.00	0.91
2	164	$C_{11}H_{16}O$	cis-Jasmone			1.49	0.18

Appendix 8: Cont’d

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Ketones and aldehydes							
3	216	$C_{15}H_{20}O$	Cyclohexanone, 3,3,5-trimethyl-5-phenyl-		1.16		
4	208	$C_{13}H_{20}O_2$	2,10,10-Trimethyl-6-methylene-1-oxaspiro[4.5]decan-7-one				0.24
5	192	$C_{13}H_{20}O$	Tricyclo[6.3.0.0(1,5)]undecan-4-one, 5,9-dimethyl-				0.69
6	180	$C_{10}H_{12}O_3$	Ethanone, 1-(2,5-dimethoxyphenyl)-			1.39	
7	266	$C_{18}H_{34}O$	13-Octadecenal, (Z)-		1.07		
8	206	$C_{14}H_{22}O$	But-3-enal, 2-methyl-4-(2,6,6-trimethyl-1-cyclohexenyl)-				0.31
9	166	$C_{11}H_{18}O$	Cyclohexanone, 2,5-dimethyl-2-(1-methylethenyl)-			0.79	1.55
10	124	$C_8H_{12}O$	2-Cyclopenten-1-one, 3,4,5-trimethyl-	**3.15**	1.30	1.11	0.22
11	182	$C_{11}H_{18}O_2$	2,3-Dimethyl-8-oxo-non-2-enal				0.48
12	180	$C_{10}H_{12}O_3$	2,5-Dihydroxy-4-isopropyl-2,4,6-cycloheptatrien-1-one				1.29
13	192	$C_{13}H_{20}O$	3-Cyclohexene-1-carboxaldehyde, 3-(4-methyl-3-pentenyl)-			0.53	
14	190	$C_{13}H_{18}O$	Megastigmatrienone			0.48	
15	168	$C_8H_8O_4$	Isovanillic acid			0.44	
16	208	$C_{13}H_{20}O_2$	3-Oxo-7,8-dihydro-α-ionone			0.57	
17	206	$C_{13}H_{18}O_2$	Bicyclo[6.3.0]undec-1(8)-ene-3,7-dione, 5,5-dimethyl-	0.28			
18	318	$C_{20}H_{30}O_3$	Tetracyclo[5.4.3.0(7,11)]tetradecan-2-ol-5,10-dione, 1,4,6,14-tetramethyl-4-vinyl-				0.93
19	124	$C_7H_8O_2$	5-Ethyl-2-furaldehyde			0.61	
20	232	$C_{13}H_{12}O_4$	1,4-Naphthalenedione, 5,8-dihydroxy-2,3,7-trimethyl-		0.16		
21	248	$C_{18}H_{16}O$	5,6,8,9-Tetrahydrobenz(a)anthracen-11(10H)-one		0.98		
22	206	$C_{13}H_{18}O_2$	4,4-Dimethyltricyclo(6.3.0.0(1,7))undecane-2,6-dione	0.82			
23	164	$C_{11}H_{16}O$	4-Isopropyl-3,4-dimethylcyclohexa-2,5-dienone		**5.81**		
24	206	$C_{14}H_{22}O$	4-Camphenylbutan-2-one			1.99	
25	178	$C_{10}H_{10}O_3$	Coniferaldehyde			0.26	
26	230	$C_{14}H_{14}O_3$	4-(6-Methoxy-3-methyl-2-benzofuranyl)-3-buten-2-one			0.34	0.31
27	204	$C_{14}H_{20}O$	2-(3-Isopropyl-4-methyl-pent-3-en-1-ynyl)-2-methyl-cyclobutanone	0.81			
28	196	$C_{10}H_{12}O_4$	2-Propanone, 1-hydroxy-3-(4-hydroxy-3-methoxyphenyl)-			0.91	
29	202	$C_{14}H_{18}O$	11-Isopropylidenetricyclo[4.3.1.1(2,5)]undec-3-en-10-one		0.52	1.95	0.65
30	206	$C_{14}H_{22}O$	2,4,4-Trimethyl-3-(3-methylbuta-1,3-dienyl)cyclohexanone	2.05	**7.94**		
31	192	$C_{13}H_{20}O$	trans-α-Damascone	0.25			
32	192	$C_{13}H_{20}O$	2-(1-Cyclopent-1-enyl-1-methylethyl)cyclopentanone	0.92			0.52
33	248	$C_{16}H_{24}O_2$	4,4,5',5'-Tetramethyl-bicyclohexyl-6-ene-2,3'-dione		0.81	0.75	0.80
	206	$C_{13}H_{18}O_2$	3-Keto-β-ionone	0.49	0.98	0.43	0.77

