

**EFFECTIVENESS OF LEMON AND LEMONGRASS COMBINATION AS
AROMATHERAPY ON STRESS REDUCTION AMONG PARENTS OF
CHILDREN WITH INTELLIGENCE DISABILITY IN KAKAMEGA
COUNTY, KENYA**

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**A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of
the Degree of Doctor of Philosophy in Nursing of Masinde Muliro University of
Science and Technology**

May, 2025

DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award.

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HNR/H/01-52483/2018

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of Masinde Muliro University of Science and Technology a thesis entitled '*Effectiveness of Lemon and Lemongrass Combination as Aromatherapy on Stress Reduction among Parents of Children with Intelligence Disability in Kakamega County, Kenya*'.

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DEDICATION

This dissertation is dedicated to my husband Dr. Reuben Ego, my children Robbie Tala Jebet and Spencer Sirma Ego for their moral support and for sacrificing their time and comfort to allow me to work on my thesis. My sisters; Sheila and Sheryl and Brother; Timothy who motivated me throughout. Lastly, in honor, appreciation and love to my parents Shadrack and Angela Kosgey who have educated and motivated me.

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ABSTRACT

Parents of Children with Intelligence Disability (PCID) undergo stress and societal stigma in their daily lives as they raise up these children with Intelligence Disability (ID). Aromatherapy, a type of complementary and alternative medicine (CAM), uses plants to extract essential oils which are used as aromatherapy through inhalation. The main aim of this study was to authenticate lemongrass and lemon essential oils and assess its effectiveness as aromatherapy on stress reduction among PCID. The study utilized a quasi-experimental pre- post non-equivalent study design. Gas Chromatography-mass spectrometry (GC-MS) was done to authenticate the lemon and lemongrass essential oils. Lemon essential oil contained 42 components with D-Limonene (33.15%) and Cyclopentene, 3-isopropenyl-5,5-dimethyl- (26.73%) as the major components. Lemongrass essential oil contained 82 components with β -Myrcene (11.34%) and Geranial (18.19%) as the major components respectively. Quantitative and qualitative approach was used and data was collected using a stress indicator tool, informant interviews and focus group discussions. Through snowballing sampling technique, the sample size consisted of 228 PCID. Majority of the PCID were women (72.4%) and most of the ID children were < 5 years old (52.2%). Lemongrass essential oil performed better in post-test on physical, sleep and emotions domains with a mean difference in stress reduction $\{\bar{x} -30.18 (p < 0.0001)\}$, $\{\bar{x} -28.66 (p < 0.0001)\}$ and $\{\bar{x} -22.51 (p < 0.0001)\}$ respectively. Mean differences in systolic blood pressure $\{(\bar{x} -24.42; p < 0.0001)\}$ and heart rate $\{(\bar{x} -21.76; p < 0.0001)\}$ were highest in the group that used a blend of lemon and lemongrass essential oils. Four themes that emerged on the factors that influence effectiveness of lemon and lemongrass essential oils were: Calming and relaxing effect of the drug, frequency of exposure, cost effectiveness and pleasant aroma with non-allergy reaction. In conclusion, Lemongrass essential oil and a blend of lemongrass and lemon essential oils are effective in reducing stress. A lemongrass and lemon essential oil protocol and algorithm is proposed to guide on the use of these essential oils on the management and reduction of stress among the PCID and community at large. This study therefore recommends that PCID use lemongrass and lemon essential oils since its natural, cost effective and readily available.

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LIST OF ABBREVIATIONS AND ACRONYMS

CAM	-	Complementary and Alternative Medicine
CHP	-	Community Health Promoter
DBP	-	Diastolic Blood Pressure
EARC	-	Educational Assessment and Resource Centre
GC-MS	-	Gas Chromatography – Mass Spectrometry
HR	-	Heart Rate
IREC	-	Institutional Review and Ethics Board
JKUAT	-	Jomo Kenyatta University of Agriculture and Technology
KISE	-	Kenya Institute of Special Education
MMUST	-	Masinde Muliro University of Science and Technology
NACOSTI	-	National Commission for Science, Technology and Innovation
PCID	-	Parents of Children with Intellectual Disability
SBP	-	Systolic Blood Pressure
WHO	-	World Health Organization

OPERATIONALIZATION OF KEY TERMS

Intellectual Disability is a condition characterized by significant limitations in both intellectual functioning such as reasoning, learning and in adaptive behavior, which covers a range of everyday social and practical skills. This disability originates before the age of 18.

Parents of Children with Intelligence Disability (PCID) is any parent or guardian taking care of a school or non-school going child with Intellectual Disability

Reproductive age is any parent from 18 years to 50 years.

CHAPTER ONE

1.0 Overview

This chapter presents the study's foundational details, problem statement, study objectives, research questions, hypothesis, theoretical framework, rationale, and importance.

1.1 Background to the study

Parents and caregivers of children with intellectual disabilities often face significant stress due to the ongoing physical, emotional, and financial demands of care giving. An intellectual disability occurs when there are limitations in cognitive abilities that impact an individual's intelligence, learning, and everyday life skills. These effects can range significantly, with some individuals experiencing minor challenges while maintaining independent living, whereas others require lifelong assistance and support. This condition typically manifests during early development and involves deficits in both intellectual and adaptive functioning (DSM-5, 2013). Between 2009 and 2017, roughly 16.93% of children between the ages of 3 and 17 in the United States were reported to have a form of developmental disability. The prevalence varied across different types of disabilities, with Attention Deficit Hyperactivity Disorder (ADHD) being the most common at 9.04% (Zablotsky *et al.*, 2019). Globally, studies indicate that around 2.0% of children and adolescents are affected by some form of intellectual disability (Maulik *et al.*, 2011).

In Kenya, the burden of caring for children with intellectual disabilities is compounded by cultural perceptions and inadequate support systems. Research indicates that chronic stress among parents of children with disabilities can lead to poor mental and physical health outcomes, negatively impacting the overall quality of life for both the family and the children they care for (Karanja *et al.*, 2019; Hassall *et al.*, 2015).

Caregivers, especially in rural areas like Kakamega County, Kenya, experience heightened stress levels due to limited access to mental health services, financial constraints, and societal stigma (Muriungi *et al.*, 2020; Mwangi *et al.*, 2019). Managing stress is crucial, as prolonged exposure to high stress levels can lead to burnout, depression, anxiety, and deteriorated physical health, negatively affecting both the caregiver's well-being and the quality of care provided to their children (Rafferty *et al.*, 2018; Hassall *et al.*, 2015). Similar to many other low-resource settings, caregivers in Kakamega County often struggle to access formal healthcare services that address mental health or stress management, leading them to seek alternative coping methods (Muriungi *et al.*, 2020; Ochieng *et al.*, 2021).

Reducing parental stress may improve their emotional resilience, enhance their caregiving capabilities, and positively impact the psychological and developmental outcomes of their children (Rafferty *et al.*, 2018). Aromatherapy, however, offers a more accessible and culturally appropriate intervention that could be easily integrated into daily routines (Khan *et al.*, 2016). While aromatherapy has been used in various parts of the world for stress relief, there is limited empirical evidence on its effectiveness in African contexts, particularly among caregivers of children with intellectual disabilities in rural Kenyan settings (Muriungi *et al.*, 2020; Ochieng *et al.*, 2021). Existing studies have primarily focused on stress management techniques such as counseling and pharmacotherapy, which may not always be accessible or culturally acceptable in rural areas (Karanja *et al.*, 2019). The combination of lemon and lemongrass essential oils is of particular interest because both oils have been independently studied for their effects on stress and anxiety (Khan *et al.*, 2020; Lee *et al.*, 2016). However, there is a paucity of research examining their combined effects,

especially in caregiving populations like parents of children with intellectual disabilities (Cavanagh & Wilkinson, 2002).

1.2 Statement of the Problem

Bringing up a child comes with a lot of stress and stressful event, but raising a child with intellectual disabilities poses unique challenges to parents. Intellectual disability (ID) is a permanent health condition that brings about negative effects on the individuals health, well-being, community participation and economic stability (Reynolds et.al., 2022). In 2019, a global survey indicated that approximately 107.62 million people with intellectual disabilities comprised about 2% of the global population (Vos *et al.*, 2019), placing significant caregiving burdens on families of children with ID. According to a United Nations report in 2015, the prevalence of disabilities increases with age, ranging from 6.1% in infants under one year old to 13.9% among adolescents aged 15 to 19 years. Studies carried out in low and middle-income countries like Kenya, India among others have shown that 47–50% of parental stress is as a result of social and psychological factors associated with raising children with intellectual disabilities (Dave *et al.*, 2017; Mbugua *et al.*, 2011; Fido & Al Saad, 2013).

According to the 2019 national census in Kenya, approximately 2.2% of the general population live with a type of disability. Higher prevalence rates were observed in central, eastern, and western regions of Kenya, with Embu County having the highest rate at 4.4%, followed by Homa Bay (4.3%), Siaya (4.1%), Kisumu (4.0%), and Kakamega (2.9%) counties. Specific prevalence rates for different disability types were recorded as follows: visual difficulties at 1.7%, hearing difficulties at 0.9%, mobility difficulties at 2.0%, cognitive difficulties at 1.3%, self-care deficits at 0.6%, and communication difficulties at 0.5%.

In March 2018, the Kenya Institute of Special Education (KISE) carried out a nationwide survey focusing on children with disabilities and special educational needs, targeting individuals aged 3 to 20 years old. The survey reached 7,609 individuals, of whom 865 (11.4%) had disabilities. Among them, 51.2% were boys and 48.8% were girls. The prevalence rates were 2.5% for intellectual disabilities, 3.0% for physical disabilities, and 3.1% for visual impairments (KISE, 2018).

Stress among these Parents of children with Intelligence disability (PCID) is a critical public health issue, with significant psychological and physical health implications. Families of children with intellectual disabilities are experiencing growing parental burdens that disrupt their daily activities, leading to social stigma, marital and emotional challenges (Sheikh *et al.*, 2018). Parents of these children commonly face elevated levels of stress compared to those raising normally developing children due to the constant demands they face in care giving services, social stigma, and financial burdens associated with specialized care (Peer & Hillman, 2014). Furthermore, PCID in Kakamega County, Kenya parents face limited access to mental health services and coping resources, exacerbating their stress levels (Ochieng *et al.*, 2021). Conventional stress management interventions, such as counseling and pharmacotherapy, exist, and may be inaccessible in rural settings like Kakamega County (Mwangi *et al.*, 2019). In addition, medications can reduce the symptoms of anxiety and stress but they do not address the root cause (Bandelow, B., *et al.*, 2017). As a result, there is a growing need for alternative, cost-effective, and culturally acceptable interventions that can help reduce stress in this population (Muriungi *et al.*, 2020).

While Aromatherapy, specifically the combination of lemon and lemongrass essential oils, has been used in various cultures as a complementary therapy for stress relief (Khan *et al.*, 2020; Lee *et al.*, 2016). However, there is limited empirical evidence on

its effectiveness among parents of children with intellectual disabilities in Kenya. In Nursing, Florence Nightingale introduced essential oils into the care process by applying lavender essential oil to the forehead of wounded war soldiers during the Crimean War to help alleviate their tension (McDowell, 2005). Watson's health concept underscores the balanced connection between an individual and their surroundings. Essential oils are viewed as organic components that enhance this harmony by complementing the body within its environment (Smith & Kyle, 2008). Martha Rogers (1970), emphasized the holistic nature of human beings as synergistic entities. Her theory focused on concepts such as totality, resonance, and biochemistry, highlighting the continuous exchange of energy fields within open systems where humans cannot be separated from their environment. According to Rogers, aromatherapy illustrates the interconnectedness between plants and people, where the energy patterns of individuals dynamically interact with those of plants encapsulated in essential oils. Each essential oil possesses a distinct vibrational frequency pattern, akin to the unique energy frequency pattern attributed to each individual. Research has shown that Lemon (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*) essential oils have physiologic effects therefore may be useful in relieving stress among PCID. Furthermore, a blend of these two essential oils could work synergistically to give better results. There are few studies showing the use of Lemon and Lemongrass plants for stress reduction therefore this study is aimed at investigating the effectiveness of Lemon (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*) essential oil aromatherapy and their blends on stress reduction among parents of children with intelligence disability.

Therefore, this study was aimed at investigating the effectiveness of Lemon (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*) essential oil aromatherapy and their combination on stress reduction among parents of children with intelligence disability.

1.3 Main Objective

The main objective of this study was to investigate the effectiveness of Lemon (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*) essential oil as aromatherapy and their combination on stress reduction and the perception among parents of children with intelligence disability.

1.3.1 Specific Objectives

- i. To authenticate the chemical content of essential oil extracts of Lemon leaves (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*).
- ii. To assess the effects of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction among parents of children with intelligence disability.
- iii. To determine the perceptions of parents of children with intelligence disability on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction

1.3.2 Research Questions

- i. What is the chemical content of essential oil extracts of lemon leaves (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*)?
- ii. What are the effects of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction among parents of children with intelligence disability?

- iii. What are the perceptions of parents of children with intelligence disability on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction?

1.4 Hypotheses of the Study

The study tested the following null and alternative hypothesis:

- i. *Null Hypothesis (H₀):* The combination of lemon and lemongrass aromatherapy has no significant effect on stress reduction among parents of children with intellectual disabilities in Kakamega County, Kenya.
- ii. *Alternative Hypothesis (H₁):* The combination of lemon and lemongrass aromatherapy significantly reduces stress levels among parents of children with intellectual disabilities in Kakamega County, Kenya.

These hypotheses guided the study in determining whether the aromatherapy intervention had a measurable impact on stress reduction in the target population.

1.5 Limitations of the study

1.5.1 Sample Size

The study focused on parents of children with intellectual disabilities in Kakamega County, which may have limited the generalizability of the findings to other regions with different cultural, social, or economic conditions. The relatively small sample size may not have fully captured the diversity of experiences among parents in other parts of Kenya or globally.

1.5.2 Sampling Technique

The study used a non-probability sampling technique which makes the findings not to be generalizable to the entire population. Additionally, the use of systematic random sampling to select sub-counties where every third sub-county was chosen could introduce bias if there was an underlying pattern in the sampling frame that influenced selection. Furthermore, the reliance on snowball sampling to identify families with intellectually disabled (ID) children through Community Health Promoters (CHPs) may have led to selection bias, as participants were identified through referrals rather than a randomized process.

1.5.3 Study Design

The study's duration may have limited the ability to observe long-term effects of the aromatherapy intervention. Stress reduction benefits from lemon and lemongrass aromatherapy might have been immediate or short-term, and it is unclear whether these effects were sustained over time. A longer follow-up period may be needed to evaluate the long-term effectiveness of the intervention.

Despite these limitations, this study will contribute valuable insights into the potential benefits of aromatherapy as a stress-reduction tool, and findings may inform future interventions and research in similar populations.

1.6 Justification of the Study

Understanding the extent and burden of psychological stress is important for improvement of chronic conditions care plans. Parents and caregiver burdens and coping mechanisms tend to be neglected and marginalized hence getting a remedy for stress management becomes difficult.

While lemon and lemongrass have been studied in various contexts, there is a lack of research specifically investigating their effects on parents of children with intellectual disabilities. Parents of these children face significant emotional, psychological, and physical challenges, often resulting in chronic stress (Hassall *et al.*, 2015; Muriungi *et al.*, 2020). In Kakamega County, Kenya, many caregivers experience limited access to mental health resources and support systems due to economic, social, and infrastructural constraints (Ochieng *et al.*, 2021). This situation leads to heightened stress levels, negatively impacting their well-being and ability to provide effective care for their children (Karanja *et al.*, 2019; Mwangi *et al.*, 2019).

Conventional stress management strategies, such as counseling or pharmacological interventions, are often inaccessible or underutilized in rural Kenyan communities due to stigma, cost, or limited availability of services (Muriungi *et al.*, 2020). Consequently, there is a need for alternative, affordable, and non-invasive interventions that are culturally acceptable and easily implemented within these communities (Ochieng *et al.*, 2021). Aromatherapy, using lemon and lemongrass essential oils, has been recognized for its potential in reducing stress and improving psychological well-being (Khan *et al.*, 2020; Lee *et al.*, 2016). However, there is a paucity of scientific research evaluating its effectiveness, particularly in low-resource settings like Kakamega County and among vulnerable populations such as parents of children with intellectual disabilities (Cavanagh & Wilkinson, 2002).

This study provided an evidence-based, cost-effective intervention for stress management that can be easily implemented in resource-limited settings and offer an alternative method of stress relief that is non-invasive, culturally acceptable, and does not require specialized training or expensive equipment.

This study contributes to the existing body of knowledge by addressing a gap in the literature concerning the use of aromatherapy in stress reduction for caregivers of children with intellectual disabilities in a Kenyan context. Further, the study empowers parents by offering a natural, accessible tool for managing stress, ultimately improving their mental well-being and enhancing the care provided to their children.

The study outcomes could inform healthcare providers, policymakers, and community health workers on the viability of incorporating aromatherapy into holistic care programs for caregivers in similar settings. This will help alleviate the burden of stress on caregivers, improving their quality of life and fostering better family dynamics and care for children with intellectual disabilities.

1.7 Theoretical framework by Nola Pender

Nola Pender's Health Promotion Model (HPM) provides a useful theoretical foundation for exploring how the use of lemon and lemongrass aromatherapy can promote stress reduction in parents of children with intellectual disabilities. By understanding the factors that influence health-promoting behaviors, the model helps in designing an effective intervention that addresses the parents' unique challenges, perceptions, and needs. Nola Pender's HPM is a widely recognized framework designed to explain and predict health-promoting behaviors. It focuses on individuals' motivations, behaviors, and actions toward promoting health and well-being rather than focusing on disease prevention. The model emphasizes the role of personal experiences, cognitions, and environmental influences in shaping health behaviors.

For this study Pender's HPM was applied as a guiding framework to understand how parents adopt health-promoting behaviors, such as aromatherapy, to manage stress.

1.7.1 Key Components of Pender's Health Promotion Model in This study

1.7.1.1 Individual Characteristics and Experiences

Pender's model considers how personal factors, such as demographic, biological, psychological, and socio-cultural influences, impact health behaviors. In this study, personal factors such as the age, gender, socioeconomic status, and previous stress-coping mechanisms of the parents can affect how they perceive the benefits of lemon and lemongrass aromatherapy. These factors influence whether parents adopt aromatherapy as a stress-relieving practice.

1.7.1.2 Behavior-Specific Cognitions and Affect

Parents must perceive that using lemon and lemongrass aromatherapy will effectively reduce their stress levels and factors such as cultural beliefs, accessibility to essential oils, or lack of knowledge may serve as barriers to adopting aromatherapy. The parents' confidence in their ability to consistently use aromatherapy to manage stress will influence their adoption and sustained use of the intervention. The parents' emotional response to aromatherapy, whether they find it enjoyable, calming, or relieving, will affect whether they continue using it.

1.7.1.3 Interpersonal Influences

The role of family, friends, and healthcare providers can influence the parents' decision to engage in health-promoting behaviors like aromatherapy. If social networks support the use of aromatherapy, parents may be more likely to try and continue using it. The involvement of health educators, nurses, or peers who advocate for the use of aromatherapy can strengthen parents' perceptions of its effectiveness for stress reduction.

1.7.1.4 Situational Influences

Environmental conditions, availability of resources, and access to aromatherapy products can shape the feasibility of using lemon and lemongrass aromatherapy in stress management. If lemon and lemongrass oils are affordable and accessible in Kakamega County, this will positively influence parents' ability to implement the aromatherapy intervention consistently.

1.7.2 Application of Pender's Health Promotion Model to the Study

The HPM helps explain why parents of children with intellectual disabilities may adopt or avoid aromatherapy as a stress-relief strategy. By examining individual beliefs, social influences, and environmental factors, the model aids in identifying the facilitators and barriers to the effective use of lemon and lemongrass aromatherapy. Based on the framework, the study can design an intervention that educates parents about the benefits of aromatherapy, increases self-efficacy through training and support, and addresses perceived barriers such as cost or cultural acceptance. Using the model, the study evaluated how perceptions of aromatherapy's effectiveness, social support, and self-efficacy influenced the adoption and sustained use of aromatherapy for stress reduction. The model also supports measuring changes in stress levels as a direct outcome of engaging in the health-promoting behavior. Figure 1.1 below shows the HPM model.

INDEPENDENT VARIABLE	INTERVENING VARIABLE	DEPENDENT VARIABLE
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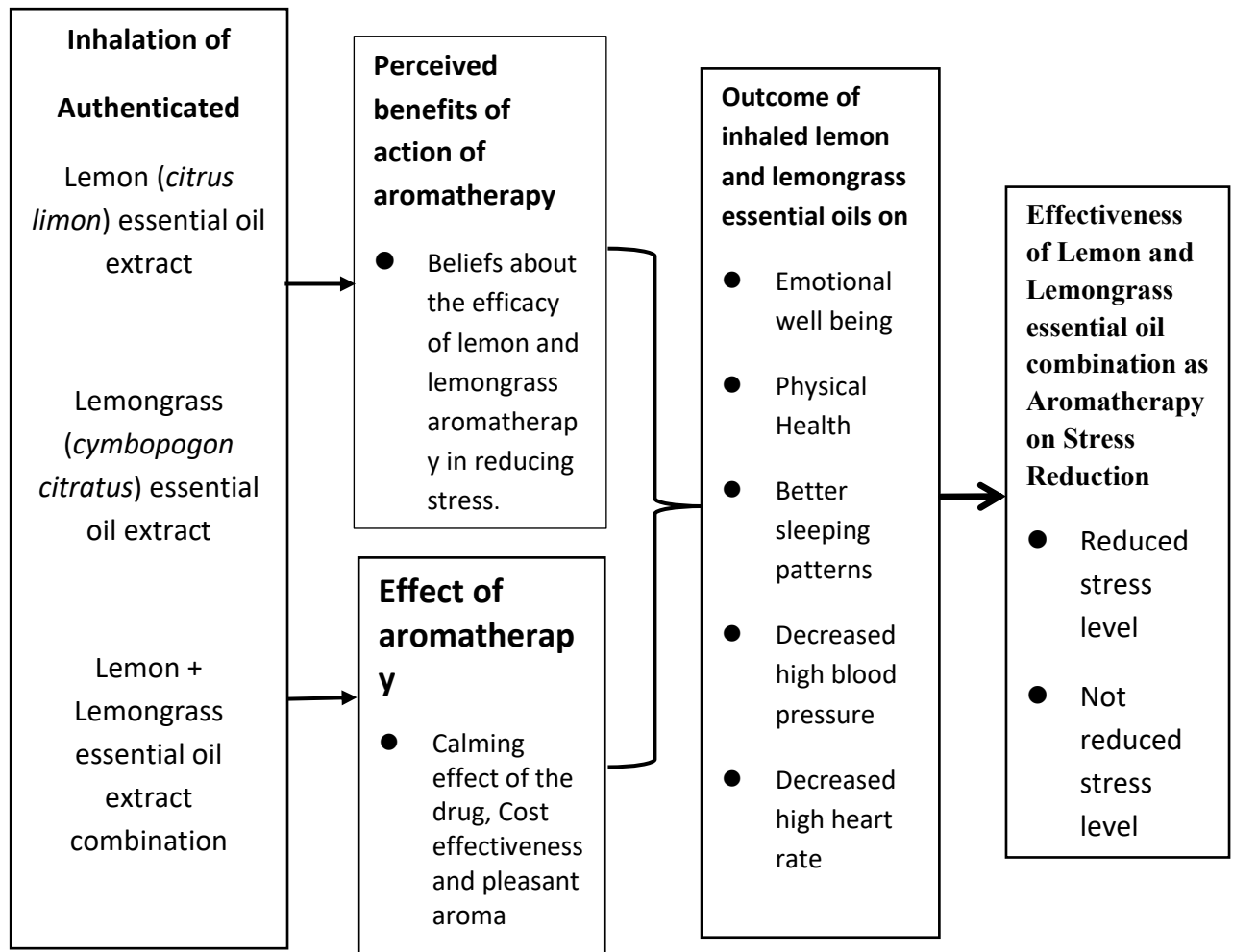


Figure 1.1: Theoretical framework adapted from Nola Pender Health Promotion Model (1982)

1.7.3 Integrating the Health Promotion Model and Stress Management

In the context of Nola Pender’s HPM, the independent and dependent variables can be clearly defined as they relate to the intervention and its outcomes.

In this study, the independent variable was the use of lemon and lemongrass essential oils as an aromatherapy intervention. This was the primary factor being applied to assess its effectiveness in reducing stress. The use of the oils (frequency, dosage,

duration) was under the control of the researcher, and its effects on the stress levels of parents were being measured.

The dependent variable in this study was the stress level of the parents, which was expected to change as a result of the aromatherapy intervention. This variable was measured using a stress assessment tool. The changes in stress levels reflected the impact of the lemon and lemongrass aromatherapy.

1.7.4 Application in Nola Pender's Health Promotion Model (HPM)

In the HPM, the independent variable (aromatherapy) served as a health-promoting behavior that parents were encouraged to adopt to manage and reduce their stress. The dependent variable (stress reduction) represented the health outcome that was affected by engaging in this behavior. Pender's model explains how personal factors, perceptions of self-efficacy, and environmental influences can either facilitate or hinder the adoption of health-promoting behaviors like aromatherapy.

- **Perceived Benefits of Aromatherapy:** Influences whether parents engage in the intervention (independent variable) and thus experience stress reduction (dependent variable).
- **Perceived Barriers:** If parents perceive challenges (e.g., cost or access), it could affect the degree of participation in the aromatherapy intervention and, consequently, the outcome.
- **Self-Efficacy:** How confident parents feel about using aromatherapy regularly may directly influence the extent of stress reduction.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides a review of literature covering complementary and alternative medicine, aromatherapy, intellectual disability, stress, the extraction and verification of chemical constituents in essential oils, the impact of essential oils on stress reduction, and factors that encourage the adoption of aromatherapy.

2.1 Background of the Study

The National Center for Complementary and Alternative Medicine (NCCAM) defines complementary and alternative medicine (CAM) as a broad range of medical interventions, practices, products, or disciplines that typically fall outside the scope of conventional medicine (NCCAM, 2015). The National Center for Complementary and Integrative Health (NCCIH) further clarifies that non-conventional practice used alongside conventional medicine is often regarded as complementary, while non-mainstream approaches used instead of conventional medicine are typically labeled as alternative. The use of a combination of conventional and complementary methods is referred to as integrative. Moreover, as stated by the NCCIH, there are five significant categories of CAM known as Alternative Medical Systems which are built upon complete theories and practices and they include homeopathy, naturopathy and traditional Chinese medicine (TCM). Additionally, there are Mind-Body Interventions designed to strengthen the mind's impact on physical functions and symptoms, such as meditation, biofeedback, and hypnosis. Biologically Based Therapies utilize natural substances like herbs and dietary supplements, to promote good health. Manipulative and Body-Based Methods use techniques like chiropractic care, massage, and yoga to focus on physical manipulation and movement (NCCIH, 2018). According to the

World Health Organization (WHO), traditional medicine involves practices and knowledge concerning health rooted in cultural beliefs and experiences, whereas complementary medicine encompasses health practices that are not integrated into a country's conventional medicine.

Complementary and alternative medicine (CAM) involves a wide variety of healthcare practices that are not integrated into conventional medical systems and primary healthcare. The First WHO Traditional Medicine Global Summit in August 2023 in India, held concurrently with the G20 health ministerial meeting, sought to gather political commitment and evidence-based strategies to promote traditional medicine as a primary approach to addressing global health and well-being needs. Traditional and complementary medicine has been integral to health practices in many households and communities for millennia, contributing significantly to the foundation of modern medical knowledge. Approximately 40% of pharmaceutical products today originate from natural sources, with key medications derived from complementary and alternative medicine (WHO, 2023).

The WHO Traditional Medicine Strategy for 2014-2023 emphasized supporting Indigenous Peoples from diverse regions such as Australia, Bolivia, Brazil, Canada, Guatemala, New Zealand, and others, in harnessing the potential benefits of traditional and complementary medicine (T&CM) to promote good physical condition, wellness, and people-centered healthcare. The strategy aimed to improve how traditional and complementary medicine (T&CM) is safely and effectively used by regulating, researching, and integrating these practices, products, and practitioners into healthcare systems.

Complementary and alternative medicine therapies take an integrative approach to healing, typically do not report side effects, and have been widely used by people around the world for decades. The global utilization of CAM among the general population ranges widely from 10% to 75% (Harris *et al.*, 2012). According to the WHO, the poorest populations, with limited access to health services, tend to use CAM more frequently, particularly relying on medicinal plants outside the scope of conventional medical care (WHO, 2013). Given the rising interest in natural and complementary therapies, this study seeks to explore whether a combination of lemon and lemongrass aromatherapy can effectively reduce stress levels among these caregivers. Addressing caregiver stress is important not only for the well-being of the parents but also for improving the overall care environment for children with intellectual disabilities (Hassall *et al.*, 2015; Muriungi *et al.*, 2020).

2.1.1 Aromatherapy

A blend of "aroma," meaning scent, and "therapy," indicating treatment together derive the term Aromatherapy. Over the past few decades, aromatherapy has garnered considerable interest and recognition. Its importance and widespread use have led to its recognition as Aroma Science Therapy (Esposito *et al.*, 2014). Ancient cultures like those in India, China, and ancient Egypt have incorporated aromatherapy as a significant form of complementary and alternative therapy for centuries (Ali *et al.*, 2015). Aromatherapy harnesses essential oils, concentrated extracts derived from various parts of plants such as flowers, leaves, stems, fruits, and roots (Dunning, 2013).

Aromatherapy involves using essential oils, volatile compounds extracted from plants, as a complementary therapy to improve physical, mental, and emotional well-being. These natural oils have been shown to positively impact both the mind and body (Brennan *et al.*, 2022). The term "Aromatherapy" was coined by French perfumer René

Maurice Gattefossé in 1928. Gattefossé discovered the therapeutic properties of essential oils when he accidentally burned his hands during a laboratory filtration process. Seeking relief, he submerged his hands in lavender oil, which promptly alleviated the pain and promoted rapid healing of the wound, leaving minimal scarring (Walters, 1998).

Aromatherapy is experiencing rapid growth as a popular complementary therapy worldwide, with Americans reportedly spending over \$30.2 billion annually on such treatments (Pace, 2020). The global market for complementary and alternative therapies predicts to reach \$5 trillion by 2050 (Swamy *et al.*, 2016). It has gained attention as a complementary and alternative therapy for stress management due to its affordability, ease of use, and non-invasive nature (Cavanagh & Wilkinson, 2002; Lee *et al.*, 2016). Aromatherapy is utilized to manage and prevent various medical conditions affecting the central nervous system (CNS). Research indicates that these ethereal oils possess anticonvulsant, antiviral, and anticancer properties (Nunes *et al.*, 2015). Moreover, they have been demonstrated to effectively lower anxiety, stress, and other negative emotions, thereby improving both biopsychosocial well-being (Li *et al.*, 2022). The effectiveness of essential oils in the body varies depending on their method of administration, such as inhalation, oral ingestion, or absorption via the skin.

Essential oils, such as lemon and lemongrass, are particularly noted for their calming and stress-relieving properties. Lemon essential oil is recognized for its mood-enhancing effects (Khan *et al.*, 2020), while lemongrass has been shown to promote relaxation and reduce anxiety (Khan *et al.*, 2016). Aromatherapy works by stimulating the olfactory system, which sends signals to the brain, particularly the limbic system, responsible for controlling emotions and stress responses (Moss *et al.*, 2010).

2.1.1.1 Aromatherapy in Nursing

Aromatherapy was first introduced by Florence Nightingale and other nursing theorists integrated this form of therapy in their theories. A few essential oils, such as lavender (*Lavandula angustifolia*) and chamomile (*Anthemis nobilis*), enhance relaxation and improve sleep. These oils can be used topically by applying them to the skin through massage, often diluted with carrier oils such as almond or jojoba oil. They can also be inhaled through the nose for their therapeutic effects. For promoting relaxation and improving sleep, placing a drop of lavender, chamomile, or sweet marjoram oil soaked onto a small ball of cotton and positioning it inside or under a pillow can be beneficial (Gnatta, 2011).

Hildegard Peplau advocated for nursing to emphasize the nurturing of interpersonal relationships within care settings, transforming these interactions into opportunities for personal growth that can be mutually shared by nurses and patients (McEwen & Willis, 2009). Peplau's theory supports using essential oils such as Melissa oil (*Melissa officinalis*) to aid patients in coping with stressful situations, helping them manage emotional trauma (Tisserand, 2004). Callista Roy developed a model where individuals are seen as systems capable of adapting to their environment by mobilizing their skills to create changes (McEwen & Willis, 2009). Aromatherapy can support this adaptation and coping process. For example, geranium essential oil (*Pelargonium graveolens*) can be employed to help stabilize emotions after experiencing traumatic events (Smith & Kyle, 2008). Aromatherapy, as advocated by Brazilian theorist Wanda Horta, aims to restore harmony. For example, bergamot essential oil (*Citrus bergamia*) can be diffused into the environment or added to bathwater to alleviate anxiety, improve depressive feelings, and provide a refreshing sensation that restores bodily balance (Tisserand, 2004).

Katharine Kolcaba's Comfort Theory underscores the nurse's responsibility in evaluating and meeting patients' comfort requirements across physical, psycho-emotional, social, and environmental dimensions (Kolcaba, 2003). By implementing interventions that holistically meet these individual needs, patient comfort can be enhanced. Aromatherapy is utilized in nursing as an intervention to enhance patient comfort, addressing both psychological and physical needs, promoting relaxation, tranquility, and overall well-being. For instance, clove oil (*Syzygium aromaticum*) not only relieves physical pain but also offers antiseptic properties when used in the environment. Additionally, lavender oil used in massage has been shown to effectively reduce anxiety in psychiatric patients, as evidenced by decreases in heart and respiratory rates among hospitalized individuals (Domingos & Braga, 2015).

2.1.2 Essential oils

According to the WHO, herbal medicine encompasses herbs and herbal materials, that are made into finished products that contain plant parts or combinations thereof as their active constituents. These products can be processed into liquids, powders, capsules, tablets, or ointments. Herbal medicines are not only used for treating illnesses but also for maintaining or enhancing health (WHO, 2008). Essential oils are categorized into top, middle and base notes (International Medical Aromatherapy Association, 2018). The time span of a fragrance depends highly on the type of essential oil, with top note oils evaporating quickly within 3 hours of application. The ethereal oils used in this research were derived from lemon (top note) and lemongrass (top note).

Essential oils are composed of complex mixtures of secondary metabolites produced by aromatic plants. These compounds serve various purposes, including defense against plant invaders, interaction with symbiotic organisms, and attraction of insects for pollination (Wink, 2018). These are composed of volatile fat-soluble constituents

(Alboofetileh *et al.*, 2014; Bilia *et al.*, 2014) that are less dense than water and dissolve in organic solvents such as benzene, toluene, acetone, ethanol, and methanol (Hassan & Mujtaba, 2019). Each essential oil comprises a complex combination of compounds, giving each plant its distinctive odor and flavor (Wink, 2018).

Essential oils, also known as ethereal oils, are aromatic liquids naturally produced by plants, known for their distinctive smells. These oils are found in oil sacs within different plant parts like leaves, bark, buds, seeds, peels and flowers. They consist of a concentrated, hydrophobic blend of volatile hydrocarbon compounds that readily evaporate at room temperature, allowing for easy inhalation through the olfactory system. Most volatile oils are extracted using hydro-distillation or steam methods, although cold-pressed or expressed methods are typically used for oils from fruit rinds, such as those from citrus fruits (Herman *et al.*, 2019). The use of essential oils originated in the medical field, deriving its name from the ancient Latin term "quinta essentia," meaning the fifth element. This fifth element was believed to be the life force, complementing the four classical elements namely air, earth, fire and water. Essential oils were believed to capture this spiritual essence of plants and were used historically for their perceived medicinal benefits (Sell, 2020).

Throughout history, essential oils have been valued for their aromatic qualities and believed therapeutic effects on mental, physical, and spiritual well-being. Ancient civilizations like Egypt and China have long employed aromatherapy as a widely accepted complementary and alternative therapy (Ali *et al.*, 2015). The preference for medicinal plants is often driven not only by their local availability but also by their perceived health benefits, as they are considered natural and free from the adverse effects associated with many conventional medicines (Santos *et al.*, 2011). These scents have been utilized in treating and managing various disorders (Tisserand &

Young, 2014). Research has shown that olfactory stimulation through inhaling fragrances has multiple psychophysiological effects on humans, including reducing headaches, pain, and insomnia. Essential oils can be used in little quantities through methods such as inhalation, massage, or direct skin application. These versatile oils offer a range of benefits and can be incorporated into daily wellness routines (Heerz, 2009; Angelucci *et al.*, 2014). For example, Lavender (*Lavandula angustifolia*) essential oil predominantly contains monoterpenoids like camphor, linalyl acetate, 1,8-cineole, β -ocimene, terpinen-4-ol, and linalool, which contribute to its aromatic and therapeutic qualities (Sharma *et al.*, 2019).

2.1.2.1 Different pathways of essential oil intake

Essential oils can be administered in different ways to achieve their desired effects. Inhalation involves using the olfactory system, where chemical compounds are absorbed through both the nose and, to a lesser extent, the skin. Topical application refers to applying essential oils directly onto the skin, primarily utilizing the skin as the main absorption route, while the aroma also reaches the olfactory system. Oral ingestion involves taking essential oils orally, primarily through the digestive system, with secondary absorption occurring through the olfactory system via the retro-nasal route from the mouth and stomach. The effectiveness of these administration routes depends on the specific chemical contents of the essential oil (Koyama *et al.*, 2019).

When essential oils are inhaled, their molecules activate olfactory nerves, which directly connect to the limbic system (Walters, 1998). Fragrances, characterized by volatile chemicals with a molecular weight below 300 Da, are detected via the olfactory system. In this process, fragrant molecules adhere to olfactory receptors in the nasal epithelium, activating guanine nucleotide-binding protein (G-protein) coupled receptors. These receptors generate electrical signals that travel via olfactory

sensory neurons to the brain, passing through the olfactory bulb and higher olfactory cortex (Angelucci *et al.*, 2014). As a result, the brain releases neurotransmitters like serotonin and endorphins, contributing to mood regulation. Nasal delivery of aromatherapy targeting the brain represents a promising treatment option for mental disorders (Krishna *et al.*, 2000). The olfactory and tactile stimulation from these oils can also enhance everyday activities such as eating and social interaction (Cino, 2014).

Figure 2.1 below shows the different pathways of essential oil uptake.

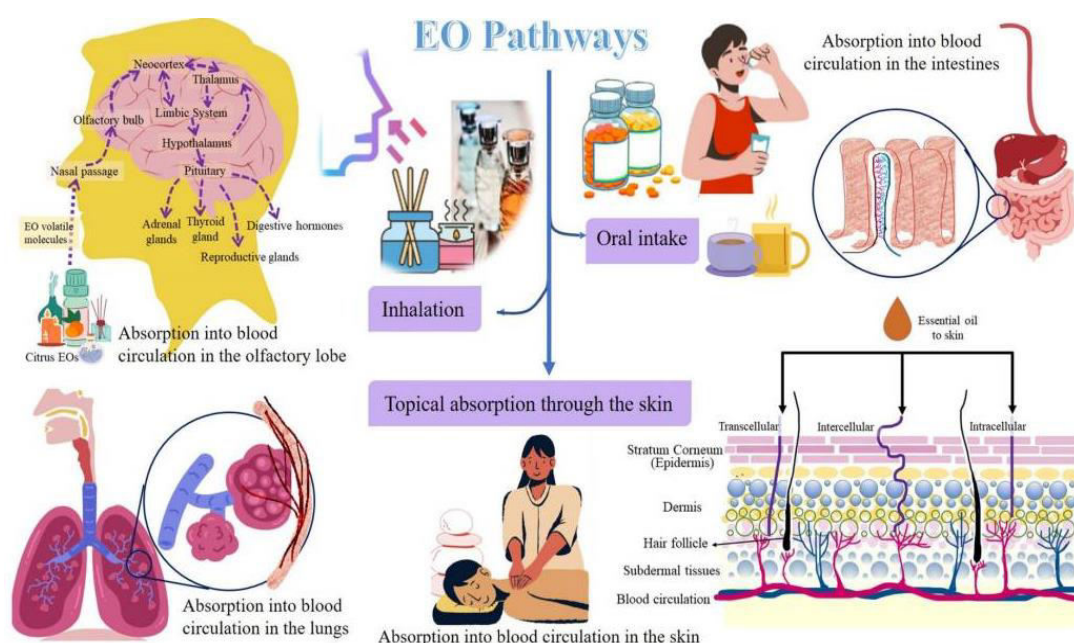


Figure 2.1: Essential oil intake by inhalation, oral and topical absorption
(Source: Agarwal *et.al.*, 2022)

2.1.2.2 Process of nasal olfactory chemoreceptors activation

This process starts with stimulation of olfactory special nerve cells that detect changes in the chemical composition of the blood and send information to the brain to regulate cardiovascular and respiratory functions, located in the nose and subsequent effects of these olfactory nerve transmissions on different brain regions. When essential oils are inhaled, they pass through the nasal passages, which are lined with thin tissues near the brain. The molecules from these oils can enter the bloodstream and reach the brain.

Odors activate specific receptors on olfactory sensory neurons, generating electrical nerve impulses that travel to the brain, facilitating the identification and distinction of various smells. Odor molecules bind to receptors on the olfactory epithelium, initiating an action potential. The process begins with the axons of sensory neurons extending and converging at the glomeruli, specialized clusters of nerve cells. Here, the axons form synaptic connections with mitral and tufted cells, which are crucial for processing olfactory information. The mitral and tufted cells then relay the signals to pyramidal neurons in the primary olfactory cortex, a critical part of the brain responsible for perception of smell. Furthermore, this sensory information does not only reach the olfactory cortex but also triggers activity in specific brain regions involved in processing and responding to odors. (Llorens, 2004).

The olfactory cortex is interconnected with several key brain regions: the amygdala, hippocampus, and hypothalamus. The amygdala is crucial for regulating aggressive behavior, hunger, thirst, and sexual activity. The hippocampus plays a significant role in processing emotions, learning new information, forming memories, and retaining odor-related memories. The hypothalamus is involved in managing critical physiological processes, such as blood sugar regulation, salt balance, blood pressure, and hormone secretion. Collectively, these interconnected areas are known as the limbic system. The olfactory cortex receives direct electrical signals from the olfactory system, which activate responses related to the perception of smells, memory recall, emotional reactions, and endocrine functions (Fung *et al.*, 2021). This integration illustrates how sensory input from odors can influence a wide range of physiological and emotional processes through the limbic system. Figure 2.2 shows the connection between essential oils and the olfactory cortex.

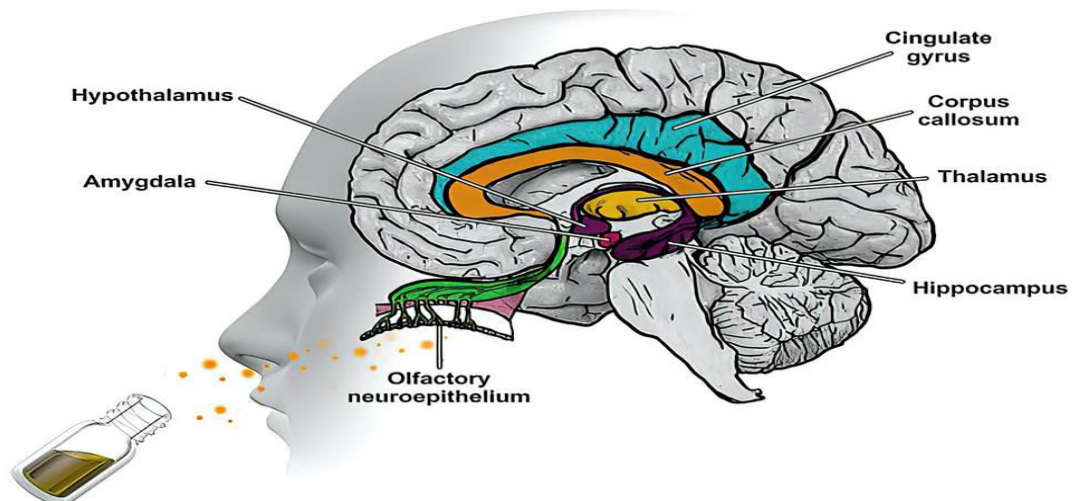


Figure 2.2: Essential oil and the olfactory cortex (Source: Releeph.com)

2.1.2.3 Process through which active essential oil (EO) molecules are absorbed into the neural pathway

The very minute highly inflammable molecules in essential oils are able to be relayed to the brain via extracellular or intracellular pathways. In the intracellular pathway, active EO molecules travel right through the neuronal pathways within the olfactory lobe. They bind to receptors on neurons, triggering receptor-mediated endocytosis, where the molecules are engulfed into vesicles and absorbed into the cell. The absorbed molecules are transported to the olfactory bulb via the axons with the help of endosomes.

In the extracellular matrix, active essential oil (EO) molecules diffuse through the spaces between olfactory sensory neurons and supporting cells, moving into the lamina propria, which is a layer of connective tissue. From the lamina propria, these molecules travel along the axons of neurons toward the brain. They manage to cross both the blood-brain barrier and the blood-cerebrospinal fluid barrier to reach various brain regions. Once inside the brain, essential oil molecules link with neuroreceptors, including transient receptor potential (TRP) channel proteins, as well as those for glutamate, GABA, serotonin (5-HT), and dopamine (DA). This interaction can lead to

effects such as reduced anxiety and improved mood (Fung *et al.*, 2021). This pathway illustrates how EO molecules can affect brain function and emotional states through their influence on neurotransmitter systems.

Aromatherapy influences mood by connecting the olfactory and limbic systems which stimulate endorphins and serotonin for release (Liu *et al.*, 2022), which have calming and relaxing properties that help reduce stress and anxiety. The limbic system affects various physiological functions, including hormone levels, heart rate, blood pressure, and breathing, through its interactions with the cerebral cortex. This interaction helps regulate emotional responses and contributes to feelings of calmness and relaxation (Karadag and Baglama, 2019).

2.1.2.4 Mode of Action of essential oils

The essential oils act on the olfactory nerve, which runs from the nose to the brain. Various aromas have been shown to effectively reduce stress. For instance, lavender oil is noted for its effective absorption through inhalation and its use in massage therapy, as demonstrated in numerous clinical studies showing positive results. It is recognized for its stress-reducing properties and ability to induce relaxation to the amygdala and hippocampus through the limbic system. It has also been found to relieve the stress that is as a result of watching a stressful video (Koulivand *et al.*, 2013; Tod & Matsuse, 2020). Linalool acts as a calming agent by modulating gamma-aminobutyric acid receptors in the central nervous system (Perry *et al.*, 2012). Furthermore, research has shown that linalyl acetate lowers blood pressure, heart rate, respiratory rate, and salivary cortisol levels. Lavender oil also affects neurotransmitters in the brain by enhancing the activity of gamma-aminobutyric acid, an inhibitory neurotransmitter (Seol *et al.*, 2013). Ylang ylang (*Cananga odorata* Hook. F. & Thomson) has shown to decrease elevated blood pressure and heart rate in

healthy men. This study also showed that ylang-ylang produced sedative effects where declination of 12-lead EKG demonstrated a decreased heart rate in a group of participants who treated with its essential oil (Jung et. al., 2013). A study by Wang (2012) indicated that sniffing *C. odorata* oil lowered the systolic and diastolic blood pressure and caused a reduction in pulse rate. Moreover, the study noted that the essential oil of the plant produced a relaxing effect, as evidenced by a decrease in the stress index following the treatment. In addition, another essential oil like Sweet orange (*Citrus sinensis*) has been shown to have anxiolytic effects on humans. Goes et. al., (2012) in their study found out that *C. sinensis* has an effect reducing anxiety and tension after the participants were exposed to 10 drops of the aroma as compared to exposure to only 2 drops. Furthermore, Rashidi-Fakari et. al., (2015) in their research found orange essential oil decreased anxiety level, lowered diastolic blood pressure and pulse rate of their study participants. A combination of Lemongrass and almond oil massage therapy was found to be effective on lowering blood pressure and pulse rate compared to baseline measurements (Kamkaen et. al., 2015).

2.1.2.5 Side effects of essential oils as aromatherapy

Aromatherapy entails the extensive application of essential oils obtained from plants, used for inhalation via the nose or direct topical application to the skin, aiming to enhance mental, physical, and spiritual well-being (Corazza et al., 2019). According to research from a general survey, many people turn to essential oils after unsuccessful conventional treatments, seeking alternative therapies, and considering oils like lavender, tea tree, and peppermint safer and more accessible than traditional treatments (Goodier et al., 2019). Although essential oils are commonly publicized as natural, it's crucial to recognize their complex composition, which can expose the skin to possible irritants. Using essential oils directly on the skin, incorporating them into personal care

products, or diffusing them has been associated with cases of atopic dermatitis, a common side effect with essential oil use, and phytophotodermatitis which is caused by essential oils from citrus fruits or bergamot (Shah *et al.*, 2019, Sindle & Martin, 2020). De Groot & Schmidt (2016) in their study found that approximately 80 essential oils can cause contact allergy.

2.1.2.6 Treatment of essential oil allergy

Use of essential oils in the form of aromatherapy can lead to irritant contact dermatitis, where the skin's epidermis is physically or chemically injured directly after topical application, unlike a delayed allergic reaction. Direct application of essential oils can cause contact or atopic dermatitis, characterized by eczematous papules and plaques, sometimes accompanied by vesiculation in severe cases or fissures in chronic cases. Patch testing is a useful method for identifying the irritant responsible (Sindle & Martin, 2020).

2.1.3 Intellectual Disability

Disability comes from the interrelationship between an individual's physical characteristics and the societal environment they live in (Disabilities WHO, 2015). Intellectual disabilities are lifelong conditions characterized by impairments in physical, learning, language, or behavioral abilities. These disabilities, which include conditions like cerebral palsy and Down syndrome, typically manifest in childhood, with symptoms such as language or motor skill delays evident by age two. Approximately 1% of the global population is affected by intellectual disabilities, with around 85% classified as mild. Males are more frequently diagnosed with intellectual disabilities compared to females (APA DSMV, 2013). The American Association on Intellectual and Developmental Disabilities (AAIDD) describes the emergence of intellectual disability during the developmental period, often before a person reaches

18 years, and is normally manifested by reduced cognitive ability (IQ < 70) and deficiencies in adaptive functioning, such as language and social skills, evaluated through standardized assessments. Both the AAIDD and the Diagnostic and Statistical Manual of Mental Disorders (DSM) jointly define intellectual disability as a developmental condition identified by significant deficits in intellectual functioning and adaptive behavior (American Psychiatric Association, 2013). The World Health Organization (WHO, 2015) outlines intellectual disability as a substantial impairment in understanding complex information, learning and applying new skills, leading to impaired social functioning, beginning in childhood and impacting long-term development.

Maternal health and nutrition significantly influence the development of intellectual disabilities (ID). Poor maternal nutrition, particularly during pregnancy, can lead to neuro-developmental deficits in children. A study in Kakamega County have shown that inadequate intake of essential nutrients such as folic acid, iron, and iodine is prevalent among pregnant women, contributing to higher rates of ID (Otieno *et al.*, 2022). Furthermore, families in Kakamega County with low socio-economic status often face challenges such as limited access to quality education, healthcare, and nutritious food. These limitations contribute to an environment where children are more susceptible to developmental delays and ID (Wamalwa & Were, 2021). Children identified with developmental disabilities typically need interventions to manage their behavioral and developmental difficulties (Boulet *et al.*, 2009).

Mothers of children with neuro-developmental disabilities undergo greater levels of stress, psychiatric issues, and poorer health compared to mothers of normally developing children (Miodrag & Hodapp, 2010). Mount & Dillon (2014) characterized

the stress faced by parents of children with disabilities as unique, involving ongoing feelings of crisis and daily challenges in addressing their child's developmental and behavioral needs.