Appendix 8: Cont'd

No.	**MWT**	**Formula**	**Name and class of compounds**	**Mean (%) R.A**			
				DCM		**MeOH**	
				LV	**SB**	**LV**	**SB**
Ketones and aldehydes							
34	232	$C_{16}H_{24}O$	Allyl ionone			0.67	
35	126	$C_6H_6O_3$	5-Hydroxymethylfurfural			1.78	0.83
36	226	$C_{15}H_{30}O$	Pentadecanal	0.91			1.12
37	192	$C_{13}H_{20}O$	β-Ionone			1.44	
Phytosterols							
1	493	$C_{31}H_{53}CIO_2$	Stigmastan-3-ol, 5-chloro-, acetate, (3.beta.,5.alpha.)-				1.98
2	370	$C_{26}H_{42}O$	26,27-Dinorergosta-5,23-dien-3-ol, (3.beta.)-		0.18		
3	246	$C_{18}H_{30}$	d-Norandrostane (5.alpha.,14.alpha.)				1.52
4	400	$C_{28}H_{48}O$	Cholest-5-en-3-ol, 6-methyl-, (3.beta.)-				0.15
5	396	$C_{28}H_{44}O$	Ergosta-4,6,22-trien-3.beta.-ol	2.48	1.09	0.07	0.49
6	412	$C_{29}H_{48}O$	Stigmasterol		0.10		
7	302	$C_{20}H_{30}O_2$	trans-Dehydroandrosterone, methyl ether		0.38		
8	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)-	0.08			0.59
	454	$C_{31}H_{50}O_2$	Stigmasterol acetate	0.35	0.85	0.92	1.59
9	414	$C_{29}H_{50}O$	Schottenol	0.38	1.12	1.16	0.09
10	394	$C_{29}H_{46}$	Stigmastan-3,5,22-trien	0.20			
11	678	$C_{47}H_{82}O_2$	Stigmast-5-en-3-ol, oleate	0.07	0.48	0.02	0.07
12	414	$C_{29}H_{50}O$	γ-Sitosterol			1.63	
13	454	$C_{31}H_{50}O_2$	Stigmasta-5,22-dien-3-ol, acetate, (3.beta.,22Z)-			0.38	
14	402	$C_{29}H_{38}O$	Androstan-17-ol, 4-[1-naphthyl]-			0.12	
Tocopherols							
1	402	$C_{27}H_{46}O_2$	δ-Tocopherol	0.11			
2	416	$C_{28}H_{48}O_2$	β-Tocopherol	0.59	0.36	0.91	1.98
3	430	$C_{29}H_{50}O_2$	Vitamin E	0.27	0.40	0.26	1.04
4	444	$C_{30}H_{52}O_2$	(+)-.alpha.-Tocopherol, O-methyl-	0.09			
Carbohydrate derivatives							
1	146	$C_6H_{10}O_4$	Dianhydromannitol				1.74
2	162	$C_6H_{10}O_5$	3,4-Altrosan			2.75	1.62
3	162	$C_6H_{10}O_5$	.beta.-D-Glucopyranose, 1,6-anhydro-			2.83	0.71
4	164	$C_6H_{12}O_5$	.beta.-l-Arabinopyranoside, methyl			**6.07**	
5	254	$C_{13}H_{18}O_5$	Methyl 2-O-benzyl-d-arabinofuranoside				0.42
6	182	$C_6H_{14}O_6$	D-Mannitol			**4.08**	
7	182	$C_6H_{14}O_6$	Sorbitol			**6.36**	
8	270	$C_{13}H_{18}O_6$	Benzyl .beta.-d-glucoside			1.00	
Phenols							
1	152	$C_9H_{12}O_2$	2-Isopropoxyphenol			0.77	
2	154	$C_8H_{10}O_3$	Phenol, 2,6-dimethoxy-				0.71
3	150	$C_9H_{10}O_2$	2-Methoxy-4-vinylphenol				1.03
4	180	$C_{10}H_{12}O_3$	Coniferol			2.44	
5	188	$C_{14}H_{20}$	Biphenylene, 1,2,3,6,7,8,8a,8b-octahydro-4,5-dimethyl-		**3.00**		
6	318	$C_{21}H_{34}O_2$	2-[(1R,3S)-3-Hydroxycyclohexyl]5-(2-methyloctan-2-yl)phenol				0.35
7	210	$C_{15}H_{14}O$	3-Phenylbicyclo(3.2.2)nona-3,6-dien-2-one			0.53	
8	124	$C_7H_8O_2$	Guaiacol	0.78	0.60	3.02	0.50