Caring for these children can result in challenges related to family dynamics, increased parenting stress, and adoption of distinct parenting approaches compared to raising typically developing children (Cuzzocrea et al., 2013). Parents of children with developmental disabilities often experience poorer sleep quality, which serves as an indicator of parental stress (Davis et al., 2009; Gallagher et al., 2010). These parents also frequently experience psychological concerns and anxiety regarding their child's future (Nimbalkar et al., 2014). Research conducted by Baker et al. (2020) indicated that parents of children with intellectual disabilities endure significantly elevated emotional distress (Cohen's $d = 0.546$). In Kenya, Mbugua et al. (2011) discovered that over 50% of caregivers of children with intellectual disabilities were at risk of developing clinical depression. Similarly, in Malaysia, Shobana & Saravanan (2014) observed that approximately 52% of mothers caring for children with developmental disabilities faced mental health challenges, with mothers of children with intellectual disabilities reporting the highest percentage (62%) compared to those with autism spectrum disorder and Down syndrome.

2.1.3.1 Prevalence of Intelligence disability

The prevalence of intellectual disabilities, marked by challenges in intellectual functioning and adaptive behaviors, is notable among children globally, potentially rising due to advancements in medical care that enhance survival rates (Dave et al., 2017). According to WHO and the World Bank (2011), around 200 million people (2.6%) of the global population have intellectual disabilities (IQ below 75).

Reports in 2019 indicated a total of 316.8 million cases of developmental conditions among children and adolescents globally. Males represented 179 million cases, outnumbering females (137 million). Among males, the prevalence ranged from 32 million (< 5 years old) to 51 million (10–14 years old) and 49 million (15–19 years old). For females, the range was from 27 million (< 5 years old) to 37 million (15–19 years old).

Neurodevelopmental conditions were most prevalent among children under 15 years, varying from around 4 % (< 5 years) to 7 % (10–14 years). Disorders related to nervous system impairment, such as vision and hearing loss, also significantly contributed to prevalence estimates in children aged 5 years and older. The prevalent conditions linked with developmental disabilities included hearing loss, idiopathic developmental intellectual disability cerebral palsy, ADHD and vision loss. Idiopathic developmental intellectual disability was particularly common among 5–9-year-olds and 10–14-year-olds, each at 2%. ADHD prevalence ranged from 0.2% in children under 5 years old to 2.3% in those aged 15–19 years. Cerebral palsy showed the highest prevalence in the 0–5 age group at 1.6% and the lowest among 15–19-year-olds (WPP, 2019).

2.1.3.2 Signs and symptoms of Intelligence Disability

Signs and symptoms of intellectual disability typically become evident during infancy or early childhood. These indicators vary based on the onset age, underlying cause, and severity of cognitive impairment (Patel *et al.*, 2018). Infants and young children with severe intellectual disability often exhibit symptoms early on, which are closely related to the specific underlying condition while on the other hand, those with a mild form of intellectual disability may not be recognized to have the condition until later in life. Physical examination of individuals with intellectual disability may reveal

abnormal findings such as unusually large or small head size (macrocephaly or microcephaly), distinctive facial features with multiple birth defects, or challenges with feeding. Infants with intellectual disability often exhibit delays in gross motor skills, while preschool and early school-age children commonly show difficulties in learning, language development, and academic skills (Shapiro & O'Neill, 2020).

2.1.3.3 Effects of intelligence disability on parents and caregivers

Parenting children with intellectual disabilities can present challenges in family dynamics, heightened parenting stress, and often necessitates the adoption of a distinct parenting approach as opposed to raising typically developing children (Cuzzocrea *et al.*, 2013). Studies examining families raising children with profound intellectual and multiple disabilities (PIMD) have found that both mothers and fathers dedicate significantly more time to taking care of these children when compared to parents of typically developing children. This increased care giving burden often leads to significant psychological distress, particularly anxiety and depression, among parents and other family members, including siblings (Luijckx *et al.*, 2017; Azeem *et al.*, 2013). Raising a child with congenital developmental issues in a family can lead to various social challenges. These include parental anxiety about the future, negative impacts on siblings, psychological stress, reduced social interactions with neighbors and relatives, intra-family misunderstandings, and economic burdens.

These reactions put parents a huge amount of stress that chronically affects their lives (Kuldeep *et al.*, 2016). Regular exposure to stress causes a restructuring of stress-regulating pathways, resulting in enduring effects on various bodily functions and promoting the release of pro-inflammatory cytokines, which can initiate inflammation (Marin *et al.*, 2011; Hori & Kim, 2019). The adverse health impacts of ongoing stress

are particularly significant for individuals experiencing high levels of cumulative stress across multiple aspects of life over an extended period (Haight *et al.*, 2023).

2.1.3.4 Management of Intelligence disability

Intellectual disability incidence can potentially be reduced by improving prenatal care, ensuring prompt accessibility to maternal and child health services, implementing newborn screening for metabolic disorders, and enhancing immunization rates through maternal education and awareness (Shapiro & O'Neill, 2020). Efforts should focus on identifying and addressing treatable causes of intellectual disability, such as hearing impairment and spasticity. Kishore *et.al.*, (2019) researched on pharmacological and non-pharmacological management of intelligence disability and found that there are some medication for comorbid disorders in intelligence disability like methylphenidate used in ADHD, and antipsychotics for schizophrenia. Non-pharmacological interventions for managing intellectual disability involve a lifespan approach that addresses developmental needs and milestones necessary for adapting to the environment at each stage. Providing parents and families with accurate information about the nature, requirements, and management of intellectual disability and its associated conditions is crucial.

Currently, there is limited research on the effects of essential oils extracted from Kenyan plants on physiological and emotional well-being. Studies conducted elsewhere have utilized massage techniques to explore how various essential oils affect physiological variables like blood pressure and heart rate (Masubuchi *et al.*, 2019). This study represents quasi-experimental research in Kenya to explore the potential stress-reducing effects of essential oil extracts from lemon, lemongrass and their combination on parents of children with intellectual disabilities.

2.1.4 Stress

The term "Stress" denotes a negative emotional state accompanied by noticeable physiological, cognitive, and behavioral changes that affect one's perception and ability to cope with a challenging situation (Wang *et al.*, 2011). Acute stress is characterized by increased heart rate, elevated blood pressure, digestive issues, headaches, panic attacks, and in severe cases, heart attacks or arrhythmias. Chronic stress, on the other hand, leads to difficulties in concentration, irritability, fatigue, increased risk of cardiovascular disease, adoption of harmful health behaviors such as use of cigarettes, eating disorders, depression, and reduced social interaction (American Psychological Association, 2013).

Stress, broadly defined as a disruption to homeostasis caused by actual or perceived threats, is an inevitable part of life for all organisms. In humans, stress can manifest physiologically or psychologically, stemming from both positive and negative experiences. When faced with a stressor, the body activates a coordinated response across multiple systems to minimize its impact on the organism. While this stress response is essential for adaptation and survival, frequent or prolonged activation can lead to dysregulation. This chronic stress may contribute to a variety of health issues, including heightened risk for developing depression, immune system dysfunction, sleep disturbances and chronic health conditions such as cardiovascular diseases, high blood sugar, cancer, cognitive decline, and brain degenerative disorders (McEwen, B. S., & Akil, H. (2020; Lupien *et. al.*,2018).

Acute stress initiates responses in both the neural and endocrine systems following the brain's reception of stress-related sensory information. The Autonomic Nervous System (ANS) promptly engages its sympatho-adrenomedullary component, leading to swift but short-lived alterations in physiological conditions. These changes include

a rise in heart rate, breathing rate, and blood pressure, along with the release of catecholamines such as norepinephrine (NE) and epinephrine. These responses help the body react effectively to perceived threats (Ulrich-Lai & Herman, 2009). Subsequently, the Hypothalamic-Pituitary-Adrenocortical (HPA) axis is triggered in response to stress, resulting in a rise in glucocorticoid hormones in the bloodstream. These hormones typically reach their highest levels approximately 25 to 29 minutes after an individual is exposed to a stressor (Dedovic *et al.*, 2009). This activation of the HPA axis ensures a continuous hormonal reaction that facilitates energy conservation, involving both the sympathetic nervous system and various brain regions. Corticotropin-releasing hormone (CRH) and arginine vasopressin (AVP), synthesized in the paraventricular nucleus and released into the hypophyseal portal system, activate the anterior pituitary gland to secrete adrenocorticotrophic hormone (ACTH). This hormone, in turn, stimulates the adrenal cortex to release glucocorticoids. During acute stress responses, glucocorticoids regulate the secretion of CRH and ACTH via a negative feedback mechanism.

Nevertheless, prolonged exposure to stress results in continued production of glucocorticoids, which can adversely affect metabolic, hormonal, and immune functions, potentially leading to pathological conditions. The Microbiome-Gut-Brain (MBM) axis is involved in regulating stress hormone levels to maintain them within a healthy range and may influence the release of CRH and ACTH, thereby promoting mental relaxation. Figure 2.3 below depicts the HPA axis under conditions of chronic stress, with solid arrows indicating positive regulation, dotted lines representing negative feedback mechanism, and dotted arrows indicating normalizing effects.

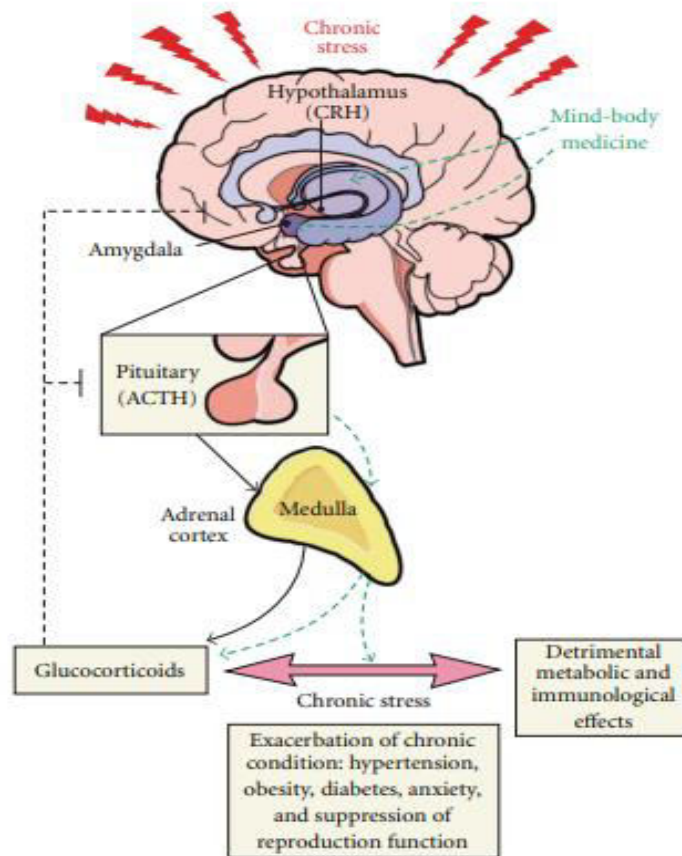


Figure 2.3: HPA axis activation and stress manifestation (Source: Hakima Amri, PhD)

2.1.4.1 Effects of stress among parents and caregivers of children with intelligence disability

Research conducted in India by Gupta & Kaur (2010) found that parents of children with intellectual disabilities undergo considerable psychological stress more than physical stress. Many of these parents face ongoing emotional strain, underscoring the critical necessity for interventions (Fletcher, 2015). According to Ramasubramanian et al. (2020), in their study on mothers of children with intellectual disabilities, these mothers frequently reported higher levels of burden and depression compared to fathers, particularly among parents of non-school-going children compared to those whose children attended special schools. Hunt et al. (2021) investigated parenting stress among caregivers in households with disabled children and concluded that

caregivers of children with disabilities experienced more stress than those caring for non-disabled children.

Several factors can contribute to the stress encountered by parents raising children with intellectual disabilities, including low self-esteem, inadequate family support, social withdrawal, and financial challenges. Each parent adopts a unique coping style to manage these circumstances, but reliance on emotion-focused coping strategies may increase the risk of psychiatric issues. In contrast, employing problem-focused coping methods could potentially improve how parents manage their stress levels (Sheikh *et al.*, 2018).

Coping is one of the ways that parents and caregiver of children with intelligence disability manage their stress. Jaiswal *et.al.*, (2018) in their study on stress management strategies used by PCID in India found that these parents used escape avoidance and Problem-solving to manage their stress. These mechanisms were used because they enabled the parents to regain emotional equilibrium during the stressful experience.

2.2 Chemical content of Essential oils

Essential oils typically contain various components such as terpenes, alcohols, esters, and alkaloids, among others. These low molecular weight compounds are volatile and are known for their pharmacological activities, including analgesic, anti-inflammatory, and antiviral properties. Citrus fruits rank among the most globally significant crops, as reported by the Food and Agriculture Organization (FAO, 2016). The genus Citrus, belonging to the Rutaceae family, encompasses approximately 140 genera and 1300 species, with Citrus limon (Lemon) being a prominent species within this genus (Kamal *et al.*, 2011).

Essential oils obtained from extracts of the peels and leaves of citrus plants like lemon contain a wide array of valuable natural compounds, including mixtures of hydrocarbons, oxygenated compounds, and non-volatile residues. These components comprise terpenes, sesquiterpenes, aldehydes, alcohols, esters, and sterols. The chemical compounds present in essential oils are thoroughly researched for their potential uses in both the food industry and pharmaceutical applications.

Monoterpenes, sesquiterpenes, and diterpenes fall into the terpene category. Monoterpenes are produced by the concatenation of two isoprene units in a linear manner whereas sesquiterpenes result from the fusion of three isoprene units. Diterpenes are structured from four linked isoprene units (Ntalii et. Al., 2011). In this study, **(6)** γ - terpinene (2.46%) was found as a component in lemon essential oil. Monoterpenes exhibit key therapeutic properties such as antibacterial, analgesic, stimulant, and expectorant effects. They are predominantly found in essential oil plants as unsaturated hydrocarbons (C₁₀). Monoterpenoids, which are oxygenated forms of monoterpenes, include alcohols, ketones, and carboxylic acids as functional groups (Espina *et al.*, 2011).

Sesquiterpenes, which are a class of organic compounds that consist of three isoprene units, are derived from farnesyl pyrophosphate, an interposed compound in the biosynthesis of terpenoids, sterols, and other terpenes through both mevalonate and nonmevalonate pathways in organisms. These substances can take on linear, monocyclic, or bi- and tricyclic structures. Linear variations, termed farnesenes, are branched hydrocarbons characterized by four double bonds (Fornari *et al.*, 2012). Typical farnesenes identified in essential oils encompass alpha-farnesene and beta-farnesene.

Farnesol, a primary alcohol, and aldehydes such as α -sinensal and β -sinensal are oxidation products of farnesenes, typically present in minor amounts in a variety of essential oils of Citrus species, including Kenyan lemon essential oil (0.03%). Monocyclic sesquiterpenes encompass bisabolene groups with a six-membered ring structure, including isomers like Z- α -bisabolene, β -bisabolene, E- γ -bisabolene, and Z- γ -bisabolene, which are found in several essential oils (Rao, 2006). For example, Kenyan lemon essential oil contains β -bisabolene at 0.02%. Bicyclic bergamotenes have a structure similar to pinenes, featuring a cyclobutane ring. Trans- α -bergamotene is found as a minor component in lemon essential oil and lodgepole pine (*Pinus contorta*), but it is a major constituent in *Pimpinella affinis* (Faraht *et al.*, 2011).

Diterpenes are compounds that consist of four isoprene units and are mostly found in essential oils. They are characterized as dense and non-volatile, meaning they do not readily evaporate during the steam distillation process used to extract aromatic oils. As a result, they are seldom isolated in these oils. Diterpenes are ubiquitous across all plant families and possess a chemical structure composed of C₂₀. There are approximately 3000 identified diterpenes categorized into different primary structural types. Derivatives from diterpenes are found in plant hormones and phytol, frequently appearing as side chains in chlorophyll (Caniard *et al.*, 2012).

Alcohols found in essential oils exhibit antiseptic, antiviral, antibacterial, and germicidal properties, often occurring as standalone components or in combination with terpenes or esters. Alcohols form when terpenes attach to hydrogen and oxygen atoms within their hydrocarbon structure. Monoterpenols specifically refer to monoterpene compounds that contain hydroxyl groups. These alcohols are generally regarded as safe for use due to their low toxicity and minimal risk of adverse reactions when applied to the skin or ingested (Bou *et al.*, 2013).

Esters in essential oils result from the interaction between alcohols and acids, contributing soothing and balancing effects. In medical applications, esters are known for their antifungal properties and sedative effects, which help balance the nervous system. Typical esters identified in essential oils include bergamiol and geranyl methanoate which are commonly found in oils such as lavender and geranium (Rao, 2006).

2.2.1 *Citrus limon* (L.) Burm. F.

C. limon is a citrus plant species classified within the Rutaceae family whose systematic classification is as shown in Table. 2.1

Table 2.1: Systematic Classification of *Citrus limon* (L.) Burm. F. (Taxonomy)

Classification	Name
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Spindales
Family	Rutaceae
Genus	Citrus
Species	Citrus x limon (L.) Osbeck

The lemon tree, scientifically known as *Citrus limon* (L.) Burm. f., typically grows to a height of approximately 3 meters. This plant has narrow, evergreen leaves and blooms with white flowers tinged with purple along the petal edges. These flowers grow in small clusters or individually at the junctions of its leaves. This fruit appears as an elongated oval berry initially green in color, turning yellow as it ripens. It contains juicy pulp segmented similar to an orange inside. Figure 2.4 below shows the lemon fruit and leaves.



Figure 2.4: Lemon tree and fruit (Source: Koppert.co.ke)

The outer layer of a lemon's peel is a thin, waxy exocarp. Below this outer layer is the flavedo, which contains oil vesicles and carotenoid pigments. The albedo lies beneath the flavedo and consists of spongy, white parenchyma tissue. This spongy tissue divides the endocarp, or fruit flesh. Lemon oil, with a color ranging from colorless to yellow and emitting a strong lemon scent, is obtained by the process of cold-pressing the fresh exocarp parts of the lemon peel (exocarpium) (Millet, 2015).

2.2.1.1 Geographical Distribution of *Citrus limon* (L.) Burm. F

Citrus limon has been grown in the southern parts of Italy since approximately the 3rd century AD, and it has been grown in Iraq and Egypt since around 700 AD. It was introduced to Spain by the Arabs, where cultivation has been ongoing since 1150. Marco Polo introduced *C. limon* to China in 1297, and Christopher Columbus introduced it to North America through seeds in 1493. Commercial cultivation of the lemon plant started in Florida and California during the 19th century. Its botanical synonyms include *C. limon* (L.) Osbeck and *C. jambhiri* Lush (Citrus pages, Updated 20 March 2021).

2.2.1.2 Phytochemistry of *Citrus limon* (L.) Burm. F

The essential oil of *Citrus limon* primarily contains monoterpenoids. When extracted from the lemon fruit's peel, the oil is predominantly composed of 1-Methyl-4-(1-methylethenyl) cyclohexene (limonene) (69%), (1S,5S)-2(10)-Pinene (β -pinene) (11%), gamma-terpinene (8.2%), sabinene (4%), 7-Methyl-3-methylene-1,6-octadiene (myrcene) (3%), 2,6-Octadienal (geranial E-citral) (3%), 3,7-dimethyl-2,6-octadienal (neral Z-citral) (1.5%), and 3,7-Dimethylocta-1,6-dien-3-ol (linalool) (1.4%). In addition, it includes linear furanocoumarins, known as psoralens, and polymethoxylated flavones. In contrast, the essential oil extracted from *Citrus limon* leaves has a different composition. Key components in this oil include 1-Methyl-4-(1-methylethenyl)cyclohexene (limonene) (31%), sabinene (15%), 6-Octenal, 3,7-dimethyl- (citronellal) (11%), 3,7-Dimethylocta-1,6-dien-3-ol (linalool) (4.6%), 3,7-Dimethyl-2,6-octadienal (neral) (4.5%), trans-3,7-Dimethyl-2,6-octadien-1-ol (geranial) (4.5%), E- β -ocimene (3.9%), 7-Methyl-3-methylene-1,6-octadiene (myrcene) (2.9%), 7-Octen-1-ol, 3,7-dimethyl- (2.3%), .beta-caryophyllene (1.7%), terpene-4-ol (1.4%), 2,6-Dimethyl-2,6-octadien-8-ol (geraniol) (1.3%), and alpha-pinene (1.2%) (Russo *et al.*, 2015; Kaskoos, 2019). This variation in chemical composition between the fruit peel and leaf oils reflects how different parts of the plant can produce essential oils with distinct profiles and potentially varying therapeutic properties.

The makeup of volatile and non-volatile compounds in ethereal oils derived from *Citrus limon* varies significantly depending on geographic location, extraction methods, and analytical approaches employed. Mehl et al. (2014) conducted a study to explore the possible effects of these compounds for classification purposes. The researchers analyzed the volatile compounds present in cold-pressed lemon oils using

advanced analytical techniques. They utilized gas chromatography coupled with flame ionization detection and mass spectrometry (GC-FID/MS) to identify and quantify these volatile substances. Additionally, they applied Fourier Transform Mid-Infrared Spectroscopy (FT-MIR) to examine these compounds. For the study of non-volatile residues, the researchers employed FT-MIR in combination with proton nuclear magnetic resonance (¹H-NMR) and Ultra-High Performance Liquid Chromatography-Quadrupole Time-of-Flight Mass Spectrometry (UHPLC-TOF-MS). This approach allowed them to analyze the non-volatile components with high precision and sensitivity. By utilizing these advanced techniques, the study was able to comprehensively identify and quantify both the volatile and non-volatile components of lemon oils. GC-FID/MS and FT-MIR are particularly effective for analyzing the aromatic compounds and essential oil fractions, while UH-NMR and UHPLC-TOF-MS provide detailed information on the non-volatile residues and complex molecular structures. This combined approach allows for a thorough understanding of the chemical composition of lemon oils, including both their fragrant volatile components and their more stable, non-volatile constituents. Their research effectively differentiated and classified samples based on their origin and extraction methods. The study highlighted that essential oil from Italian Citrus limon fruit is notably rich in compounds such as alpha-thujene, alpha-pinene, and alpha-terpinene, along with sesquiterpenoids like beta-caryophyllene and furocoumarins like bergamottin. These components are significant because they contribute to the unique aromatic and therapeutic properties of the Italian lemon oil. In contrast, essential oils extracted from *Citrus limon* fruits obtained from Spain and Argentina are characterized by their high terpene content, with limonene being especially prevalent. However, these oils exhibit differences in the levels of other compounds like imperatorin and byakangelicol.

Specifically, Spanish Citrus limon oil is distinguished by its higher concentrations of camphor and 4-terpineol, which can influence its scent and effects. On the other hand, Argentinian *Citrus limon* oil contains elevated amounts of sabinene and cis-sabinene hydrate, which contribute to its distinct aroma and potential benefits.

2.2.1.3 Therapeutic Actions of *Citrus limon* GC-MS Compounds

Lemon, scientifically classified as *C. limon*, is an important pharmaceutical plant within the Rutaceae family. It has a rich historical use in traditional medicine for treating ailments such as common colds, irregular periods, and hypertension. The bioactive compounds responsible for its therapeutic effects, particularly in the fruit and juice, are primarily flavonoids (Singh *et al.*, 2020). The chemical composition of lemon essential oil offers various health benefits, largely due to its prominent component, D-limonene. This compound has been demonstrated to effectively manage high cholesterol and high blood sugar levels. Research indicates that administering D-limonene at approximately 400 mg/kg daily for a month can significantly lower LDL cholesterol levels in male rats, prevent lipid buildup, and aid in blood sugar regulation. These effects are partly attributed to its antioxidant properties (Millet, 2014). Furthermore, inhaling 0.5% and 1.0% concentrations of D-limonene has shown significant calming and anxiety-reducing effects in mice. This is achieved through its action on serotonin and dopamine receptors in the brain, which play crucial roles in mood regulation and emotional well-being (Lima *et al.*, 2013).

D-limonene has shown promising antidiabetic effects, as demonstrated in a study involving hyperglycemic rats induced by streptozotocin. For a duration of 45 days, D-limonene was given orally at three daily doses of 50, 100, and 200 mg/kg of body weight, alongside glibenclamide. The results revealed that D-limonene consistently

reduced blood glucose levels, with the most significant decrease observed at the 100 mg/kg body weight dose. Additionally, in these hyperglycemic rats, administration of D-limonene led to an increase in the activity of gluconeogenic enzymes, including glucose 6-phosphatase and fructose 1,6-bisphosphatase. At the same time, it reduced the activity of the glycolytic enzyme glucokinase and decreased liver glycogen levels. These effects were notably more pronounced at the 100 mg/kg dose compared to the lower doses (Murali & Saravanan, 2012). Other chemical compositions and properties of lemon essential oils re shown in Table 2.2.

Table 2.2: Therapeutic Actions of *Citrus limon* GC-MS Compounds

Name of the compound/synonym	Activity
β -Myrcene	Anti-inflammatory, anxiolytic, antioxidant, anti-ageing, analgesic
D-Limonene	Antioxidant, anticancer, anti-inflammatory, cardioprotective, antidiabetic, gastroprotective, hepatoprotective, immune modulatory, anti-fibrotic, anti-genotoxic
β -Phellandrene	Anti-inflammatory, anti-depressant, analgesic and anti-cancer
β -Ocimene	Uplifting effects, anti-convulsant, anti-inflammatory, anti-viral, and anti-fungal properties.
γ -Terpinene	Antifungal qualities and antioxidant properties
Linalool	Antidepressant agent, antimicrobial, anti-inflammatory, anti-cancer, anti-oxidant
Isogeranial	Antineoplastic, anti-inflammatory, antimicrobial properties, and hepato, cardio, and neuroprotective effects
α -Terpineol	Anticancer, anticonvulsant, antiulcer, antihypertensive, anti-nociceptive properties
Citronellol	Antimicrobial, anthelmintic, antioxidant, anticonvulsant antitrypanosomal, mosquito repellent
cis-Isolimonenol	Antifungal Properties, Antibacterial Properties, Anti-inflammatory Properties, Calming and uplifting effect on the mind and body.
Caryophyllene	Antibacterial, antioxidant, gastroprotective, anxiolytic, antiinflammatory
Humulene	Analgesic, mild sedative effects and antibacterial
β -copaene	Antiviral, antibacterial, anti-inflammatory, antifungal
β -Bisabolene	Anti-adipogenic, cytotoxic and antibacterial activities.
(-)-Spathulenol	Antiseptic, antibacterial, antifungal, and antitumor activities.

2.2.2 *Cymbopogon citratus* (DC.) Stapf.

Lemongrass is a plant species in the genus *Cymbopogon* which belongs in the Poaceae family whose systematic classification is as shown in Table 2.3

Table 2.3: Systematic Classification *Cymbopogon citratus* (DC.) Stapf. (Taxonomy)

Classification	Name
Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Poales
Family	Poaceae/ Gramineae
Genus	<i>Cymbopogon</i> Spreng
Species	<i>citratus</i>

Cymbopogon citratus (DC.) Stapf is a plant that forms dense clumps and can grow to a height of 3 meters, characterized by short rootstalks. The entire plant releases a scent reminiscent of lemon and possesses a bitter taste. Its upright leaves are smooth and flat, measuring over 1 meter in length and 5-15 mm in width, with a whitish upper surface and a closed base. The leaf margins are rough and membranous, with ligules approximately 4-5 mm long as depicted in Figure 2.5. Locally, the leaves of this plant are used to flavor tea and are cultivated in home compounds to repel rodents and reptiles such as snakes. The essential oil of *Cymbopogon citratus* (*Cymbopogonis citrate aetheroleum*) is extracted via hydro-distillation, a process typically lasting approximately 3 hours (Srivastava *et al.*, 2013). The resulting oil is light yellow in color and emits a distinctively strong and refreshing lemon-like aroma (Ghosh, 2013).



Figure 2.5: Cymbopogon citratus plant (Source: Science Direct)

2.2.2.1 Geographical Distribution of *Cymbopogon citratus* (DC.) Stapf.

Cymbopogon citratus (DC.) Stapf originates from southwest Asia but has spread naturally across the globe, particularly thriving in tropical and subtropical areas in recent years (Machraoui *et al.*, 2018). Botanical synonyms include *C. asiatica* and *Trisanthus cochinchinensis*. Other common names include: *Sera*, *Verveine*– Hindi, *Sakumau* - Malaysia, *Ta-khrai* - Thailand *Sereh*- Indonesia, *Capim-cidrao*, *Capim-santo* – Brazil, *Manduki*, (Shah *et. al.*, 2011).

2.2.2.2 Phytochemistry of *C. citratus* (DC.) Stapf

The chemical content *Cymbopogon citratus* essential oil varies depending on the geographical location and has been found to contain compounds as mainly aldehydes, terpenes, alcohols, ketones and esters. *Cymbopogon citratus* oil primarily compose of monoterpene fractions (Ganjewala, 2009). Citral, a mixture of terpenoids including geranial, plays a big role in the plant's flavor development (Ranitha *et al.*, 2014). Major components identified include neointermediol (7.2%), selina-6-en-4-ol (27.8%), α -cadinol (8.2%), methylheptenone (1.2%), eudesma-7(11)-en-4-ol (5.3%), 3,7-dimethyl-1,3,6-octatriene (0.58%), decanal (0.25%), and naphthalene (0.79%) (Vahid *et al.*, 2013). Other analyses have reported constituents such as elemol (41%), β -eudesmol (45%), cubebol (4.7%), humulene (4%), citral acetate, and citral

diethylacetal (Bharti *et al.*, 2013). Limonene (19.33%), p-Mentha-1(7),8-dien-2-ol, acetate, cis- (17.34%), trans p- mentha-2,8-diene-1-ol (13.91%), trans-isocarveol (13.95%), and 2-Cyclohexen-1-ol, 1-methyl-4-(1-methylethenyl)- (8.10%) are also components found in this plant (Nanon *et al.*, 2014). Furthermore, it contains essential mineral components such as potassium (K), sodium (Na), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn), phytate, and phosphorus (P) (Fagbohun *et al.*, 2010).

2.2.2.3 Therapeutic Actions of *C. citratus* GC-MS Compounds

Lemongrass (*Cymbopogon citratus*), extensively used in traditional medicine worldwide, offers a wide range of therapeutic benefits. These properties refer to the diverse beneficial effects that certain substances can have on health like antibacterial, antifungal, and antiprotozoal properties (Pratama & Permana, 2021). Its ability to lower blood sugar levels suggests it could be effective as an antidiabetic agent, and research indicates it can induce programmed cell death in different cancer cells by elevating levels of reactive oxygen species (Cortes-Torre *et al.*, 2023). Lemongrass owes its broad biological activities to a variety of bioactive compounds.

The plant exhibits antibacterial and antifungal properties that are effective against both Gram-negative and Gram-positive bacterial strains, as well as fungi including *Aspergillus* spp., *Botrytis cinerea*, *Aspergillus flavus*, and *Aspergillus parasiticus* (Sharma & Kaur, 2022; He *et al.*, 2023; Sawadogo *et al.*, 2022). Moreover, lemongrass demonstrates protective effects on the liver, preventing damage in diabetic rats. It also shows potential for lowering cholesterol by reducing absorption in the gut and has the ability to counteract resistance to doxorubicin in cancer cells (Falode *et al.*, 2023; Da Ressurreição *et al.*, 2022; Mukhtar *et al.*, 2023).

The calming and anti-seizure properties of β -Myrcene found in lemongrass suggest it may have preventive effects on Alzheimer's disease. These effects are associated with the plant's ability to protect nerves, which is attributed to volatile compounds such as citral, geraniol, and linalool (Hacke *et al.*, 2021). The medicinal benefits of *Cymbopogon citratus* are largely attributed to the secondary metabolites found in its essential oils such as flavonoids, alkaloids and especially terpenes, which are primarily present in the leaves. Notable compounds such as 3,7-Dimethyl-6-octenal, 7-Methyl-3-methylene-1,6-octadiene, and β -pinene are also acknowledged for their potential biological activities (Pino *et al.*, 2018).

Further details outlining the chemical constituents of *C. citratus* are provided in Table 2.4 based on GC-MS analysis.

Table 2.4: Therapeutic Actions of *C. citratus* GC-MS Compounds

Name of the compound/synonym	Activity
β -Myrcene	Potent anti-inflammatory, anxiolytic, antioxidant, anti-ageing, analgesic
D-Limonene	Antioxidant, antidiabetic, anticancer, anti-inflammatory, cardioprotective, gastroprotective, hepatoprotective, immune modulatory, anti-fibrotic, anti-genotoxic
trans- β -Ocimene	Anticonvulsant activity, antifungal activity, antitumor activity
Linalool	antidepressant agent, antimicrobial, anti-inflammatory, anticancer, anti-oxidant
Camphor	skin antipruritic, anti-infective agent, antitussive
Alpha Phellandren -8-ol	Antifungal Properties, Antibacterial Properties, Anti-inflammatory Properties, Calming and uplifting effect on the mind and body.
Isogeranial	Antineoplastic, anti-inflammatory, antioxidative, and antimicrobial activities, and hepatoprotective, cardioprotective, and neuroprotective effects.
Citronellol	antimicrobial, anthelmintic, antioxidant, anticonvulsant antitrypanosomal, mosquito repellent
2,6-Octadienal,3,7-dimethyl-, (E)-	flavouring agent, a fragrance, an insecticide, antioxidant, anti inflammatory
β - Caryophyllene	antibacterial, antioxidant, gastroprotective, anxiolytic, antiinflammatory
trans- α .-Bergamotene	antioxidant, anti-inflammatory, immunosuppressive, cytotoxic, antimicrobial, antidiabetic, and insecticidal effects.
cis- β .-Farnesene	potential anti-inflammatory modulator of human neutrophils.
1-Bromo-3,7-dimethyl-2,6-octadiene	antimicrobial, anti-inflammatory, antioxidant, anti-cancer, and neuroprotective
α -ylangene	antioxidant, anti-inflammatory, and anticarcinogenic

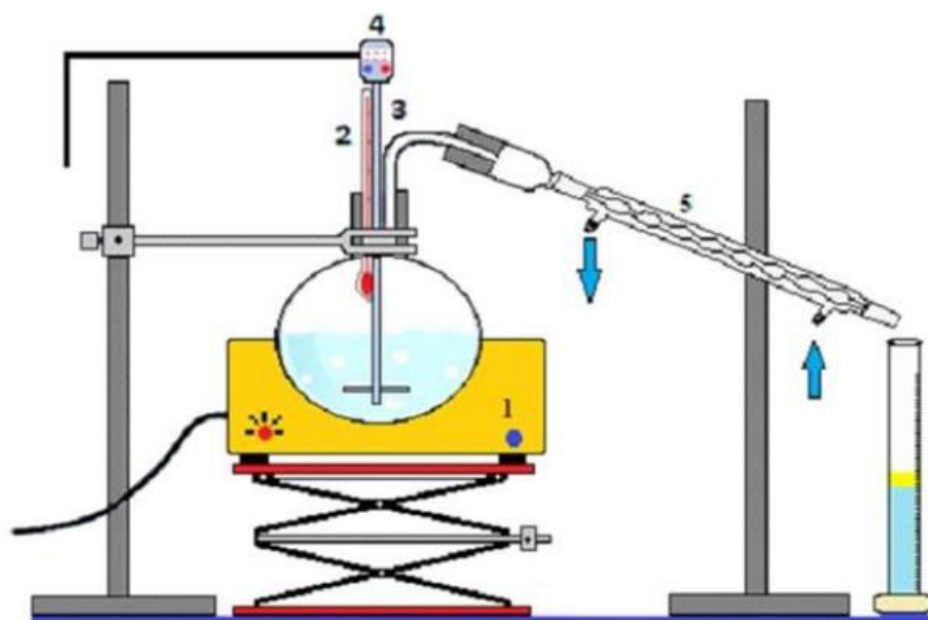
2.2.3 Extraction methods for essential oils

Ethereal oils obtained from parts of aromatic plants like barks or leaves play diverse roles in cosmetics, pharmaceuticals, and food industry. The extraction method used significantly influences the quality of these oils, as improper techniques can degrade them, affecting the consistency and efficacy of their phytochemical components (Tongnuanchan & Benjakul, 2014).

2.2.3.1 Hydrodistillation

Hydrodistillation, the most ancient and straightforward technique for extracting essential oils, was pioneered by Avicenna, who developed the technique using an alembic. The rose plant was the first to undergo this purification process. The method involves immersing plant materials directly inside water in an alembic vessel, which is then heated to boiling. Essential oils vaporize along with steam, condense in a separate condenser, and are collected in a decanter where they separate from water. This technique is particularly ideal and effective for extracting hydrophobic plant materials with high boiling points, like barks or flowers. By keeping oils surrounded by water, hydrodistillation protects them from excessive heat, ensuring extraction at temperatures below 100°C. This method is valued for its ability to preserve the integrity of essential oils during extraction (El Asbahani *et al.*, 2009).

The figure 2.6 below shows the hydrodistillation set up.



Schematic diagram of the hydro-distillation setup: 1; Water bath, 2; thermometer, 3;stirrer, 4; Electric motor and 5; condenser 2.2. Kinetic Model of Peppermint Oil Extraction

Figure 2 6: Hydrodistillation set-up (Source: Tariq M. Naife, 2018)

2.2.3.2 Steam Distillation

Steam distillation is the primary method employed in the extraction of essential oils from plants. This method typically extracts approximately 93% of the essential oils, leaving about 7% that may be extracted using other extraction methods (Masango, 2005). Steam distillation begins by heating plant materials with steam supplied from a steam generator. Heat plays a crucial role in breaking down plant structures, causing them to release aromatic components or essential oils (Babu & Kaul, 2005). The figure 2.7 below shows the steam distillation process.

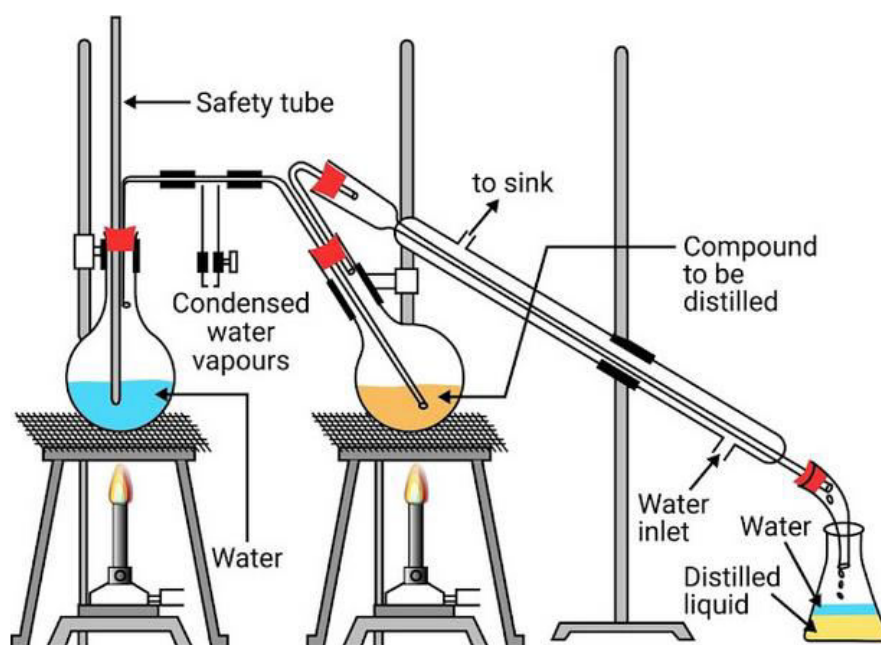


Figure 2.7: Steam distillation set- up (Source: <https://www.solnpharma.com>)

2.2.3.3 Hydrodiffusion

Hydrodiffusion extraction is a method where steam is introduced into a container containing dried plant materials. This technique is specifically used for plants that are sensitive to damage at high temperatures. Hydrodiffusion utilizes steam supplied from the top of the apparatus compared to steam distillation, where steam is introduced from beneath the apparatus. This method is undertaken in low pressure or vacuum conditions, maintaining the steam temperature below 100°C (Vian *et al.*, 2008). Figure 2.8 below shows the hydrodiffusion set up.

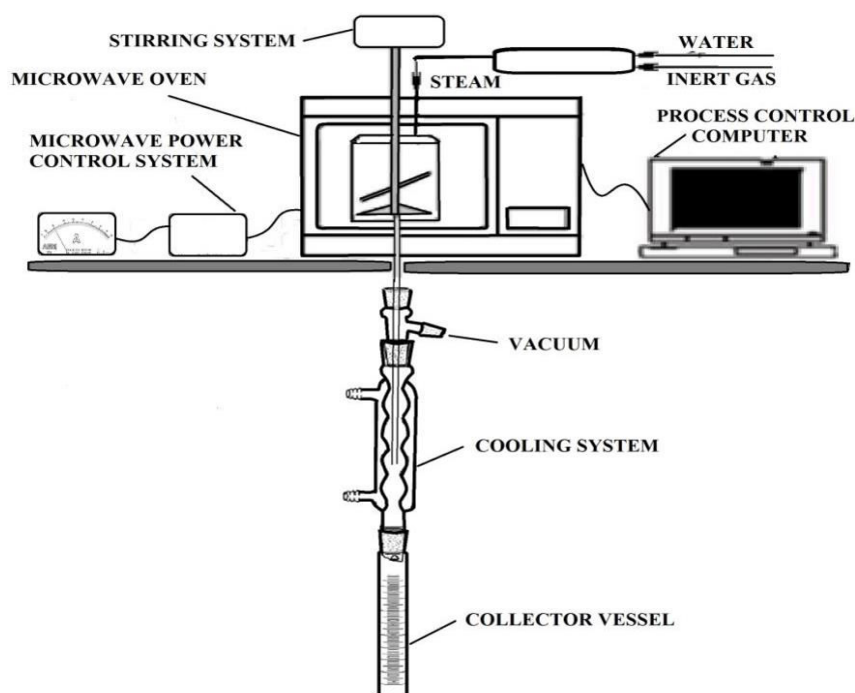


Figure 2.8: Hydrodiffusion set-up (Source: Mahfud Mahfud, 2015)

2.3 Effects of Essential oils and their combination on Stress

Stress is an unavoidable part of life, prompting ongoing research into effective strategies for managing it and minimizing its negative impacts. Complementary and alternative medicine (CAM) offers numerous promising approaches that integrate physical, mental, and spiritual aspects of healthcare. These forms of therapies are categorized by the U.S. National Center for Complementary and Integrative Health (NCCIH, 2019) into biologically based therapies that These therapies involve the use of natural substances such as herbs, vitamins, and other dietary supplements, mind-body interventions which focuses on practices and techniques designed to enhance the mind's ability to influence bodily functions and improve overall well-being, and manipulative and body-based methods that involve physical techniques aimed at improving health by manipulating or adjusting the body.

Aromatherapy entails extracting essential oils from raw materials found in nature such as flowers, petals, and plant bark through processes like steam distillation and hydrodistillation. These oils are known for their capacity to enhance both physical and psychological health in individuals coping with stress, contributing to holistic wellness (Ahmad *et al.*, 2017; Life Science, 2016). Essential oils are categorized into high, middle and low notes, where high notes are lighter, refreshing, stimulating and antidepressant; middle notes are more balanced, harmonizing, calming, and anxiolytic; and low notes are heavier, relaxing, sedative, and hypnotic. Examples of high-note oils include extracts from lemon, orange, bergamot, grapefruit, eucalyptus, peppermint, rosemary and thyme. Lavender, chamomile, geranium, ylang-ylang, jasmine, sage, marjoram, and tea tree are notable middle-note oils, while valerian, vetiver, cedarwood, sandalwood, frankincense, patchouli, and myrrh fall into the low-note category. High-note essential oils are recommended for combating stress caused by fatigue, lack of motivation, apathy, depression, lack of concentration, memory, and creativity issues, as they help revitalize, energize, uplift, cheer, clarify, stimulate, and awaken the mind and body (Sattayakhom *et.al.*, 2023). These naturally derived aromatic products are used to improve cognitive and memory functions. Common essential oils used in aromatherapy, such as lavender, rosemary, jasmine, and peppermint oils, are recognized for enhancing cognitive function, reducing pain, and uplifting mood (<http://www.aromatherapy.com>, Updated 2018).

Numerous studies have demonstrated that inhaling fragrances can induce diverse psychophysiological responses in both humans and animals. Fragrances can be administered in small quantities through methods like inhalation, massage, direct application to the skin, and occasionally, oral ingestion (Angelucci, 2014).

Cho et al. (2017) administered extracts from lavender essential oil to participants in their study to assess the outcome of aromatherapy on vital signs of patients admitted into the Intensive Care Unit. Through repeated measurements, they observed notable differences between the treatment and control groups. Their study findings revealed that lavender essential oil effectively lowered stress levels, lowered blood pressure, and decreased heart rates in the treatment group as compared to that of the control group. Moreover, lavender oil was established to better the sleep quality of these patients. Another study utilizing rosemary essential oil demonstrated a significant immediate and sustained decrease in stress scores as compared to the control group (Rahimi et al. 2019).

Lopez et al. (2017) in their experimental research to explore the mechanisms by which lavender essential oil reduces stress investigated its effects on molecular pathways including Monamine oxidase-A (MAO-A), Serotonin Reuptake Transporter (SERT), Gamma-Amino Butyric Acid (GABA_A), and N-Methyl-D-aspartate (NMDA) receptors within the central nervous system of winstar mice. This study revealed that the stress-reducing and anxiolytic properties of essential oil obtained from lavender stemmed from its antagonistic action on the NMDA receptor and inhibition of SERT (Lopez *et al.*, 2017). While direct experimental evidence in human brains is lacking, these findings provide a plausible neurological basis for lavender's therapeutic use as a stress-relieving oil.

In a study by Bikmoradi et al. (2015), 60 patients who underwent a coronary artery bypass graft surgery were randomly assigned to either an aromatherapy group or a control group in a single-blinded randomized controlled trial. Stress levels and vital signs were assessed and differences compared between the groups. The results showed that participants who were exposed to lavender essential oil had notably lowered

systolic blood pressure as compared to those patients who were in the control group. Similarly, Kim et al. (2011) conducted a study investigating how lavender essential oil affects reducing bispectral index (BIS) values, stress, and pain during needle injections among healthy volunteers. Participants in the experimental group used oxygen masks infused with lavender essential oil, while those in the control group used regular face masks for approximately five-minute intervals. The study participants demonstrated a significant reduction in stress levels and BIS values in those given lavender essential oil compared to those not given, suggesting that lavender essential oil is effective for alleviating stress.

Johnson et al. (2017) conducted a quasi-experimental study with lavender essential oils as a stress relief therapy among staff members in trauma intensive care units. They developed a specialized survey tool to assess stress levels before and after continuous exposure to lavender essential oil through diffusion over a month. The outcomes revealed a notable decrease in stress among staff members, with instances of stress episodes shifting from frequent to occasional occurrences. These results underscored the effectiveness of lavender essential oil in lowering stress within hospital environments. Moreover, research conducted at Hong Kong University demonstrated that aromatherapy could effectively lessen pain, alleviate depression, and mitigate stress in adults (Tang *et al.*, 2014).

Lemongrass has shown to be effective in relieving anxiety as shown in a study conducted by Radhalakshmi *et al.*, (2018). This study showed that the anxiety level of children undergoing a dental procedure reduced after they inhaled lemongrass essential oil prior to the exercise as compared to the control group. This could be attributed to the effect of lemongrass essential oil main component geranial (18.19%) and neral (11.4%), which had been extensively used in aromatherapy to relieve chronic

depression. Additionally, Goes et al. (2015) researched the anxiety-reducing effects of lemongrass essential oil in a study involving 40 men aged 18–30. Participants underwent a video-monitored version of the Stroop Color and Word Test (SCWT) to bring about anxiety. Following exposure to the aroma (administered in doses of three and six drops), significant decreases in anxiety levels and subjective tension were noted compared to a control group. Assessment using the State-Trait Anxiety Inventory (STAI) and Social Phobia Inventory (SPIN) questionnaires supported these results. The study suggested that lemongrass essential oil's anxiolytic properties may be attributed to interactions between its components and the GABAergic neurotransmitter system.

Chen et al. (2017) did a research to evaluate the efficacy of aromatherapy massage in reducing stress responses among pregnant women. In this research, 62 randomly selected participants were grouped into two groups namely an aromatherapy massage group, which received a 60-minute massage using lavender oil biweekly for 10 sessions, and a control group that received standard prenatal care. Saliva samples were taken from all participants at 4 months gestation and immediately after each session (with a 10-minute interval for the experimental group) to assess stress levels based on cortisol levels. At the outset, there were no noticeable variations in stress levels between the groups during the initial saliva sampling, which established a baseline stress level. However, by the 32nd week of gestation, stress levels in the control group had risen compared to their baseline levels at 16 weeks. In contrast, the experimental group showed consistent stress levels across all 10 sessions, indicating that aromatherapy massage effectively maintained stable stress levels throughout the study period.

Different studies have also shown the effectiveness of the synergistic mechanisms of essential oils on the reduction of stress. In their study, Bae et al. (2017) observed that stress scores among their subjects decreased significantly 10- 15 minutes after treatment using essential oils compounded with lavender, ylang ylang, rosemary, and lemon, compared to a slower reduction observed after 30 minutes when using a single essential oil. Moreover, the application of aromatherapy using a combination of lavender, Roman chamomile, and neroli essential oils in the ratio 6: 2 : 0.5 was shown to lower anxiety levels and improve quality of sleep among patients admitted to the Intensive Care Unit for Percutaneous Coronary Intervention (PCI) procedure (Cho *et al.*, 2013).

In a randomized controlled trial, Safajou et al. (2020) studied the efficacy of blended lemon and peppermint essential oils in reducing nausea and vomiting among pregnant women. They observed a reduction in the frequency of these symptoms over time among participants who used the essential oil blend through inhalation. Furthermore, another randomized clinical trial with 100 pregnant women suffering from nausea and vomiting discovered that inhaling lemon essential oil significantly decreased the frequency of these symptoms (Yavari *et al.*, 2014). Nakayama et al. (2016) conducted a randomized controlled trial to investigate the impact of aromatherapy on preventing salivary gland damage in patients undergoing Radioactive Iodine (RAI) therapy for differentiated thyroid cancer (DTC). Their findings indicated that inhaling a blend of lemon and ginger essential oils effectively mitigated treatment-related salivary gland disorders.

2.4 Perceptions of parents of children with intellectual disability on the positive attributes associated with use of essential oils

Traditional medicine has gained considerable international traction. According to a WHO report (2019), member states with national offices dedicated to traditional and complementary medicine rose from 49 to 107 between 1999 and 2018. As of 2018, 170 member states acknowledged the incorporation of traditional and complementary medicine into their healthcare frameworks, underscoring enduring worldwide interest in these approaches. In many developing countries, indigenous or traditional healers are essential as primary healthcare providers for millions of people living in rural areas, where the ratio of traditional health practitioners to the general population can be as low as 1:500, compared to 1:40,000 for medical doctors (WHO, 2013). Complementary and alternative medicine (CAM) encompasses various traditional therapies such as aromatherapy, tai chi, meditation, and yoga, among others.

Kenya possesses a diverse plant heritage that has long been utilized by various ethnic communities for treating various illnesses. The popularity of herbal medicines in the country is often linked to a cultural belief that emphasizes closeness to nature, as well as their accessibility and affordability (Umair *et al.*, 2019). Factors such as individual preference and sensory perception, environment of use, method of application, psychological expectation and belief and duration of use of the essential oils can influence the effectiveness.

Limited qualitative research has explored the perceptions of individuals experiencing stress regarding the utilization of essential oils for stress reduction. Positive themes emerging from these studies include feelings of comfort and relaxation, improved sleep quality, enhanced energy levels, and reduced fatigue. For instance, a study by

Kwong et al. (2016) highlighted that cancer patients often reported immediate feelings of comfort and reconnection to daily life through aromatherapy. They described aromas as providing a moment of pleasure that helped them temporarily forget their illness, a sense of being cared for that preserved their dignity, and a means of communicating with their bodies amidst illness. Similarly, Kerr et al. (2020) conducted a study among nurses working in hospital wards and found that sixteen staff members preferred aromatherapy due to the pleasant scent of essential oils diffused in the environment compared to other odors in the ward. This positive sensory experience influenced their preference for using aromatherapy while on duty.