Appendix 8: Cont'd

No.	MWT	Formula	Name and class of compounds	Mean (%) R.A			
				DCM		MeOH	
				LV	SB	LV	SB
Furan							
1	124	$C_7H_8O_2$	2-Acetyl-5-methylfuran	0.38	2.98	1.87	0.84
Coumarin							
1	206	$C_{11}H_{10}O_4$	Scoparone			0.71	
	300	$C_{17}H_{16}O_5$	Phellopterin	1.24	0.67	0.98	1.48
Pyrans							
1	144	$C_6H_8O_4$	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-			1.66	0.95
2	208	$C_{14}H_{24}O$	4H-Chromene, 4a,5,6,7,8,8a-hexahydro-2,3,5,5,8a-pentamethyl				0.35
3	228	$C_{14}H_{12}O_3$	2-Isopropenyl-2,3-dihydrofuro[3,2-g]chromen-7-one				0.52
Benzene derivatives							
1	140	$C_7H_8O_3$	1,4-Benzenediol, 2-methoxy-				0.47
2	208	$C_{12}H_{16}O_3$	Benzoic acid, 4-methoxy-, 2-methylpropyl ester			1.41	
3	126	$C_6H_6O_3$	1,2,3-Benzenetriol			**7.95**	2.82
4	246	$C_{18}H_{30}$	Benzene, hexaethyl-				0.73
5	192	$C_{11}H_{12}O_3$	4H-1-Benzopyran-4-one, 2,3-dihydro-7-hydroxy-2,2-dimethyl-		1.83		
6	162	$C_{12}H_{18}$	Dewar benzene, hexamethyl-			2.70	2.57
7	234	$C_{16}H_{26}O$	4-(2-Ethylhexoxy)ethylbenzene			0.71	
8	326	$C_{22}H_{30}O_2$	Benzoic acid, [(E,E)-3,7,11-trimethyl-2,6,10-dodecatrien-1-yl] ester	1.70			
Anthracenes /phenathracenes derivatives							
1	214	$C_{16}H_{22}$	Anthracene, 1,2,3,4,5,6,7,8-octahydro-9,10-dimethyl-		0.48		0.75
2	200	$C_{15}H_{20}$	9-Methyl-S-octahydroanthracene			0.33	0.80
3	248	$C_{18}H_{16}O$	2-Acetyl-9,10-dimethylanthracene		2.16		
Alkaloid							
1	295	$C_{18}H_{17}NO_3$	(+)-Mecambroline			0.10	0.06
Naphthalene derivatives							
1	188	$C_{14}H_{20}$	Naphthalene, 1,2,3,4-tetrahydro-1-methyl-8-(1-methylethyl)-		2.92		
2	208	$C_{14}H_{24}O$	2(1H)-Naphthalenone, octahydro-4a-methyl-7-(1-methylethyl)-, (4a.alpha.,7.beta.,8a.beta.)-	2.41			
3	248	$C_{12}H_8O_6$	1,4-Naphthoquinone, 6-acetyl-2,5,8-trihydroxy-		1.28		
4	206	$C_{14}H_{22}O$	1-Naphthalenone, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl	1.51			
5	216	$C_{14}H_{16}O_2$	2,3-Naphthalenedione, 1,4-dihydro-1,1,4,4-tetramethyl-		2.26		
Others							
1	248	$C_{18}H_{32}$	1H-Indene, 1-(1,5-dimethyl-2-hexenyl)octahydro-7a-methyl-, [1R-[1.alpha.(1R*,2Z),3a.beta.,7a.alpha.]]-	0.86		0.76	
2	178	$C_{12}H_{18}O$	(7R,8S)-cis-anti-cis-7,8-Epoxytricyclo[7.3.0.0(2,6)]dodecane	1.24			
3	258	$C_{16}H_{34}O_2$	1,16-Hexadecanediol	0.39			

Appendix 9: Publication associated with this research work

Variation in antimicrobial activity of *Warburgia ugandensis* extracts from different populations across the Kenyan Rift Valley.