In another qualitative study conducted by Kwon et al. (2023), involving 20 university students who engaged in regular exercise, aromatherapy was found to elicit positive feelings during exercise and reduce fatigue, thereby enhancing participants' post-exercise recovery experiences. The research findings indicated that participants who underwent aromatherapy experienced more positive outcomes compared to those who did not receive any aromatherapy intervention.

2.5 Summary

The background of the study highlights the growing recognition of complementary and alternative medicine (CAM), particularly aromatherapy, as a non-invasive, cost-effective intervention for stress management. Aromatherapy, which utilizes essential oils like lemon and lemongrass, has demonstrated anxiolytic and mood-enhancing effects through olfactory stimulation of the limbic system, influencing emotional and physiological stress responses. This study focuses on PCID a population experiencing chronic stress due to the demands of caregiving. While existing research supports the efficacy of aromatherapy in reducing stress, there are notable gaps in the literature.

First, most studies on aromatherapy have been conducted in Western or Asian contexts, with limited research on its application in African settings, particularly Kenya, where traditional medicine is widely used but lacks scientific validation. Second, while lemon and lemongrass essential oils have been individually studied for their stress-relieving properties, there is limited evidence on their combined effects, which could offer synergistic benefits. Additionally, the physiological mechanisms of essential oils such as their impact on cortisol levels, heart rate variability, and inflammatory markers remain understudied in real world caregiving contexts. There is also a need for more rigorous experimental designs, including randomized controlled trials (RCTs), to establish causal relationships between aromatherapy and stress reduction in high-stress populations like PCID. Addressing these gaps could enhance the credibility of aromatherapy as an evidence-based complementary therapy and inform healthcare policies on integrative stress management approaches.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter outlines the research methodology employed to address the research questions. It covers the research design, study area, study population, sampling methods, details of the sample, description of research tools, ethical considerations, procedures for collection of data and analysis methods.

3.1 Study Design

This study adopted a mixed-methods approach, combining a quasi-experimental pre-post test non-equivalent group design with qualitative exploratory methods to comprehensively assess the effectiveness and perceptions of lemon and lemongrass aromatherapy on stress reduction among parents of children with intellectual disabilities in Kakamega County, Kenya. The design gave an opportunity to identify and relate events to particular exposures and define it in regard to time. This study was designed to compare benefits of an intervention versus a placebo to show cause and effect. Participants were chosen from a study population and allocated to different research groups, then monitored over a period to assess the outcomes resulting from a new drug therapy, treatment, or intervention. Both experimental and control groups were matched for similar characteristics. This design allowed researchers to observe how the intervention affected the target population and also tracked changes over time in individual subjects (WennMacker *et al.*, 2018).

3.2 Study Area

This study was done in Kakamega County, Kenya, which is bordered by Vihiga County to the south, Siaya County to the west, Bungoma County to the north, and Nandi County to the east. It covers an area of 3050.3 square kilometers (Kakamega

CDP, 2013). Kakamega County is subdivided into 12 constituencies, 12 sub-counties, 24 divisions, 72 locations, and 233 sub-locations. According to the 2019 Kenya Population and Housing Census, the county has a total population of approximately 1.9 million comprising of around 897,133 and 970,406 males and females respectively. The majority of residents are involved in subsistence farming due to limited job opportunities. Key crops grown include sugarcane, maize, beans, cassava, finger millet, and sorghum, with maize being the staple food. Livestock farming, including cattle, sheep, goats, chickens, and pigs, is also prevalent.

Kakamega County was chosen because it was ranked the second county with the highest population, in the 2009 Kenya national census with a population of approximately two million people. In 2014, the county was listed as the fifth among fifteen counties with the most challenging reproductive, maternal, neonatal, child, and adolescent health indicators in Kenya (UNICEF, 2017). The county also has a notable incidence of intellectual disabilities, affecting 2.9% of the population. Furthermore, Kakamega residents commonly use traditional herbal medicine for physical and psychological ailments (Kipkore *et al.*, 2014) and lemon and lemongrass are familiar and culturally acceptable, increasing participation rates.

3.3 Study Population

According to Kombo and Delmo (2006), population is defined as a collection of individuals, objects, or items from which samples are selected for measurement. Mugenda and Mugenda (2003) describe population as the complete set of individuals, events, or objects that possess a shared observable characteristic. The study population comprised of parents of children with intellectual disabilities who had been diagnosed in the hospital in the children's clinic in collaboration with a psychiatry specialist. The target population comprised of 1039 parents of children with intelligence disability

according to Mumias Educational Assessment and Resource Centers (EARC) records of 2021. This population was chosen because of the magnitude of stress they undergo in their daily lives.

3.4 Sampling Technique

Purposive sampling is a non-probability sampling method where study participants are selected based on specific characteristics required by the researcher. This study employed purposive sampling to select Kakamega County which has 12 sub counties. 30% of the 12 sub counties was taken for the study which gave a total of 4 sub counties as the sample size Mugenda and Mugenda (2004). A register of all the subcounties in Kakamega county was used as a sampling frame. Systematic random sampling was used to pick the 4 sub counties included in the study where every third subcounty was selected. The subcounties picked were: Matungu, Shinyalu, Khwisero and Likuyani. The study participants were selected from the 4 sub counties using snowballing sampling technique which the trained CHPs used to identify the families that had an ID child.

3.5 Inclusion and Exclusion Criteria

3.5.1 Inclusion Criteria

Parents included in this study were required to:

- Consent to participate in the study
- Parents and caregivers of children of ages between 1- 18 years old

3.5.2 Exclusion Criteria

- A parent or caregiver who used herbal medicine or specific types of supplements during the week before and throughout the research period.
- A parent or caregiver smoking or drinking alcohol at the time of study.

- A parent or caregiver with a respiratory system condition such as asthma or flu, known allergic reaction to the essential oil to be used.
- Parent or caregiver who was pregnant at the time of study
- Parent or caregiver who had an Intelligence Disability child with epilepsy
- Parents or caregivers engaged in other complementary medical practices like yoga, meditation, aromatherapy and massages.

3.6 Sample size

The sample size was determined based on the total number of PCID cases across the 12 subcounties of Kakamega county subdivided into 4 groups; control (1 sample) and experimental (3 different treatments). The first cohort which forms the control group were not subjected to any test. The second cohort was subjected to a sample containing lemon essential oil, the third cohort to lemon grass essential oil and the fourth cohort to one containing a 1:1 ratio blend of lemon and lemongrass essential oils.

3.6.1 Sample Size calculation

To obtain the sample size of the experimental study, the following formula by Cohen (1992) was used. A 95% confidence level and $p = 0.05$ were assumed. The formula used was:

$$n_f = \frac{N}{1 + N(e)^2}$$

Where n_f is the sample size, N is the target population, and e is the level of precision as indicated. From the data collected from EARC, Kakamega County. As at March 2021, the total number of children with intelligence were 1039. Basing on this target population and using 95% confidence interval and $p=0.05$, the sample size was computed as follows;

$$n_f = \frac{1039}{1+1039(0.05)^2} = 289$$

From the computed sample size n_f , we obtained the proportion

$$p = \frac{n_f}{N} = \frac{289}{1039} = 0.28 \text{ which forms the prevalence in the case group and}$$

$1 - p = 0.72$ forming the prevalence in the experimental group. Using the following statistical formula and incorporation of the effect size the sample size became;

$$\text{Sample size} = \frac{2(Z_{\alpha/2} + Z_{\beta})p(1-p)}{\text{effectsize}^2}$$

Where p is the prevalence, $Z_{\alpha/2} = Z_{0.05/2} = 1.96$ (Z score for the normal distribution at $\alpha=5\%$ confidence interval), and $Z_{\beta} = Z_{0.05/2} = 0.842$ (Z score for the normal distribution at 80% power size). Using the effect size of -0.12 (the difference between the proportions), we obtain

$$\text{Sample size} = \frac{2(1.96 + 0.86)0.28(1-28)}{(-0.12)^2} = 228 \text{ participants}$$

10% for non-response was computed as follows

$$\frac{10}{100} \times 228$$

$$228 + 22 = 250$$

The sample size was 250.

3.7 Study Tool

Both quantitative and qualitative methods were employed for data collection. The quantitative data collection instrument was adapted from Noor (2019). One on one interviews and Focus group discussions (FGDs) were conducted using writing pads and pens and tape recorders for qualitative data collection.

3.8 Sample Collection and Preparations

Fresh *Citrus limon* leaves and *Cymbopogon citratus* leaves were collected from Kenya Agriculture and Livestock Research Organization (KALRO) farm in Kiambu and Kakamega Counties respectively. The plant species identification and authentication was done by botany department in Masinde Muliro University of Science and Technology (MMUST), after which sorting out the sample was done and plants cleaned up using tap water.

3.8.1 Process of essential oil extraction from fresh leaves of *Citrus limon* peels and *Cymbopogon citratus*

Essential oil of both *Citrus limon* and *Cymbopogon citratus* was extracted in collaboration with the Department of Pure and Applied Chemistry, MMUST. This was done using the hydrodistillation method.

10 kg of dry leaves was put in a hydrodistillation chamber, 30 liters of de-ionized water was added to the hydrodistillation chamber and a heating mantle used to heat the chamber content at 3-4kpa. A condenser, with separation funnel and Clevenger was fitted on the flask for extraction with tap water running in and out of the condenser for cooling. Each extraction took 3 hours, the volatile oil together with oil evaporated to the condenser was let down to the separation funnel. The essential oil that was extracted from 10 kg dry matter was 50ml of essential oil that floated on the water

after cooling. Excess water was removed by putting it on a beaker leaving oil on the separation funnel part, after 2 hours of removal of all water, and no addition of Essential oil noted. Oil was drained carefully from the separation funnel into an amber glass vial for storage, the essential undiluted oil was stored in darkness at 5°C until the start of the essential oils analysis.

The *Citrus limon* and *Cymbopogon citratus* essential oils were solubilised in n-Hexane (PubChem CID: 8058) for gas chromatography and mass spectrometry analysis.

3.8.2 Authentication of essential oil content

The samples collected were analyzed at the Jomo Kenyatta University of Science and Technology by utilizing Gas Chromatography – Mass Spectrometry (GC-MS). The data obtained was compared with that in literature for the same plants.

3.8.3 Preparation of samples for therapy

Essential oils were extracted from Lemon and Lemongrass plants. These oils were chosen because of their potential therapeutic properties for reducing stress. Extraction was done in collaboration with MMUST Department of Pure and Applied Chemistry.

3.9 Data Collection Procedure

The study used GC-MS for authentication of the essential oils, a structured questionnaire as a tool for quantitative data collection, and observational schedule and key informant interviews for qualitative data.

3.9.1 Authentication of lemon and lemongrass essential oil

Fresh leaves of lemon and lemongrass plants were collected in the month of August 2023 during the morning hours for a period of one week and dried in a cool dry room for 3 weeks. Essential oil was extracted using hydrodistillation method and samples

were taken for GC-MS analysis. The sample obtained was packed into small 30ml amber vials as shown in table 3.1.

Table 3.1: Sample Preparation

Sample	Label
Lemon E.O	A
Lemongrass E.O	B
Lemon and Lemongrass E.O blend	AB
Placebo	C

3.9.2 Pilot study

A pilot study was conducted in Vihiga County, Kenya to assess the feasibility and preliminary effectiveness of lemon-lemongrass aromatherapy for stress reduction among parents of children with intellectual disabilities prior to the main Kakamega County study. Using a mixed-methods approach, the study recruited 30 caregivers (15 intervention, 15 control) from special needs schools through a quasi-experimental pre-post design with follow-up focus group discussions. The intervention group received daily 10-minute inhalation therapy using a combination of 3 drops each of lemon and lemongrass essential oils for two weeks, while the control group maintained usual practices. Quantitative measures using the Perceived Stress Scale (PSS-10) showed an 18% stress reduction in the intervention group ($p=0.03$), with high adherence rates (85%). Qualitative findings from post-intervention FGDs revealed strong cultural acceptance of the therapy, with participants describing improved relaxation and sleep quality, though some noted initial sensitivity to the aroma's intensity and recommended longer session durations. The pilot confirmed the intervention's feasibility in rural Kenyan settings while identifying key refinements for the main study, including extending the intervention period to four weeks and adjusting oil concentrations. These results provided critical effect size estimates for sample size

calculations and demonstrated the need to incorporate physiological stress markers in subsequent research.

3.9.3 Effects of lemon and lemongrass essential oil on stress reduction

A stress indicator tool was used to measure the effects of Lemon (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*) essential oils and periodic measurements of blood pressure and heart rate was done. Subjects of the research were parents of children with intelligence disability who went through the recruitment process. They were selected using snowballing technique and assigned a random number. The oils used in the research were lemon essential oil, lemongrass essential oil and sweet almond oil as a carrier (placebo) for the control group. The essential oils were filled into sealed aromatherapy bottles to prevent subjects from accidentally touching the essential oil. This was to ensure that the administration condition of the aromatherapy would be through inhalation and not topical administration. Each essential oil was diluted with sweet almond oil, a carrier oil, to a concentration of 95% using a 5 mL pipette and transferred into 15 mL bottles. Each vial that contained the essential oil was labeled and dated.

Before the experiment began, the subjects were divided into four treatment groups, each comprising N subjects, specifically three test groups and one control group. Each N group per sub county was further divided into four equal groups of $n1, n2, n3$ and $n4$ with 14 PCID in each. The 4 groups received different treatments using either lemon essential oil, lemongrass essential oil, a blend of lemon and lemongrass essential oil or a placebo which was sweet almond oil. The essential oils were administered for a period of 12 weeks. Table no. 3.2 below shows composition of samples for various test groups.

Table 3.2: Composition of samples for various test groups in each sub-county

Groups	GRP 1 (n1)	GRP 2 (n2)	GRP 3 (n3)	GRP 4 (n4)
Lemon E.O (V/V) %	5%	0%	2.5%	0%
Lemongrass E.O (V/V) %	0%	5%	2.5%	0%
Carrier Oil	95%	95%	95%	100%
Total	100%	100%	100%	100%

3.9.3.1 Recruitment Selection and Training of the Research Assistants

In this study, snowballing sampling technique was employed to strategically identify participants who possess specific characteristics pertinent to the research objectives. The selected and willing Community Health Extension Worker (CHEW) played a pivotal role in this process by identifying a willing Community Health Assistant (CHA), who then facilitated the researcher's connection with 3 willing Community Health Promoters (CHPs) in each of the four subcounties. This selection was deliberate, as the CHEW's familiarity with local health dynamics ensured that the chosen CHPs had relevant experience and insights regarding community health issues. By focusing on individuals who are actively engaged in health promotion within the community, the researcher aimed to gather rich, contextually relevant data that would enhance the study's findings. The selected CHPs were recruited and trained by the researcher for three days on knowledge on intelligence disability and aromatherapy, how to use the research tool for data collection from the study participants. It was important for them to be familiar with the research for them to collect information from the PCID.

First step involved testing the knowledge of the CHPs on Intelligence Disability. This was done by administering a pre- test on intelligence disability. Afterwards, the CHPs were trained on knowledge on Intelligence Disability, how to identify its signs and

symptoms and management. The CHPs were then given a post-test to test their retention on the acquired knowledge tested on use of structured tool and interview to collect the data. Once the training was done, the CHPs identified the households with children with intelligence disability. Each CHP covered 100 households in the community as that's their expected catchment area. Each CHP identified about 19 parents of children with intelligence disability. Table 3.3 shows the distribution of the CHPs per subcounty and the number of CHP used in this study in the specific subcounties.

Table 3.3: Distribution of the CHPs per subcounty

Subcounty	Likuyani	Shinyalu	Khwisero	Matungu
Total no. of CHEWs	6	6	3	3
Total no. CHAs	8	7	7	9
Total no. of CHPs	280	410	260	350
No. of CHPs used in this study	3	3	3	3

3.9.3.2 Recruitment and selection of PCID

The study recruited Parents/Caregivers of Children with Intellectual Disabilities (PCID) through a multi-pronged approach in Kakamega County. Primary recruitment was done by CHPs who helped identify potential participants during routine home visits and clinic appointments. To ensure diversity, snowball sampling was employed, where enrolled participants referred other eligible caregivers from their social networks. Prospective participants were screened using the study's inclusion criteria (primary caregivers of children aged 1-18 with diagnosed intellectual disabilities, residing in Kakamega, and reporting elevated stress) and exclusion criteria (e.g., use of conflicting therapies, pregnancy, or respiratory conditions). Written informed consent was obtained before enrollment, with emphasis on voluntary participation and confidentiality. This strategy ensured a representative sample of PCID facing measurable stress burdens while maintaining cultural sensitivity and ethical rigor. Recruitment continued until the target sample size was achieved, with particular

attention to reaching caregivers in both rural and urban sub-locations of Kakamega County to capture varied experiences.

3.9.3.3 Intervention - Aroma Inhalation

Each participant received either one of the three pre-mixed oils or a placebo and was instructed to apply 2-3 drops onto an absorbent paper attached to their clothing collar three times daily for 12 weeks. Baseline measurements of blood pressure and heart rate were taken before starting the intervention. Participants were informed that their blood pressure and heart rate would be monitored every Tuesday and Friday throughout the 12-week study period. This was done very early in the morning by the trained CHPs totaling the number of blood pressure and heart rate measurements to 24 for each participant. They were also informed that they would fill out the stress indicator tool as post test after 12 weeks of intervention. At the end of the study, the participants who still required the aromatherapy were referred to a health care facilities for further management.

Participants in both the treatment and control groups underwent an initial assessment during the first week of the study visit. This initial data collection involved measuring their blood pressure and pulse frequency, as well as having each participant complete a stress assessment tool. After completing the pre-test, participants received information on aromatherapy, its therapeutic uses, its role in reducing stress, and the specific therapeutic benefits of the oils used in the study. Each participant was assigned a unique identifier combining the code from their assigned essential oil bottle and the last three digits of their cell phone number. This identifier ensured the confidentiality and anonymity of participant responses, which were recorded in an Excel spreadsheet throughout the study. The figure 3.1 below shows an algorithm of how the intervention conducted.

Aromatherapy: The Use of Lemon and Lemongrass Essential Oils – Administration Algorithm

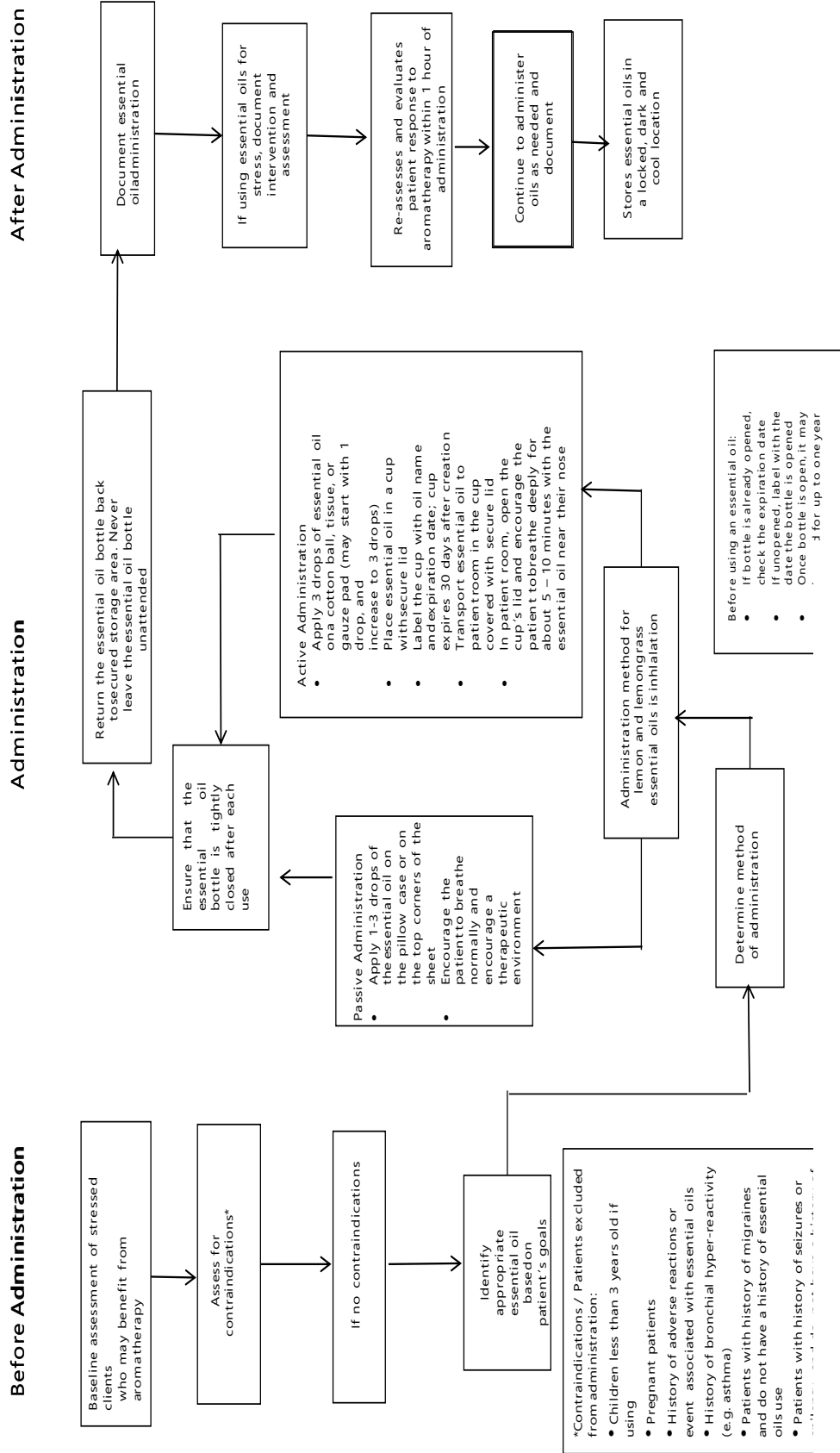


Figure 3.1: Algorithm for lemon and lemongrass essential oil use

Figure 3.1 Content and use of the Stress Indicator Tool in the Study

The stress indicator tool was used in this study as a standardized self-report questionnaire to measure stress levels among parents of children with intellectual disabilities before and after the aromatherapy intervention. Participants were asked to reflect on their experiences since becoming caregivers and indicate how frequently they encountered each stress symptom during a typical week. The tool assessed stress across three key domains: physical, sleep, and emotional indicators, with responses scored on a 5-point Likert scale (1 = Never, 5 = Almost Always). For each domain, participants circled their responses, and the scores for all items were summed to calculate a total point score for physical, sleep, and emotional stress. Higher scores indicated greater stress severity. The tool was administered twice—once before the aromatherapy intervention (pre-test) and once after (post-test)—to evaluate changes in stress levels. This quantitative data was complemented by qualitative insights from interviews and FGDs, providing a holistic understanding of how lemon-lemongrass aromatherapy influenced caregivers' stress. The tool's design ensured cultural relevance by focusing on locally observable stress while aligning with global stress assessment frameworks.

3.9.5 Perceptions of parents of children with intelligence disability on the positive attributes associated with the use of lemon and lemongrass essential oils

Open-ended questions were used to collect qualitative data on the participants' perceptions regarding the beneficial effects of lemon and lemongrass essential oils for stress reduction. The questions were written in both English and Kiswahili languages, and the interviews and FGDs were done by the researcher and trained research assistants fluent in the local language to facilitate data collection.

Selection of the participants to be included in the FGD was done using systematic random sampling. Each questionnaire has been numbered from no.1 - 57 where every 3rd participant in each sub county was selected to respond to the questionnaire. In each sub-county, 17 participants, resulting in a total of 68 participants were selected for the qualitative data for the entire study. The main list of enrolled participants was used as the sampling frame, selecting every 3rd participant from each sub-county for inclusion in the qualitative aspect of the study.

3.10 CONSORT diagram to show flow of the study

All the participants were PCID. The CONSORT flow diagram is shown in figure 3.2. A total of 250 participants were enrolled into the study (n=250) and 22 were excluded remaining with 228. The reasons for exclusion were non- response, inability to continue with the treatment and health related issues like allergies that made the participants drop out of the study. The remaining 228 PCIDs, 57 were enrolled from each of the four selected subcounties and adhered to the treatments up to the end of 12 weeks.

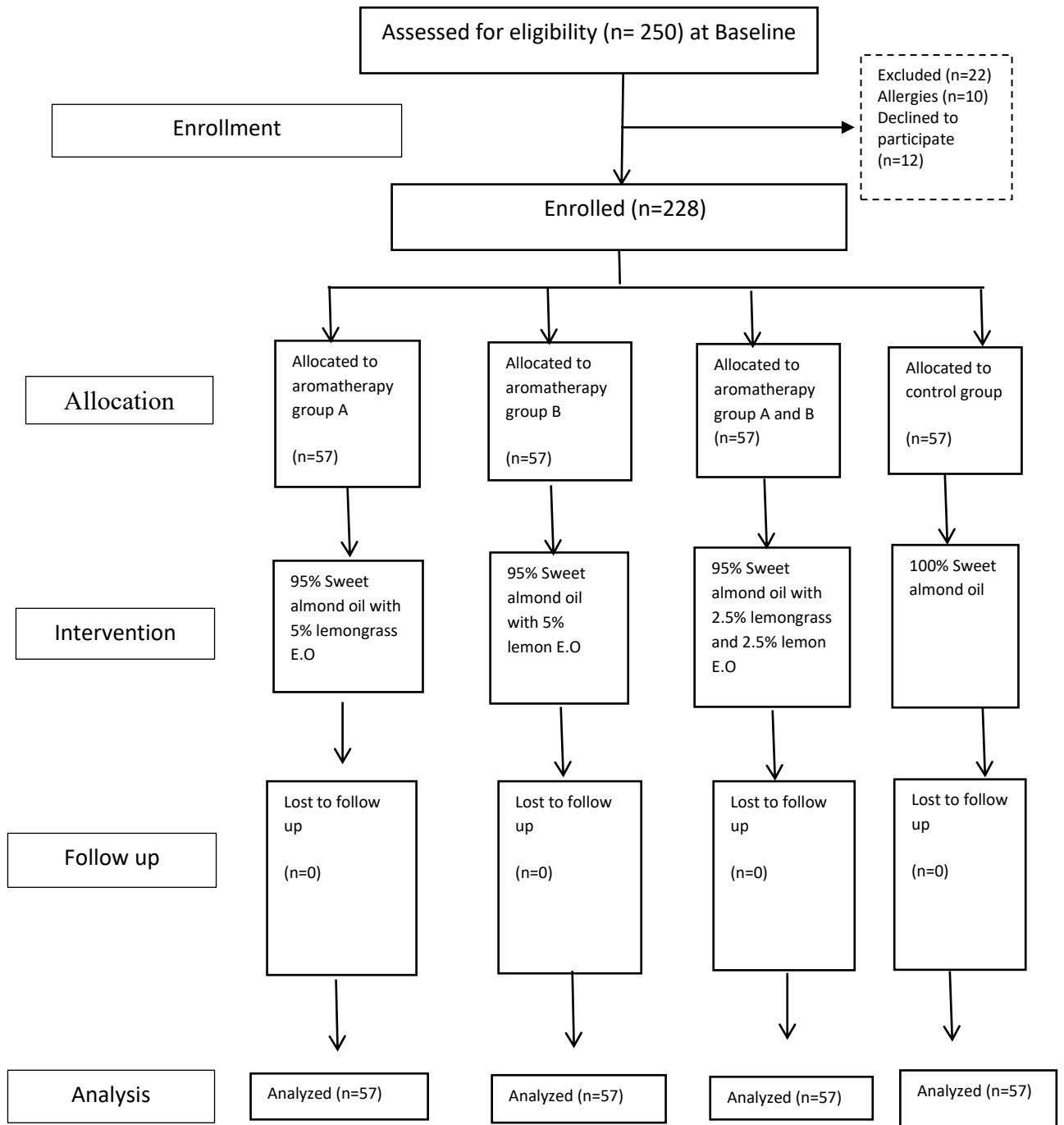


Figure 3.2: CONSORT Flow Diagram of the quasi-experimental study

3.11 Study Assumptions

As community-based research, this study operated under the assumption that information provided during data collection was truthful and unbiased. Participants were encouraged to express their genuine thoughts and feelings, without feeling pressured to impress the researcher.

3.12 Strengths of the study

Extraction and authentication of the Kenyan lemon leaves and lemongrass essential oil showed the chemical contents of the oils which may vary with those of other countries or regions. The qualitative research method employed to capture the experiences of parents and guardians regarding the usage of ethereal oils helped to uncover factors influencing the positive attributes of these two essential oils in reducing stress among children with intellectual disabilities in four sub-counties of Kakamega County.

3.13 Questionnaire Response Rate

The study involved 250 persons with intellectual disabilities (PCID) residing in four selected sub-counties: Likuyani, Shinyalu, Khwisero, and Matungu in Kakamega County. A total of 228 questionnaires were deemed complete and suitable for data analysis, representing 91.2% of the initial sample size. According to Mugenda and Mugenda (2003), a questionnaire response rate of 50% is considered adequate, 60% is deemed good, and 70% is considered very good. Thus, achieving a response rate of 91.2% in this study provided a robust foundation for making conclusions. Some respondents dropped out of the survey, mainly due to stigma, cultural beliefs, and reluctance to be associated with aromatherapy. In many cultures, there is a belief that disability is linked to malevolent spirits, leading to discrimination.

3.14 Reliability test

A pre- test was done to check on the reliability and a Cronbach alpha coefficient was done to test on the validity of the tool used in this study. According to Gliem (2003), a reliability coefficient above 0.65 is considered acceptable. In this study, the Cronbach's alpha coefficient for the entire questionnaire was 0.760, which surpasses the minimum threshold of 0.70, indicating strong internal consistency reliability. This is shown in the table 3.4 below.

Table 3.4: Reliability Statistics

Cronbach's Alpha	No. of Items
.760	45

3.15 Data Processing and Analysis

Both quantitative and qualitative methods were employed in the data analysis process. Quantitative data gathered from the questionnaires underwent coding and entry into a computer system for the computation of descriptive statistics. Statistical analysis was conducted using the Statistical Analysis System (SAS) to generate frequency distributions and percentages. Inferential statistics including ANOVA and Chi-square tests were utilized to explore associations between variables and assess their significance. Tukey's test was used to determine significant differences between treatments, while ANCOVA was employed to investigate potential differences among the treatments administered to participants.

To analyze quantitative data, categorical variables between groups were compared using the Pearson chi-square test, and continuous variables were assessed using one-way ANOVA with the Tukey HSD post hoc test. An independent t-test was employed to compare physiological measures between the control and lemongrass-treated groups both before and after inhalation. Additionally, ANCOVA was conducted with the post-

test measure as the dependent variable, and the pre-test measure and intervention groups as covariates. This model assessed the differences in the post-test means for each stress domain after controlling for pre- test stress scores and intervention. The outcome was expected to assess whether pre- test scores for stress domains had effect on post-test stress outcome accounting for the intervention groups. All statistical tests were conducted using a two-tailed approach and were evaluated at a significance level of 5%.

Data analysis for qualitative data was done using inductive method. A thematic content analysis was done to help weed out biases. The goal was to find common patterns across the data set. The four main themes that arose from the data set were: Effect of the drug, frequency of exposure, cost effectiveness and pleasant aroma and non-allergic reaction. The table 3.5 below shows the specific objectives, variables, research design and method of analysis.

Table 3.5: Specific objectives, variables, research design and method of analysis

Specific Objective	Variables	Research Design	Method of Analysis
OBJECTIVE ONE Authentication of chemical content of essential oil extract from Lemon leaves (<i>Citrus limon</i>) and Lemongrass (<i>Cymbopogon citratus</i>).	-Lemon essential oil -Lemongrass essential oil	Experimental	GC- MS
OBJECTIVE TWO To assess the effects of Lemon leaves (<i>Citrus limon</i>), Lemongrass (<i>Cymbopogon citratus</i>) essential oils extracts and their combination on stress reduction in parents of children with intelligence disability	-Physical indicators -Sleep indicators -Emotional indicators -Blood pressure Hear rate	Quasi experimental pre- post test	CHI SQUARE ANOVA TUKEYS. ANCOVA
OBJECTIVE THREE To determine the perceptions of parents of children with intelligence disability on the positive attributes associated with the use of Lemon leaves (<i>Citrus limon</i>), Lemongrass (<i>Cymbopogon citratus</i>) essential oils extracts and their combination on stress reduction	-Aroma/ scent Relaxation -Frequency of exposure -Cost effectiveness Effect of the drug	Qualitative research	Descriptive narratives

3.16 Quality Control

A preliminary test was conducted to validate and confirm the reliability of the research instruments, following the procedures outlined in the research design and methodology. This procedure guaranteed that the language employed was easily comprehensible within the study's framework. The research instruments were deemed suitable by the participants, thereby bolstering the validity and reliability of the research tool.

3.17 Ethical Considerations

All ethical considerations were strictly adhered to throughout the study. Participants were treated with utmost respect, following key principles of modern biomedical ethics. Informed consent, a cornerstone of ethical practice in both therapy and research,

was obtained from all participants through written authorization forms. Participants were educated on the essential components of valid consent: it must be given voluntarily, by a competent individual, and with adequate information provided. Participants were informed on the potential risks and benefits associated with the treatments, awareness of procedures they might undergo (including aspects like blinding and randomization in the case of RCTs), acknowledgment of the voluntary nature of participation in research, and comprehension of the research objectives. These measures ensured that ethical standards were upheld and that participants made informed decisions regarding their involvement in the study.

According to the Helsinki Declaration, any research must prioritize the protection of human rights for participants. This includes safeguarding their privacy, upholding their dignity to the highest standards, and ensuring that participant data remains anonymous (Burns & Grove, 2011).

Adherence to these ethical principles guided the research process. The researcher obtained ethical approval to conduct the study from Masinde Muliro University's Research Ethics Committee, Directorate of Post Graduate Studies, National Commission of Science, Technology, and Innovation (NACOSTI), following institutional research policies. This ensured adherence to all protocols related to research conduct. Ethical considerations focused on maintaining excellent research practices in line with global standards.. Additionally, the institutions where data collection took place also granted the researcher permission to conduct the study.

3.17.1 Autonomy

Autonomy, as a principle, requires researchers to ensure that subjects have the freedom to make their own decisions without any form of coercion during the study. Therefore,

the researcher respected and acknowledged whatever decisions the subjects made. Information was provided to subjects before they signed the informed consent document. Participants in this study belonged to a legally recognized category capable of providing such consent. For those with reduced autonomy, the researcher sought institutional consent to protect their rights.

3.17.2 Informed Consent

In research, informed consent involves providing participants with comprehensive information about all relevant aspects of the study so they can make an informed decision after evaluating the information (Nijhawan *et al.*, 2013). Participants voluntarily indicated their willingness to participate. In this study, informed consent was secured from participants following a thorough explanation of the consent form. Written consent was provided, and for Community Health Providers (CHPs) and study participants, they signed the consent form without writing their name after being informed about the study's purpose. Throughout the consent process, potential benefits and risks were discussed, and participants were reassured of their ability to withdraw from the study at any point without repercussions (Owonikoko, 2013). Importantly, participation in the study was entirely voluntary throughout.

3.17.3 Confidentiality

Confidentiality was rigorously maintained throughout the study as another critical aspect. Upholding confidentiality is essential to maintain trust and ensure that participants' information remains secure (Rhodes *et al.*, 2009). Participants were protected from discomfort or disadvantages resulting from their involvement in the study and willingly providing their information. Data from research tools and key informant interviews were coded during the data analysis process.

3.17.4 Non-maleficence

This principle required the researcher to ensure that subjects were not exposed to any harm during the research process. However, if potential harm was anticipated, it was crucial for the researcher to provide a plan outlining how the study intended to mitigate such risks. Potential harms in this study could include accidental ingestion or skin exposure to essential oils, asking embarrassing questions, causing disappointment, or inducing anxiety or fear among respondents. The researcher was tasked with clarifying the potential outcomes of the research, weighing them against associated risks, and adhering to ethical guidelines.

At the end of the study, it was important for the researcher to hold debriefing sessions with participants, explaining the precise goals of the study and addressing any remaining questions (Akaranga & Makau, 2016). In this particular study, the participants were carefully taken through the interview questions and ensuring participant anonymity were measures taken to prevent psychological harm to participants. Finally, the participants who still required the aromatherapy were referred to a health care facilities for further management.

3.19.5 Justice

Justice in research necessitates that all participants are treated fairly and equally. It requires that the burdens placed on participants are proportionate to the potential benefits of the research outcomes achievable. To achieve this, the researcher randomly chose institutions involved in the study and then assigned participants to either the treatment or control groups using random assignment. This approach guaranteed that every participant had an equal opportunity to be included or excluded from the study, thereby evenly distributing any potential benefits or risks among them.

3.19 Dissemination of Research Findings

Dissemination of research findings involves sharing the research output with relevant audiences. It is important to note that dissemination can attract the attention of policymakers and stakeholders, thereby influencing change (Mavin-Gonzalez *et al.*, 2017). The data from this study will be disseminated through scientific conferences and strategic institutional meetings at various organizations. Furthermore, the findings will be published in scholarly journals to ensure wider accessibility and dissemination.

CHAPTER FOUR

RESULTS

4.0 Overview

This chapter discusses the findings from the research data. The research focused on assessing how effective lemon oil, lemongrass essential oil, and their blend are in alleviating stress levels among parents of children with Intellectual Disabilities in Kakamega County, Kenya. It includes a comprehensive presentation of the findings derived from data analysis. Results are presented using basic percentages, means, and standard deviations as relevant, based on the characteristics of the variables studied.

The analysis focused on the following objectives:

- i. To authenticate the chemical content of essential oil extract from Lemon leaves (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*).
- ii. To assess the effects of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction in PCID.
- iii. To determine the perceptions of parents of children with intelligence disability on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction.

4.1 Chemical composition of the essential oil

4.1.1 Lemon Essential Oil

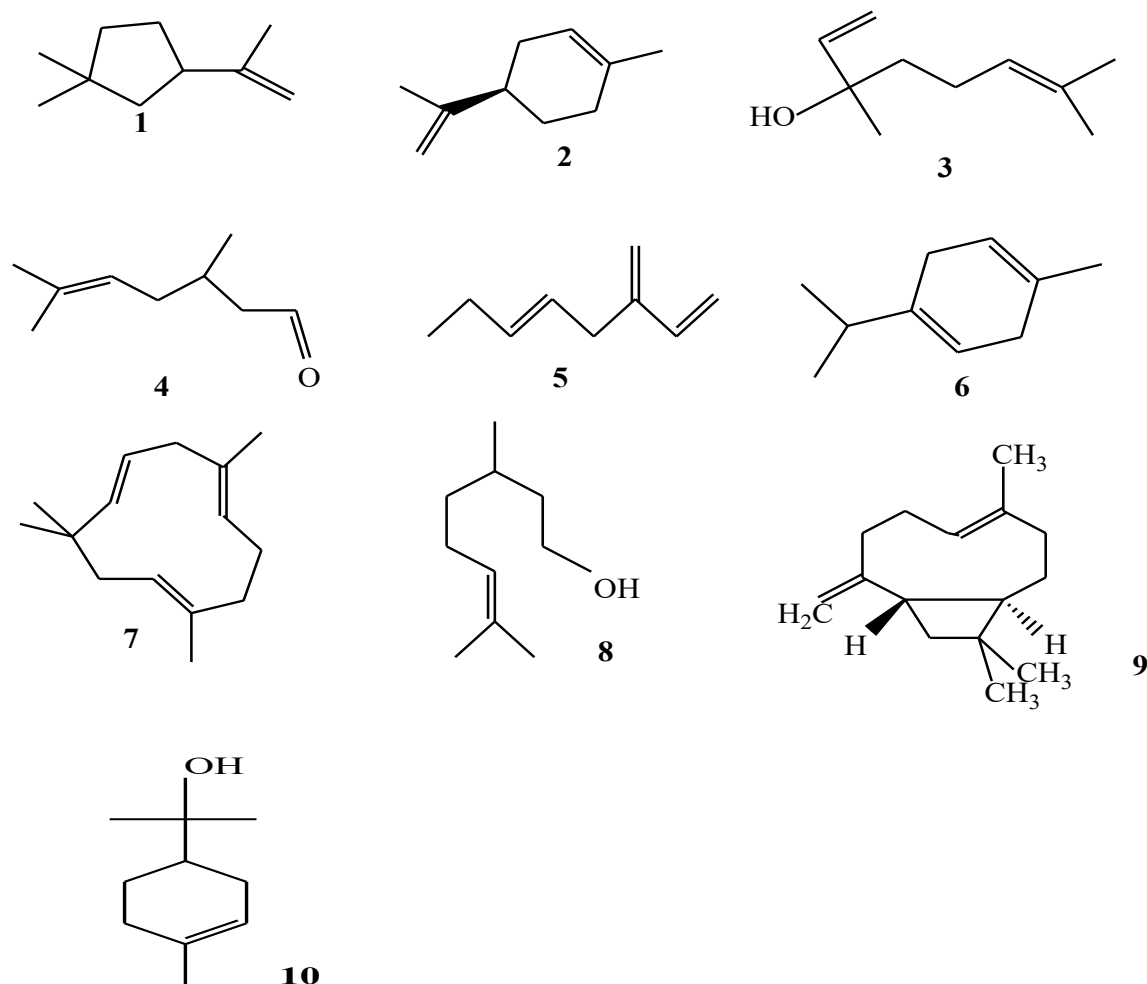
The essential oil obtained from fresh *C. limon* leaves through hydrodistillation displayed a light yellow hue. GC-MS analysis of the *C. limon* essential oil identified

fifty-two distinct compounds. Table 4.1 presents these compounds along with their relative percentages and retention times.

Table 4.1: Compounds identified in *C. limon* through GC-MS

S. No	RT	Name of Compound	Area %	Grouping
1	5.534	trans-4-Thujanol. sabinene hydrate	0.38	Alkene Hydrocarbon
2	5.732	L-.alpha.-Pinene	1.41	Alkene Hydrocarbon
3	6.748	Cyclopentene, 3-isopropenyl-5,5-dimethyl-	26.73	Fatty Acid
4	6.870	(1S,5S)-2(10)-Pinene	2.10	Alkane Hydrocarbon
5	7.052	.beta.-Myrcene	3.44	Sesquiterpene
6	7.619	Tricyclene	4.01	Alkane Hydrocarbon
7	7.841	Alpha- terpinene	1.40	Alkene Hydrocarbon
8	8.258	D-Limonene	33.15	Monoterpene
9	8.300	.beta.-Phellandrene	0.88	Monoterpene
10	8.598	.beta.-Ocimene	5.50	Alkatriene
11	8.813	trans-4-Thujanol. sabinene hydrate	0.03	Hydrocarbon
12	8.980	.gamma.-Terpinene	2.46	Monoterpene
13	9.396	trans-4-Thujanol	0.03	Alcohol
15	9.724	Cyclohexene, 3-methyl-6-(1-methylethylidene)-	1.05	Hydrocarbon
16	10.154	Linalool	1.23	Acyclic Monoterpene
17	10.322	Nonanal	0.08	Saturated Fatty Aldehyde
18	11.710	6-Octenal, 3,7-dimethyl-, (R)-	8.23	Aldehyde
19	11.934	cis-Verbenol	0.04	Bicyclic Monoterpene Alcohols.
20	12.469	Isogeranial	0.07	Homoallylic Alcohol
21	12.588	Terpinen-4-ol.	0.97	Alcohol
22	13.030	.alpha.-Terpineol	0.05	Phenol
23	13.181	Decanal	0.15	Saturated Fatty Aldehyde
24	13.765	Citronellol	0.25	Monoterpene
27	15.025	2,6-Octadienal, 3,7-dimethyl-, (E)-	1.43	Aldehyde
28	15.976	Undecanal	0.04	Aldehyde
29	16.180	cis-p-Mentha-2,8-dien-1-ol	0.07	Alcohol
30	16.323	trans-Geranic acid methyl ester	0.12	Fatty acid ester
31	16.591	delta-Elementene	0.06	Alkane Hydrocarbon
32	16.988	Citronellol acetate	0.43	Alcohol
34	17.783	lavandulyl acetate	0.66	Fatty Acid
35	18.080	β-elementene	0.35	Saturated Fatty Acid
36	18.935	Caryophyllene	0.36	Sesquiterpene
37	19.871	Humulene	0.08	Sesquiterpene
38	20.509	.beta.-copaene	0.04	Sesquiterpene
39	20.880	Bicyclogermacrene	0.15	Alkene Hydrocarbon
40	21.052	.beta.-Bisabolene	0.02	Sesquiterpene
41	21.191	(-)-Germacrene A	0.02	Alkene Hydrocarbon
42	21.373	α-Muurolene	0.02	Aromatic hydrocarbon
43	21.933	Cedren-13-ol, 8-	0.02	Alcohol
44	22.330	β-cis-Caryophyllene.	0.02	Fatty acid
45	22.467	Germacrene B	0.05	Fatty acid
46	22.895	gamma.-Amorphene	0.02	Alkaloid
47	22.969	(-)-Spathulenol	0.01	Phenol
48	23.089	Caryophyllene oxide	0.04	Sesquiterpene
49	24.152	beta-Vetivenene	0.03	Aromatic hydrocarbon
50	24.778	.tau.-Cadinol	0.03	Alcohol
51	25.411	Levomenol	0.02	Alcohol
52	25.524	(2Z,6E)-beta-sinensal	0.40	Aldehyde

The analysis revealed that the essential oil of Citrus limon consists predominantly of hydrocarbon monoterpenes, oxygenated monoterpenes, and aldehydes, forming a complex mixture. The major components that were detected in the Kenyan sample included Cyclopentene, 3-isopropenyl-5,5-dimethyl- (26.73%) **(1)**, D-Limonene (33.15%) **(2)**, Linalool (1.23%) **(3)**, 6- Octenal,3,7-dimethyl- (R)- (8.23%) **(4)**, β -Myrcene (3.44%) **(5)** and gamma - Terpinene (2.46%) **(6)**. The minor components (less than 1%) were identified as: Humulene (0.36%) **(7)**, Citronellol (0.25%) **(8)**, Caryophyllene (0.52%) **(9)** and α -Terpineol (0.07%) **(10)**.



The concentrations of active ingredients in essential oils sourced from natural origins can fluctuate due to factors such as geographical location, temperature, rainfall, altitude, and duration of sunlight exposure (Hossein *et al.*, 2014).

4.1.2 Lemongrass Essential Oil

Lemongrass plant is highly valuable for both food and fodder due to its significant content of vitamins such as A (6 IU), C (2.6 mg), folate (75 µg), niacin (1.1 mg), and riboflavin (0.135 mg), as well as protein (1.82 g), antioxidants, and essential minerals including nitrogen (0.75%), phosphorus (0.08%), potassium (2.15%), sulfur (0.19%), magnesium (0.14%), calcium (0.36%), zinc (35.51 ppm), manganese (155.82%), iron (126.73%), and copper (56.64 ppm) (Khandro *et al.*, 2011). The essential oil extracted from fresh *Cymbopogon citratus* leaves through hydrodistillation displayed a color ranging from dark yellow to amber. Analysis using GC-MS identified eighty-two different compounds in the *C. citratus* essential oil. These compounds, along with their relative percentages and retention times, are detailed in Table 4.2.

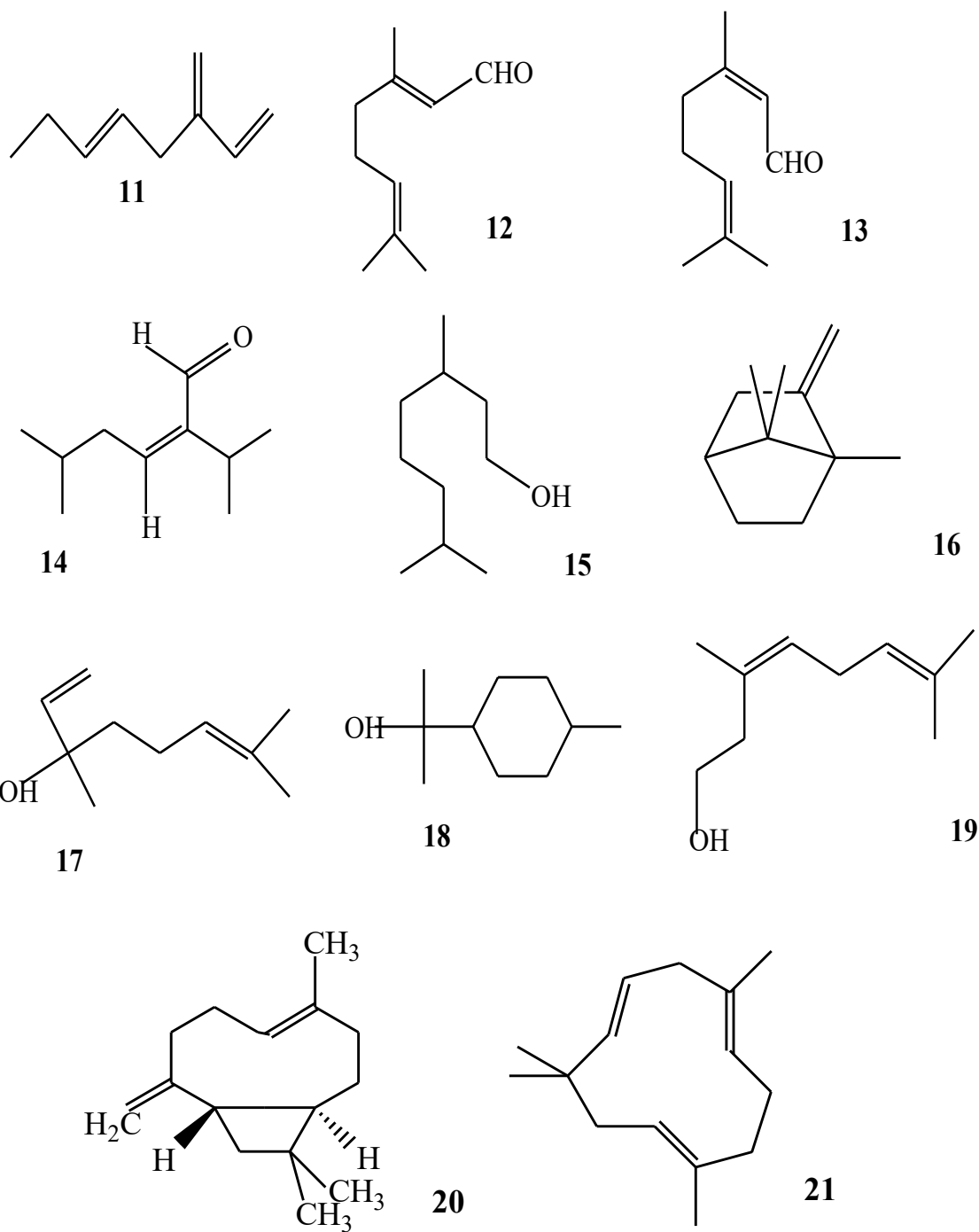
Table 4.2: GC-MS analysis of the hydrodistilled extract from *Cymbopogon citratus* leaves

S. No	RT	Name of Compound	Area %	Grouping
1	6.168	Camphene	0.05	Aromatic hydrocarbon
2	7.050	.beta.-Myrcene	11.34	sesquiterpenoids
3	7.172	Ethanone, 1-(2-methyl-1-cyclopenten-1-yl)-	0.05	Ketone
4	8.089	o-Cymene	0.03	Hydrocarbon
5	8.171	D-Limonene	0.07	sesquiterpenoids
6	8.278	trans-.beta.-Ocimene	0.33	Hydrocarbon
7	8.571	.beta.-Ocimene	0.15	sesquiterpenoids
8	9.344	4-Nonanone	0.56	Ketone
9	9.904	Undecane	0.10	Alkane
10	10.150	Linalool	2.04	sesquiterpenoids
11	10.904	trans-isocarveol	0.04	Alcohol
12	10.993	(E)-6-Methylhept-4-en-1-ol	0.04	Alcohol
13	11.733	Camphor	3.80	Sesquiterpenoids
14	11.930	p-Mentha-1(7),8-dien-2-ol, acetate, cis-	0.08	Alcohol
15	12.388	alpha-phellandren-8-ol	0.85	Alcohol
16	12.465	Isogeranial	0.17	sesquiterpenoids
17	13.128	alpha-phellandren-8-ol	0.86	Aromatic hydrocarbon
18	13.803	Citronellol	7.10	sesquiterpenoids
19	14.219	2,6-Octadienal, 3,7-dimethyl-, (E)-	7.38	Aldehyde
20	14.518	geranyl bromide (GERANIAL)	18.19	ALkene hydrocarbon
21	15.060	2,6-Octadienal, 3,7-dimethyl-, (E)- (NERAL)	11.40	Aldehyde

22	15.547	2-Undecanone	0.39	Ketone
23	16.204	cis-3-Cyclopropyl-7-(2-methoxyethyl)norcarane	1.81	Arene
24	16.993	Citronellol acetate	0.12	Phenol
25	17.378	Phenol, 2-methoxy-3-(2-propenyl)-	0.47	Phenol
26	17.780	lavandulyl acetate	0.23	Alcohol
27	18.936	Caryophyllene	0.44	bicyclic sesquiterpene
28	19.159	trans-.alpha.-Bergamotene	0.05	sesquiterpenoids
29	19.595	cis-.beta.-Farnesene	0.02	sesquiterpenoids
30	19.810	(.+/-)-Gymnomitrene	0.02	Fatty acid
31	19.875	Humulene	0.02	sesquiterpenoids
32	20.585	beta-chamigrene	0.04	Fatty acid
33	20.762	2-Tridecanone	0.19	Ketone
34	20.847	isolekene	0.02	Alkene Hydrocarbon
35	21.196	alpha-chamigrene	0.02	Fatty acid
36	21.306	.gamma.-Muurokene	1.02	sesquiterpenoids
37	21.375	α-Muurokene	0.04	Aromatic hydrocarbon
38	21.514	(E)-γ-Bisabolene.	0.10	Alkene Hydrocarbon
39	21.864	.alpha.-ylangene	0.08	sesquiterpenoids
40	22.187	Linalyl butyrate	0.13	Ester
41	23.091	Caryophyllene oxide	0.04	sesquiterpenoids
42	23.815	.alfa.-Copaene	0.02	sesquiterpenoids
43	24.074	.delta.-Selinene	0.06	sesquiterpenoids
44	24.230	.gamma.-Selinene	0.01	sesquiterpenoids
45	24.826	.beta.-Humulene	0.03	sesquiterpenoids
46	27.886	(1Alpha,3beta,4beta)-p-menthane-3,8-diol	0.05	Alcohol
47	28.303	Carbamic acid, N-phenyl-, 1,5-dimethyl-1-vinyl-4-hexenyl Ester	0.02	Ester
48	28.592	5-(1-Bromo-1-methyl-ethyl)-2-methyl-cyclohexanone	0.01	Alcohol
49	28.838	Pulegone	0.01	Monoterpene
50	28.973	Cyclopropanemethanol, 2,2-dimethyl-3-(2-methyl-1-propenyl)-	0.02	Aromatic hydrocarbon
51	29.292	Methanol, [6,8,9-trimethyl-4-(1-propenyl)-3-oxabicyclo[3.3.1]non-6-en-1-yl]-	0.01	Alcohol
52	29.540	Carbamic acid, N-phenyl-, 1,5-dimethyl-1-vinyl-4-hexenyl ester	0.08	Fatty Acid Ester
53	30.219	5-(1-Bromo-1-methyl-ethyl)-2-methyl-cyclohexanone	0.81	Alcohol
54	30.586	Dispiro[2.1.2.4]undecane, 8-methylene-	0.05	Hydrocarbon
55	30.672	Cycloheptene, 5-ethylidene-1-methyl-	0.07	Fatty Acid
56	30.804	Bicyclo[2.2.1]heptane, 2-[9-borabicyclo[3.3.1]non-9-yloxy]-, 1,7,7-trimethyl-	0.23	Alkane hydrocarbon
57	31.053	4-Thujanol, cis-(+/-)-	4.58	Ketone
58	31.230	trans-isocarveol	0.40	Alcohol
59	31.423	5,11,14,17-Eicosatetraenoic acid, methyl ester	0.10	Ester
60	31.596	2-Isopropenyl-5-methylhex-4-enal	6.66	Aldehyde

61	31.781	2-Isopropylidene-5-methylhex-4-enal	2.04	Aldehyde
62	31.916	Cyclopropanemethanol, 2-methyl-2-(4-methyl-3-pentenyl)-	0.24	Alcohol
63	32.044	trans-Verbenol	0.20	Alcohol
64	32.167	geranyl bromide	0.06	Alkene
65	32.261	1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-, (all-E)-	0.29	Alcohol
66	32.369	(-)-(Z)-Verbenol	0.22	Alcohol
67	32.520	2-Isopropenyl-5-methylhex-4-enal	3.89	Aldehyde
68	32.590	(-)-(Z)-Verbenol	0.77	Alcohol
69	32.704	cis-3,7-dimethyl-2-octenol	0.08	Alcohol
70	32.887	α -Citral	0.42	Aldehyde
71	33.040	trans-isocarveol	0.57	Alcohol
72	33.119	5,8,10-Undecatrien-3-ol	0.04	Alcohol
73	33.221	α -Citral	1.49	Aldehyde
74	33.482	Ethanol, 2-(3,3-dimethylcyclohexylidene)-, (Z)-	2.42	Alcohol
75	33.578	Nerolidol	1.08	Alcohol
76	33.634	Formic acid, 3,7,11-trimethyl-1,6,10-dodecatrien-3-yl ester	0.38	Ester
77	33.804	(-)-(Z)-Verbenol	0.08	Alcohol
78	33.905	Ethanol, 2-(3,3-dimethylcyclohexylidene)-, (Z)-	0.51	Alcohol
79	34.338	Formic acid, 3,7,11-trimethyl-1,6,10-dodecatrien-3-yl ester	1.52	Acid Ester
80	34.526	Dehydrolinalool	0.08	Alcohol
81	34.835	(Z)-sesquisabinene hydrate	0.07	Sesquiterpene
82	34.926	trans-isocarveol	0.06	Alcohol

The analyses of this Kenyan sample revealed the following major components: β -Myrcene (11.34%) (**11**), Geranial (18.19%) (**12**), Neral (11.40%) (**13**), 2-Isopropenyl-5-methylhex-4-enal (6.66%) (**14**), Citronellol (7.10%) (**15**), Camphor (3.80%) (**16**) and Linalool (2.04%) (**17**). The minor components (< 1%) were identified as: α -phellandren-8-ol (0.86%) (**18**), Isogeranial (0.17%) (**19**), Caryophyllene (0.50%) (**20**) and Humulene (0.02%) (**21**).



Lemongrass essential oil is sourced from young, fast growing leaves and flower tops, where it is stored in unique parenchymal oil cells located near vascular bundles and non-photosynthetic tissue (Ganjewala & Luthra, 2010). Typically, the yield of lemongrass oil ranges from 1% to 3% of the plant's total dry weight (Ranade, 2015). Lemongrass essential oil primarily consists of a few major components, including 3,7-Dimethyl-2,6-octadienal, 3,7-Dimethyl-6-octenal, germacra-1(10),4(15),5-triene, and

elemolic acid. These substances collectively make up about 60–80% of the oil's composition. In addition to these predominant components, lemongrass essential oil contains smaller quantities of other compounds such as (1R,4S)-2,2-dimethyl-3-methylidenebicyclo[2.2.1]heptane, Cyclic Dexadiene, (+)-p-mentha-1,8-diene and β -Caryophyllene epoxide (Mukarram *et al.*, 2021). The precise chemical composition of lemongrass essential oil can differ depending on various factors, such as the extraction method employed, the plant's growth stage, and the type of solvent used during extraction (Muturi *et al.*, 2020). This variability highlights the influence of extraction techniques and plant conditions on the composition of the essential oil.

4.2 Effects of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction in PCID.

4.2.1 Participant Demographics

The study covered four sub-counties in Kakamega County: Matungu, Shinyalu, Khwisero, and Likuyani. Each sub-county contributed equally with 57 participants, ensuring balanced representation across these areas. This even distribution helped ensure that the findings were generalized across the region, reflecting the diverse socio-economic conditions within Kakamega County.

A majority of the participants were female (72.4%), while males constitute 27.6%. This skewed gender distribution indicated that female caregivers were more likely to participate or be primary caregivers.

Most of the PCID were aged 33 years or older (79.3%), with a smaller proportion under 33 years (20.7%). A significant majority of participants were married (68.4%), with 31.6% unmarried. Most participants had attained primary education (74.6%), while a smaller proportion had secondary education (25.4%). A higher proportion of

participants were unemployed (59.7%) compared to those who were employed (40.3%). There was a relatively balanced distribution between male (55.3%) and female (44.7%) children with intellectual disabilities. Slightly more children were 3rd born or above (53.9%) compared to 1st or 2nd born (46.1%). The children were almost evenly split between those under 5 years (52.2%) and those 5 years or older (47.8%). Table 4.3 presents the socio-demographic details of the study participants.

Table 4.3: Socio-demographic profile of of the study participants

		N	%
Sub- county	Matungu	57	100.0%
	Shinyalu	57	100.0%
	Khwisero	57	100.0%
	Likuyani	57	100.0%
Gender of PCID	Male	63	27.6%
	Female	165	72.4%
Age group of PCID	< 33 years	47	20.7%
	≥ 33 years	181	79.3%
Marital status of PCID	Married	156	68.4%
	Unmarried	72	31.6%
Education status of PCID	Primary	170	74.6%
	Secondary	58	25.4%
Employment status of PCID	Employed	92	40.3%
	Unemployed	136	59.7%
Gender of ID child	Male	126	55.3%
	Female	102	44.7%
Birth order of the child	1st or 2nd	105	46.1%
	3rd and above	123	53.9%
Age group of child	< 5 years	119	52.2%
	≥ 5 years	109	47.8%

4.2.2 Number of PCID who used each of the treatments

These results present the distribution of study participants across different treatment groups based on gender. Each treatment group (Lemongrass, Lemon, Blended, and Control) has a count of participants along with the percentage of participants within each gender category. Among the participants who received the Lemongrass treatment, 28.0% were male, and 71.9% were female. For the Lemon treatment group, 19.3% were male, and 80.7% were female. In the Blended treatment group, 26.3% were male,

and 73.7% were female and within the Control group, 36.8% were male, and 63.2% were female. Table 4.4 below displays the distribution of males and females across the four groups.

Table 4.4: Number of PCID who used each of the treatments

Characteristic	Study groups			
	Lemongrass (n=57)	Lemon (n=57)	Blended (n=57)	Control (n=57)
Gender				
Male	16 (28.0%)	11 (19.3%)	15 (26.3%)	21 (36.8%)
Female	41 (71.9%)	46 (80.7%)	42 (73.7%)	36 (63.2%)

4.2.3 Effect of aromatherapy on stress reduction

Aromatherapy used in this study yielded the following results. Pre and post-test mean difference scores by treatment are presented in Table 4.5. Overall, all three aromatherapy treatments (Lemongrass, Lemon, and Blended) showed statistically significant improvements in physical stress reduction, sleep quality, and emotional well-being ($p < 0.0001$ for all outcomes). The mean differences post and pre-test for these treatments were consistently negative, indicating reductions in stress levels, improvements in sleep, and better emotional states following the aromatherapy interventions. Conversely, the group that did not receive any treatment did not demonstrate statistically significant improvements in any of the outcome measures ($p > 0.05$ for all outcomes). The mean differences for the Control group were close to zero, indicating negligible changes in stress levels, sleep quality, and emotional well-being without the aromatherapy intervention.

Lemongrass performed better in post-test on physical, sleep and emotional domains with a mean difference in stress reduction of $\bar{x} -2.1$ ($p < 0.0001$), $\bar{x} -2.0$ ($p < 0.0001$), and $\bar{x} -1.6$ ($p < 0.0001$), respectively. Blended also posted similar changes in stress reduction with higher mean differences of $\bar{x} -2.0$ ($p < 0.0001$), $\bar{x} -2.1$ ($p < 0.0001$),

and \bar{x} -1.5 ($p < 0.0001$), respectively. Minimal mean differences were also noted on stress reduction for lemon on physical (\bar{x} -1.0; $p < 0.0001$), sleep (\bar{x} -1.1; $p < 0.0001$) and emotional (\bar{x} -0.7; $p < 0.0001$) domains. Changes in control group for all the three domains were not statistically significant.

Table 4.5: Effect of aromatherapy on stress reduction

Treatment	Outcome	Mean difference (Post and pre-test) Mean±SD	t -test	p value
Lemongrass	Physical	-2.1±0.52	-30.18	< 0.0001
	Sleep	-2.0±0.54	-28.66	< 0.0001
	Emotional	-1.6±0.54	-22.51	< 0.0001
Lemon	Physical	-1.0±0.42	-17.46	< 0.0001
	Sleep	-1.1±0.50	-17.33	< 0.0001
	Emotions	-0.7±0.47	-11.43	< 0.0001
Blended	Physical	-2.0±0.56	-26.98	< 0.0001
	Sleep	-2.1±0.60	-26.31	< 0.0001
	Emotions	-1.5±0.52	-21.99	< 0.0001
Control	Physical	0.0±0.10	1.20	0.236
	Sleep	0.0±0.55	0.58	0.564
	Emotions	0.1±0.71	1.10	0.277

4.2.4 Stress measurements

Table 4.6 provided information on group differences in the effects of aromatherapy on stress reduction across different outcome variables: Physical, Sleep, and Emotional well-being. This table displays the mean differences between groups and associated p-values for post-test scores. The ANOVA Tukey test results indicated that there was no statistically significant difference in the mean between the Lemongrass and Blended groups ($p > 0.05$). All other pairwise comparisons, such as Lemongrass vs. Lemon, Lemongrass vs. Control, Blended vs. Lemon, Blended vs. Control, and Lemon vs. Control, demonstrated statistically significant differences ($p < 0.05$). These results suggest that each treatment (Lemongrass, Lemon, and Blended) significantly varied in their effects on reducing physical stress compared to one another and the Control group. Similar to the Physical stress outcome, the Lemongrass vs. Blended comparison

showed a non-significant mean difference ($p > 0.05$). All other pairwise comparisons demonstrated a statistically significant difference ($p < 0.05$). This indicates that all treatments had significant differences in their effects on sleep quality compared to each other and the Control group. The Lemongrass vs. Blended comparison showed a non-significant mean difference ($p > 0.05$). All other pairwise comparisons showed statistically significant differences ($p < 0.05$). This suggests that all treatments had significant differences in their effects on emotional well-being compared to each other and the Control group.

Table 4.6: Group differences of aromatherapy in relation to stress domains

Variable		Mean differences between groups	Mean difference	p value
Physical	Post-test	Lemongrass - Blended	0.003	*
	Post-test	Lemongrass - Lemon	-1.107	< 0.05
	Post-test	Lemongrass - Control	-2.362	< 0.05
	Post-test	Blended - Lemon	-1.110	< 0.05
	Post-test	Blended - Control	-2.365	< 0.05
	Post-test	Lemon - Control	-1.255	< 0.05
Sleep	Post-test	Lemongrass - Blended	0.056	*
	Post-test	Lemongrass - Lemon	-1.067	< 0.05
	Post-test	Lemongrass - Control	-2.151	< 0.05
	Post-test	Blended - Lemon	-1.122	< 0.05
	Post-test	Blended - Control	-2.207	< 0.05
	Post-test	Lemon - Control	-1.084	< 0.05
Emotional	Post-test	Lemongrass - Blended	-0.074	*
	Post-test	Lemongrass - Lemon	-0.976	< 0.05
	Post-test	Lemongrass - Control	-1.752	< 0.05
	Post-test	Blended - Lemon	-0.902	< 0.05
	Post-test	Blended - Control	-1.678	< 0.05
	Post-test	Lemon - Control	-0.776	< 0.05

4.2.5 Effect of aromatherapy on blood pressure and heart rate

This table 4.7 presents the impact of aromatherapy on blood pressure (BP) and heart rate among participants, categorized by different treatment groups: Lemongrass, Lemon, Blended (combination of lemon and lemongrass), and Control (no aromatherapy). The table categorized the treatments into four groups: Lemongrass,

Lemon, Blended, and Control. The measured outcomes included Systolic Blood Pressure (mm Hg), Diastolic Blood Pressure (mm Hg), and Heart Rate (beats/min). In general, all three aromatherapy treatments (Lemongrass, Lemon, and Blended) demonstrated statistically significant decreases in Systolic Blood Pressure and Heart Rate after the intervention compared to before ($p < 0.0001$ for both outcomes). Significant reduction was highest for systolic blood pressure (\bar{x} -14.0; $p < 0.0001$) and heart rate (\bar{x} -5.3; $p < 0.0001$) for the blend group. The control group showed a statistically significant increase in Systolic Blood Pressure (0.2; $p = 0.0003$) after the intervention compared to before. There were no statistically significant changes in Diastolic Blood Pressure within the Control group ($p = 0.109$).

Table 4.7: Effect of aromatherapy on blood pressure and heart rate

Treatment	Outcome	Mean difference (Post and pre- test) Mean±SD	t -test	p value
Lemongrass	Systolic BP (mm Hg)	-4.1±2.05	-15.26	< 0.0001
	Diastolic BP (mm Hg)	-0.1±0.54	-1.73	0.0897
	Heart rate (beats/min)	-2.6±1.47	-13.61	< 0.0001
Lemon	Systolic BP (mm Hg)	0.0±1.93	-16.23	< 0.0001
	Diastolic BP (mm Hg)	-2.7±0.40	0.33	0.742
	Heart rate (beats/min)	-5.3±1.73	-11.87	< 0.0001
Blended	Systolic BP (mm Hg)	-14.0±4.32	-24.42	< 0.0001
	Diastolic BP (mm Hg)	0.0±0.13	1.00	0.321
	Heart rate (beats/min)	-5.3±1.86	-21.76	< 0.0001
Control	Systolic BP (mm Hg)	0.2±0.41	3.86	0.0003
	Diastolic BP (mm Hg)	-0.1±0.49	-1.63	0.109
	Heart rate (beats/min)	-0.5±0.60	6.17	< 0.0001

ANCOVA was performed using post-test measure as the dependent variable, pre-test measure and intervention groups as covariates. This model assessed the differences in the post-test means for each stress domain after controlling for intervention groups. The outcome was expected to assess whether pre-test scores for stress domains had effect on post-test stress outcome accounting for the intervention groups. The results indicate that even after adjusting for sleep and emotional scores at pre-test, post-test

stress scores, the two domains still significantly differ by type of intervention ($p < 0.0001$). On the contrary, after adjusting for physical scores at pre-test, post-test stress scores for this particular domain significantly differ by type of intervention and the physical test scores ($p < 0.0001$) suggesting that there is interaction effect between pre-test scores for physical domain and the type of intervention. Thus, effect of pre-test scores for physical domain on post-test scores depends on the type of intervention administered. Therefore, a comparison of the four intervention group means, depends on the scores of pre-test for physical domain. The reduction in mean post-test scores for physical domain was highest between pre-test physical domain score and blended intervention (Est. -1.066, $p < 0.0001$) and lowest for pre-test physical domain score and lemon (Est. -0.90; $p < 0.0001$). This is shown in table 4.8 below.

Table 4.8: Mean differences in the post-test means controlling for pre-test stress scores and intervention

Variable	F	P value
Group	1043.98	< 0.0001
Physical (Pre-test)	31.91	< 0.0001
Group	978.54	< 0.0001
Sleep (Pre-test)	0.40	0.530
Group	599.38	< 0.0001
Emotional (Pre-test)	1.85	0.175

4.3 Perceptions of parents of children with intelligence disability on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction

Open ended questions were administered to the study participants. Using these questions, the researcher sought comprehensive responses from participants, aiming to understand their perspectives fully and to delve deeper into the context and significance of their answers through various probing techniques. The responses were taken and some keywords noted for theme formation.

After extensive analysis of the data, the following themes were observed:

1. Calming effect of the drug
2. Frequency of exposure
3. Cost effectiveness
4. Pleasant aroma and non- allergic reaction

4.3.1 THEME1: Calming effects of the drug

Some of the participants who were interviewed mentioned that the duration of using the essential oil brought about a relaxing effect. The sensation of relaxation came unexpectedly, leaving some individuals amazed by how quickly and effortlessly they were able to relax, to the point where they reported improved sleep at night. The inhalation periods created an atmosphere of calmness to the mind and body. This was as verbalized by participant no. 1 (Respondent 1) as follows:

*“The first time I used this drug **A** brought about a feeling of instant relaxation to my body. Infact the first night of using it made me sleep like a baby. This drug has a very calming effect even to my mind. ”*

Another Respondent 2 reply was as follows

*“This drug **AB** has made my heart to stop beating fast all the time. I definitely feel better and it relieves some of my anxiety.....”*

Response of participant 3 was as follows as follows

*“My back and waist has really been painful for so many days lets say almost one year since I started taking care of this child. I normally go to the lady herbalist so that she helps me by massaging my back a little. Truthfully, this drug **AB** that you gave me has helped me so much and I find its strength to be okay and that has made me feel more relaxed.”*

Another respondent 4 response was as follows:

*“Since I was brought for this child by her mother two years ago, I have had a problem with remembering things. I always forget time to time and truthfully speaking, this drug **A** has really helped me so much on this problem that I have. I find it not so difficult to remember where I put things unlike before. I think if you gave me an even stronger scent my memory will become perfect..”*

Response from participant 5 was as follows:

*“When I inhaled the drug **B**, I felt a sense of well-being as I went about my daily house work. By the end of the day I would feel so calm and end up sleeping early unlike before I started using this.”*

4.3.2 THEME 2: Frequency of exposure to the drug

The participants who were interviewed using key informant interviews said that the number of times they inhaled the drug made them feel different and even performed their activities of daily living well. This was as verbalized by (respondent 6) as follows

*“Since the time I started using this drug throughout the day, I find myself completing all my planned activities of the day well, especially taking care of this baby. The prescribed number of times I use this drug **A** is sufficient and the good thing is that its 3 times a day making it easy to use..”*

Another participant responded as follows (respondent 7)

*“Using this drug **B** 3 times a day is convenient because it coincides with meal times. I have never skipped using it and it gives me a sense of well-being. I really appreciate.”*

Furthermore, another response by (respondent8) was as follows

“I am happy that this drug is 3 times a day just like the panadol I take when I am sick. What I like most is that this drug A makes me energized through out the day especially after inhaling it in the morning, lunchtime and when going to bed in the evening”

4.3.3 THEME 3: Cost effectiveness of the drug

Severity of stress manifestation can affect the general health of someone and this in turn has an impact on the amount of money one spends on treatment. Acute conditions are likely to respond to treatment fast and for chronic conditions treatment may last for a very long time. A majority of the participants in this study were the primary caregivers of children with intellectual disabilities (PCID) and had been caring for their children for an extended period. This has impacted negatively on the general health of these PCID which has made them spend a lot on treatment of illnesses caused by stress. This can be seen from the response of respondent 9 who verbalized

Respondent 9:

“Since I started using this drug AB, I have not gone to the hospital for treatment of headaches and body aches because this drug has made me feel healthy unlike before when I used to spend so much time and money for seeking treatment.”

Another participant (respondent 10) responded as follows:

“Using this drug B has reduced my expenditure of going to the hospital for treatment. I am grateful for this drug indeed”

4.3.4 THEME 4: Pleasant aroma and non allergic reaction

The scent of the essential oil has an effect on its effectiveness. Some of the participants who were interviewed expressed that the drug had a good scent and that they did not

react to it in any way. The scents also made them feel good as they went about their daily chores.

Respondent 11 verbalized as follows:

*“This drug **AB** is the best. I find it to be even better than perfume that I use sometimes since I don’t sneeze after inhaling it. The smell is good and when I walk around I feel its calming effect.”*

Another participant (respondent 12) verbalized as follows

*“The smell of this drug **A** is so good and it doesn’t disturb my nose and the fact that it comes from what we plant around here makes it even better for us who live in Kakamega. When I use this drug I feel happy and feel a connection between nature and me..”*

CHAPTER FIVE

DISCUSSION

5.0 Overview

This chapter presents the research outcomes focused on identifying and examining the chemical constituents of lemon (*Citrus limon*) and lemongrass (*Citratrus cymbopogon*) essential oils. Additionally, it explores the efficacy of these oils in aromatherapy for alleviating stress levels among parents of children with intellectual disabilities in Kakamega County, Kenya. The factors that were researched were:

1. To authenticate the chemical content of essential oil extract from Lemon (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*).
2. To assess the effectiveness of Lemon (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction in parents of children with intelligence disability.
3. To determine the perceptions of parents of children with intelligence disability on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination on stress reduction.

5.1 Chemical composition of *C. limon*

Gas Chromatography-Mass Spectrometry (GC-MS) was utilized to single out the constituents of the essential oils. This analytical process is widely recognized for its simplicity, speed, efficiency, and extensive application in determining the chemical constituents of essential oils. GC-MS analysis provides a unique profile for each batch of essential oil, enabling insights into its distinct properties based on chemical

composition. Additionally, GC-MS analysis can often assess the purity of essential oils (Daferera *et al.*, 2000).

The main constituents in lemon leaf essential oils identified in my study included Cyclopentene, 3-isopropenyl-5,5-dimethyl- (26.73%); D-Limonene (33.15%), β -Ocimene (5.50%); β -Myrcene (3.44%); γ -Terpinene (2.46%); Linalool (1.23%) and 6-Octenal, 3,7-dimethyl-, (R)- (8.23%) whereas the minor components were Isogeranial (0.07%); Citronellol (0.25%); α -Terpineol (0.05%); Caryophyllene (0.36%) and trans-Geranic acid methyl ester (0.12%). Other studies done have shown similar chemical components as what was found in this study but with a variation in the percentage. Approximately 27 compounds were identified in Iranian lemon leaf essential oil with linalool (30.62%), geraniol (15.91%), α -terpineol (14.52%), and linalyl acetate (13.76%) as the main constituents (Hojjati *et al.*, 2017). This is in contrary to this study which found that the lemon oil in my study of lemon leaf essential oil contained D-Limonene (33.15%) as the highest chemical component and Linalool (1.23%) was found to be lower than that of Iran. Japanese lemon leaf oil primarily consists of geranial as the main component, with limonene and neral following closely behind (Kamiyama, 1967).

Egyptian lemon leaf oil was found to have caryophyllene as the primary component, followed by linalool, nerol, and limonene, while Turkish lemon leaf oil primarily includes limonene (44.2%), geranial (14.1%), β -pinene (10.6%), sabinene (2.4%), myrcene (1.8%), and (E)- β -ocimene (1.7%) (Gülay Kirbaslar & S. İsmail Kirbaslar, 2004). Italian lemon leaf oils, according to Dugo *et al.* (1997), typically featured limonene (\leq 34.8%), β -pinene (\leq 16.0%), and geranial (\leq 14.1%). Meanwhile, lemon leaf oils from Benin were reported to contain primarily limonene, β -pinene, and citronellal (Ayedoun, 1996).

In another research carried out by Hsouna et al. (2017), *Citrus limon* essential oil was found to contain nine major components, which were 6,6-Dimethyl-2-methylenebicyclo[3.1.1]heptane (β -Pinene) (25.44%), (+)-p-mentha-1,8-diene (Limonene) (39.74%), 3,7-Dimethyl-1,6-octadien-3-ol (Linalool) (2.16%), α -Terpineol (7.30%), 3,7-dimethylocta-1,6-dien-3-yl acetate (linalyl acetate) (3.01%), geranyl acetate (3.03%), Nerolidol (6.91%), neryl acetate (1.74%), and Farnesol (4.28%). Minor components (<1%) included 2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene (α -Pinene), Sabinene, 7-Methyl-3-methylene-1,6-octadiene (Myrcene), 1,3,3-Trimethyl-2-oxabicyclo[2.2.2]octane (Eucalyptol), carbamate, and (E)-3,7-Dimethylocta-2,6-dien-1-ol (Geranial). The reason for these observed differences in chemical composition and predominant ingredients could be attributed to variations in geographic region, topography, and external environmental factors such as temperature, rainfall, height, and sunlight exposure. The percentage composition of certain components like α -Terpineol differed significantly between studies; for example, it was a major component (7.30%) in the research by Hsouna et al. (2017) but a minor one (0.05%) in this present study. Conversely, β -myrcene was identified as a major component (3.44%) in this study but considered minor in others, possibly influenced by variations in plant drying and essential oil extraction methods. Key constituents found in lemon essential oil, such as limonene and β -myrcene, find application in the perfume industry, flavorings, medicines, and serve as local antiseptics in the pharmaceutical sector.

5.2 Chemical composition of *C. citratus*

This study identified major and minor components present in lemongrass essential oils. The lemongrass essential oil utilized in this study was analyzed and the following major components were identified β -Myrcene (11.34%); Geranial (18.19%); Neral

(11.40%); 2-Isopropenyl-5-methylhex-4-enal (6.66%); Citronellol (7.10%); Linalool (2.02%) and Camphor (3.80%) while the minor components that were identified included D-Limonene (0.07%); alpha-phellandren-8-ol (0.85%); Isogeranial (0.17%); α -ylangene (0.08%), γ -muurolene (1.02%), camphene (0.05%) and Caryophyllene (0.44%). Lemongrass originating from Brazil was characterized by its primary compounds, including neral (31.5%), citral (26.1%), nonan-4-ol (6.54%), camphene (5.19%), sulcatone (4.36%), citronellal (3.83%), β -caryophyllene (3.26%), citronellol (2.95%), caryophyllene oxide (2.63%), γ -muurolene (2.46%), limonene (2.32%), geranyl acetate (2.27%), and geranial (2.15%) (Brügger *et al.*, 2019). Differences in the composition of lemongrass essential oils can be attributed to factors such as the age of the plant, geographical location of cultivation, and method of extraction. Hydrodistillation, used in both the Brazilian study and this current research, may have influenced the results.

Terpenoids, the primary constituents of lemongrass essential oil, are frequently present in plants where they play vital roles in plant physiology and serve essential functions in cellular membranes (Loza-Tavera, 1999).

A study using Ecuador lemon grass essential oil found the major constituents of their oil as geranial (39.8%) and neral (33.20%) as major components (Pino *et al.*, 2018). These components were also found to be consistent with those found in the lemongrass used in this present research but with higher percentages which could be attributed to the topography and climate which are different between the 2 countries. Hadjilouka *et al.*, (2016) in their study using lemongrass essential oil from Greece found the main chemical components of the oil as geranial (38.5%), neral (28.7%), limonene (6.9%), geraniol (4.4%), geranyl acetate (4.3%), methyl-5-hepten-2-one (1.8%), linalool

(1.6%), and caryophyllene (1.4%). The outcomes align with the findings of this study, but with varying percentages in the chemical composition.

5.3 Effects Lemon and Lemongrass essential oils on stress among PCID

Inhalation-based aromatherapy can swiftly impact the human body by eliciting a response from the central nervous system and releasing neurotransmitters within about 4 seconds (Han *et al.*, 2018). This method of application is both direct and reduces the likelihood of skin contact with essential oils, thereby lowering potential risks like skin burns. The effectiveness of aromatherapy varies depending on the particular essential oil employed and how it interacts with receptors in the body. Various plant essential oils, including lavender, peppermint, orange, lemon, and chamomile, possess unique compositions that contribute to their therapeutic effects. Lavender essential oil, for instance, contains linalyl acetate, linalool, and caryophyllene, known for their calming properties (Keene *et al.*, 2019). Orange essential oil, with its pleasant aroma and anti-anxiety effects, is primarily composed of limonene (Zhang & Hu, 2013). Chamomile essential oil, an aromatic ester, is valued for its ability to alleviate tension, anxiety, and promote relaxation and sleep, making it a potent psychotherapeutic agent (Li *et al.*, 2016). Similarly, lemon essential oil used in this study contained D- limonene which has anti-anxiety properties, β -Phellandrene and linalool which have anti-depressant properties. Furthermore, Lemongrass essential oil used in this study also contained D- limonene and linalool which are have anti-anxiety and anti-depressant properties. The choice of device for diffusing essential oils can influence the dosage process, as the amount of essential oil emitted by the diffuser can affect the desired effects of the oils (Halligudi and Al Ojaili, 2013). Inhaling essential oils through cloths or pads preserves their concentration and quality, ensuring that aromatic molecules can efficiently and directly reach brain regions via olfactory pathways (Erdö *et al.*, 2018).

The findings from this study indicate that lemon and lemongrass essential oils, whether used individually or in combination and by using 2-3 drops on the collar of the clothes, effectively lowered stress levels among parents of children with intellectual disabilities. These results align with previous research by Kamrani et al. (2016) and Özer et al. (2022), which also noted significant reductions in anxiety levels in groups using lemon essential oil compared to control groups. Özer et al. (2022) specifically observed a 43.3% reduction in exam anxiety in nursing students who used *c. limon* essential oil. The above findings could be attributed to the chemical compositions such as D- limonene and linalool of these essential oils which contain anti- anxiety and anti-stress properties.

Research has investigated the use of aromatherapy with lavender, lemon, and bergamot essential oils, revealing their ability to alleviate symptoms of depression. These include impacts on impaired neurogenesis, inhibited dendritic growth of immature neurons, and reduced levels of Brain-derived neurotrophic factor (BDNF) in the hippocampus (Sánchez-Vidaña *et al.*, 2019; Ruan *et al.*, 2014). In clinical studies involving patients experiencing signs of stress and depression manifestation, such as attention deficit hyperactivity disorders, a one month aromatherapy intervention led to decreased levels of anxiety and depression, accompanied by increased BDNF levels in hippocampal tissues (Ayuob, 2017). Stress, depression, and anxiety disorders are associated with elevated cortisol levels, and studies using lavender essential oil as aromatherapy have indicated a decrease in the secretion of stress hormones, resulting in reductions in salivary and serum cortisol levels (Shiina *et al.*, 2008). Additionally, bergamot and grapefruit seed essential oils have been noted for their ability to decrease blood cortisol levels, thereby relieving symptoms associated with stress. Bergamot essential oil has been observed to modulate the HPA axis and reduce corticosterone

levels in mice (Saiyudthong & Marsden, 2011). Lemon essential oil has shown antidepressant effects by increasing dopamine turnover in the hippocampus, highlighting the therapeutic promise of essential oils in addressing depression and related symptoms (Fung *et al.*, 2021). These findings align with this study's results, which demonstrated that aromatherapy using lemon and lemongrass essential oils reduced stress-related symptoms.

Inhalation of lemongrass and lemon essential oils in this study led to a notable decrease in systolic blood pressure levels (-15.26; $p < 0.0001$) and (-16.23; $p < 0.0001$) in the lemongrass and lemon groups, respectively, among individuals with PCID after 8 weeks of oil inhalation. Comparable outcomes were observed in other research, such as Moradi *et al.* (2021), who carried out a research involving clients undergoing coronary angiography, where one group inhaled *Citrus aurantium* essential oil 15–20 minutes prior the procedure, while the control group used deionized water. Notable decreases in anxiety-related vital signs, such as pulse rate and both systolic and diastolic blood pressure, were observed after inhaling bitter orange essential oil. The consistent results might be due to the similar chemical compositions found in the citrus species used in both studies.

Inhalation of orange essential oil for 90 seconds significantly reduced oxy-hemoglobin accumulation in the right prefrontal region of the brain, resulting in feelings of relaxation and comfort among participants (Igarashi *et al.*, 2014). Zhang *et al.* (2019) demonstrated that limonene, a component of *Citrus sinensis* (L.) Osbeck Essential Oil, exhibited clinical effectiveness as an antidepressant by impacting neuroendocrine, neurotrophic, and monoaminergic systems in laboratory mice immediately after inhalation. Lima *et al.* (2013) found that D-limonene, the primary compound in *C. limon* essential oil, induced calming and anxiolytic effects in mice when inhaled at

concentrations of 0.5% and 1.0%, by activating dopamine and serotonin receptors. Additionally, D-limonene showed pain-relieving effects comparable to indomethacin and hyoscine. Soto-Vasquez & Alvarado-García (2016), in their study, treated one group (EG2) with *Silene brevicalyx* essential oil and observed a greater reduction in anxiety scores compared to another group (EG3) treated with *Satureja boliviana* essential oil. This distinction was attributed to the anxiolytic properties of essential oils containing linalool, which affects the central nervous system with sedative, hypnotic, and anxiolytic effects. Zahra et al. (2021) found that anxiety scores significantly decreased immediately after inhalation of both lavender and *Citrus aurantium* essential oils compared to a placebo group. However, there was no significant difference between the lavender and *Citrus aurantium* groups three hours post-intervention. Similarly, in the current study, significant reductions in stress scores were observed in the lemon, lemongrass, and blended essential oil groups compared to the control group post-intervention. This outcome is likely due to the specific chemical compositions of the essential oils used.

Shirzadegan et al. (2020) explored the effects of *Citrus aurantium* aroma on anxiety and fatigue in myocardial infarction patients. Their research demonstrated that *Citrus aurantium* significantly alleviated anxiety by inducing relaxation through olfactory stimulation. This effect is attributed to the essential oil's capacity to stimulate the central nervous system, thereby enhancing mood, and its recognized sedative, antispasmodic, and diuretic properties. Similarly, our study observed that inhaling lemon and lemongrass essential oils over an 8-week period reduced stress levels among parents of children with intellectual disabilities (PCID). Lemongrass essential oil, in particular, contributed to decreases in stress related to physical and sleep domains (-2.1, $p < 0.0001$ and -2.0, $p < 0.0001$, respectively). The duration of exposure

to the essential oils likely influenced the extent of stress reduction, with longer usage correlating with more pronounced effects.

5.4 Effects of lemon and lemongrass essential oils blend on stress among PCID

Aromatherapy using blended essential oils has been shown to significantly reduce test anxiety in college students. Research by McCaffrey et al. (2009) revealed that a mixture of lavender and rosemary essential oils was effective in alleviating test anxiety among nursing postgraduates. Lavender oil contributed to a sense of calm, while rosemary oil improved focus and memory. The synergistic effect of these essential oils heightened the concentration of aromatic molecules, thereby amplifying the therapeutic effects of aromatherapy. Similarly, Anggraini et al. (2022) investigated the inhalation of a combination of lemon and lemongrass essential oils among pregnant women in their third trimester, finding significant improvements in sleep quality. This finding aligns with our study, which also observed improved sleep quality (-1.6; $p < 0.0001$) among parents of children with intellectual disabilities (PCID) after 8 weeks of inhaling a blend of lemon and lemongrass essential oils. This could be due to the synergistic effects brought about by fusing two essential oils that have similar chemical compositions. From this research, both lemon and lemongrass essential oils contain Linalool and β -myrcene which work together to bring out the essential oils desired effect.

Siahaan et al. (2014) conducted a single-blind clinical trial involving 60 healthy women, who were divided into three groups: one treated with an Indonesian essential oil blend, another with lavender oil, and a control group. Psychological relaxation assessments indicated that the Indonesian essential oil blend was equally effective as lavender oil in inducing relaxation, with both significantly outperforming the control group. In terms of physical relaxation, the Indonesian essential oil blend demonstrated

greater efficacy than lavender oil, particularly in reducing mean arterial pressure (MAP) scores. Similarly, in our study, the combination of lemon and lemongrass essential oils (-19.9; $p < 0.0001$) led to a significant reduction in systolic blood pressure. This finding suggests a synergistic effect when blending oils with similar calming properties.

The study indicated that combining lemongrass and lemon essential oils resulted in improved sleep and alleviation of physical symptoms associated with stress. These findings align with Lee Mi-kyoung et al. (2017), who investigated an essential oil blend containing lemon, eucalyptus, tea tree, and peppermint. Lee et al. assessed perceived stress, stress index, autonomic nervous system (ANS) activation, glycated hemoglobin (HbA1c) levels, sleep quality, and immune status, revealing significantly lower perceived stress levels ($p < .001$), reduced depression ($p = .049$), and enhanced sleep quality ($p = .001$) in participants receiving aromatherapy. The synergistic effects of the essential oil blend were credited for these positive outcomes.

Ke et al. (2022) investigated how aromatherapy impacts physical and mental health, as well as stress relief, in elderly members of the community. Their study demonstrated significant reductions in perceived "pressure" following interventions involving blended essential oil massage combined with inhalation, blended essential oil massage alone, and blended essential oil inhalation alone. In contrast, groups receiving pure base oil massage or no aromatherapy intervention showed no significant differences. This research underscored the synergistic benefits of a 5% concentration blend of lavender, bergamot, and marjoram essential oils in enhancing the general biopsychosocial health of middle-aged and elderly individuals, thereby reducing stress. These findings align with the current research, where a 5% concentration blend of 2.5% lemon and 2.5% lemongrass essential oils used in inhalation significantly

decreased stress levels among parents of children with intellectual disabilities compared to those using either essential oil independently.

Kholibrina & Aswandi (2021) conducted a study examining the impact of aromatherapy blends containing citronella (*Cymbopogon nardus*), nutmeg (*Myristica fragrans*), and benzoin (*Styrax sumatrana*) essential oils on relaxation and blood pressure. The study found that aromatherapy led to notable reductions in blood pressure for both men and women. Specifically, men experienced decreases of 8.6 mmHg in systolic pressure and 1.3 mmHg in diastolic pressure, while women saw reductions of 8.4 mmHg in systolic pressure and 1.1 mmHg in diastolic pressure. These findings indicate that inhaling a blend of essential oils can effectively reduce psychological stress and lower blood pressure in individuals with hypertension. These findings are consistent with the current study, which observed a significant decrease in systolic blood pressure (-14.0; $p < 0.321$) following inhalation of a blend of lemon and lemongrass essential oils. However, no significant change was noted in diastolic pressure (0.0; $p < 0.0001$) in this current study.

5.5 Perceptions of PCID on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination for stress reduction

Aromatherapy utilizes essential oils extracted from plants, either through inhalation or topical application, to achieve specific effects (Boehm *et al.*, 2012). In this study, participants were assessed regarding their experiences with lemon and lemongrass essential oils. They documented a diverse range of physical and psychological benefits resulting from inhaling aromatherapy, such as increased comfort, relaxation, reduced muscle tension, improved sleep, heightened energy levels, and enhanced mood. Study participants reported no adverse experiences. The qualitative objective aimed to

investigate the perceptions of individuals with profound cognitive and intellectual disabilities regarding the beneficial aspects of using lemon and lemongrass essential oils for stress relief. The study identified four main themes through key informant interviews: calming effect of the drug, frequency of exposure, cost-effectiveness, and pleasant aroma without allergic reactions.

These findings are supported by other researches that found similar themes. Kerr et al. (2021) observed in their research that ten participants reported feeling more relaxed due to the diffusion of essential oils. For instance, one participant expressed, *"I've noticed a change in how I feel when I use the essential oils. I tend to be calmer and more relaxed."* Another participant mentioned, *"When I smelled the essential oil being diffused as I walked down the hallway, I felt a sense of well-being and positivity."* This is similar to the findings from this current research where some of the participants stated that they felt more relaxed and calmer after inhaling the lemon and lemongrass essential oil. This could have been due to the chemical composition of essential oils used in these two studies.

Another theme that emerged from this study was the pleasant aroma and non- allergic reaction from the aromatherapy. Participants in this research stated that they liked the pleasant aroma from the lemon and lemongrass essential oils used in this study. This finding is similar with other studies that found the pleasant aroma to have a positive effect. A participant in one research verbalized *"Aromatherapy is much pleasant than the other odors on this ward"* (Kerr et.al.,2021). In another study, participants reported experiencing improved mood after using aromatherapy, as one participant explained, *"I had never used fragrances before, so I wasn't aware of their beneficial effects. However, I believe I felt better because I was working out while breathing in that scent."* Another participant in the same study stated, *"I was jogging at a similar speed*

and aiming for the same heart rate as the previous time, but it wasn't as challenging as I expected. I kept jogging on the treadmill while wondering why that was. I think starting off in a pleasant mood was because of the good smell." (Kwon et al., 2020).

These findings are similar to those of this current study where the PCID did not report of any allergies after inhalation of the essential oils for a period of 8 weeks. This could have been due to the aromatic and anti inflammation effects produced by the chemical composition of the essential oils like 2,6-Octadienal, 3,7-dimethyl-, (E)- and beta myrcene respectively.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.0 Overview

Aromatherapy utilizes essential oils derived from plants such as flowers, herbs, or trees, to promote therapeutic benefits, address health concerns, and improve physical, emotional, and spiritual well-being (National Health and Medical Research Council, 2020).

This chapter provides a synopsis of the findings along with conclusions and recommendations.

6.1 Conclusion

6.1.1 Authentication of the chemical content of essential oil extract from Lemon leaves (*Citrus limon*) and Lemongrass (*Cymbopogon citratus*)

This study provides novel insights into the chemical composition of lemon and lemongrass essential oils sourced from Kenya. Through gas chromatography-mass spectrometry (GC-MS) analysis, the bioactive compounds in these oils were identified, confirming their therapeutic potential for stress reduction. The findings contribute to the limited literature on the phytochemical profiles of these plants in the East African region, validating their traditional use in aromatherapy.

6.1.2 Effects of lemon, lemongrass essential oils and their combination on stress among PCID

The results demonstrated that lemongrass essential oil was particularly effective in reducing blood pressure, a key physiological marker of stress, compared to lemon essential oil alone. However, the combination of both oils showed synergistic benefits, significantly improving sleep quality and lowering systolic blood pressure among Parents/Caregivers of Children with Intellectual Disabilities (PCID). These findings

suggest that blended essential oils may offer a more holistic approach to stress management by addressing both physical and psychological symptoms.

6.1.3 Perceptions of PCID on the positive attributes associated with the use of Lemon leaves (*Citrus limon*), Lemongrass (*Cymbopogon citratus*) essential oils extracts and their combination for stress reduction

Participants reported favorable perceptions of the essential oils, citing their calming effects, pleasant fragrance, and absence of adverse reactions. The oils were widely accepted as a non-invasive, culturally appropriate intervention, with many caregivers expressing willingness to incorporate them into daily routines. This positive reception underscores the potential for community-based adoption of aromatherapy in low-resource settings.

6.2 Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance stress management among parents of children with intellectual disabilities in Kakamega County and similar settings:

6.2.1 Integration of Aromatherapy into Community Health Programs

Kakamega county health departments and community-based organizations should consider incorporating lemon and lemongrass aromatherapy as a low-cost, culturally acceptable stress-relief intervention for caregivers of children with disabilities.

6.2.2 Further Research

Longitudinal studies should assess the long-term effects of aromatherapy on chronic stress, including physiological bio markers e.g., cortisol levels. Comparative research with other stress interventions e.g., mindfulness, support groups could identify optimal combinations for holistic care.

6.2.3 Economic Empowerment Initiatives

Local farmers and women's groups should be supported to cultivate lemongrass and citrus plants, creating income-generating opportunities while promoting sustainable access to aromatherapy materials.

6.2.5 Integration into healthcare Provider Curriculum

Train nurses and clinicians in Kakamega's maternal and child health clinics to screen for caregiver stress and recommend aromatherapy as a non-pharmacological option, particularly where mental health services are scarce. In addition, regulatory bodies like Nursing Council of Kenya could infuse CAM into the Nursing curricula.

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APPENDICES

APPENDIX 1: Consent form

Dear participants:

We are pleased to invite you to take part in this study examining the effectiveness of lemon and lemongrass essential oils in managing conditions among parents of children with intellectual disabilities. Please read this informed consent form thoroughly and carefully consider whether you wish to participate. If you have any questions or need clarification about the study, feel free to ask the researcher or research assistants. They will provide answers and explanations until you are fully satisfied.

Aim of this study

The aim of this study is to investigate the effectiveness of lemon and lemongrass essential oils on the management among Parents of children with intelligence disability.

The study and the informed consent have received approval from the Institutional Review and Ethics Committee (IREC) at Masinde Muliro University of Science and Technology.

People will be recruited in this study

A total of 250 people will be recruited in this study.

What are the prerequisites for patient's participating in this study?

Firstly, you sign this informed consent to show that you have volunteered and met the inclusion criteria of this study which are:

- Aged between 22-49 years, have no history of chronic disease, not consuming herbal medicine or certain types of supplements one week before and during the research.
- Are the guardian of an intellectually disabled child aged between 4-18 years (school going)
- Their child with ID as diagnosed by a psychiatric clinical officer.

Study procedure

You will be administered with lemon and lemongrass essential to inhale and counselling for a period of 8 weeks. Prior to inhalation of the essential oils and counselling, you will fill a stress indicator form and after the inhalation will be done. After you have signed the informed consent, the researcher/ research assistants will randomly group you into 4 groups. Once you obtain the vial containing the essential oil, you will be requested to drop 2- 3 drops on the sleeve of your blouse or shirt for every morning, noon and evening for the next 8 weeks. Periodic blood pressure and heart rate measurements will be taken. You will also fill out a stress indicator questionnaire the day when blood pressure and heart rates measurements will be taken.

Risks

While the possibility of this happening is very low, you should still be aware of the possibility. The following are the risks of using lemon and lemongrass essential oils.

- Photosensitivity when used topically
- Skin irritation and rash when applied topically
- Dryness and stinging around the eyes, ears, mouth, and other mucous membranes, such as the genital area.
- Dizziness, drowsiness, increased appetite and increased urination.

The above side effects occur initially but resolve after continued use of the essential oils. However, if headaches persist, you will be given paracetamol and advised to stop participation of the study.

Advantages to participants for participation in this study

This study will evaluate a reliable method for stressed parents to use for the management of symptoms of stress.

Cost for the patient to participate in this study

No extra cost need to be paid by participants for participation in this study.

Confidentiality for participants in this study

I assure you that your personal information will not be included in the study results, even if the research is published in a journal. The research materials and specimens will be kept at Masinde Muliro University of Science and Technology, with the researcher responsible for their safekeeping. However, the Institutional Review and Ethics Committee (IREC) retains the right to access the subject's information if needed.

Rights of the participants in this study

As a study participant, you have the following rights

- Right to withdraw from the study any time
- Right to inquire for any information of the study

Who can explain the inquiries for patients by telephone when they have problems?

If you have any question related to this study, please directly contact the who is called Sharon Kosgey.

The telephone number of Sharon Kosgey is 0725091881

Informed Consent Signature Page

Research Title: EFFECTIVENESS OF LEMON (*CITRUS LIMON*), LEMONGRASS (*CYMBOPOGON CITRATUS*) AND THEIR COMBINATION AS AROMATHERAPY ON STRESS REDUCTION AMONG PARENTS OF CHILDREN WITH INTELLIGENCE DISABILITY (PCID) IN KAKAMEGA COUNTY, KENYA

I have read the above information and understood the purpose and the potential benefits of participating in this study. All the questions I put forward on the study procedure and the study content have been answered to my satisfaction. I agree to inhale the aromas therefore I voluntarily sign this consent form and volunteer to participate in this study.

Participants signature: _____ Date of signature:

I have read and explained the informed consent to the participant, and then answered all the questions he/she has raised. Him/herself has also already understood and agreed to participate in the study.

Signatures of researcher: _____ Date of signature:

2nd reading after aromatherpy inhalation					
3rd reading after aromatherpy inhalation					
4th reading after aromatherpy inhalation					
5th reading after aromatherpy inhalation					
6th reading after aromatherpy inhalation					
7th reading after aromatherpy inhalation					
8th reading after aromatherpy inhalation					
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15th reading after aromatherpy inhalation					
16th reading after aromatherpy inhalation					
17th reading after aromatherpy inhalation					

Stress indicator tool

This questionnaire will show how stress affects different parts of your life. Circle the response which best indicates how often you experience each stress indicator during a typical week.

When you have answered all the questions add the point totals for each section.

SINCE YOU STARTED TAKING CARE OF THIS CHILD, HOW OFTEN WOULD YOU SAY:

S/No	Particulars	Almost always	Most of the time	Some of the time	Almost never	Never
1	My body feels tense all over.	5	4	3	2	1
2	I have a nervous sweat or sweaty palms.	5	4	3	2	1
3	I have a hard time feeling really relaxed.	5	4	3	2	1
4	I have severe or chronic lower back pain.	5	4	3	2	1
5	I get severe or chronic headaches.	5	4	3	2	1
6	I get tension or muscle spasms in my face, jaw, neck or shoulders.	5	4	3	2	1
7	My stomach quivers or feels upset.	5	4	3	2	1
8	I get skin rashes or itching.	5	4	3	2	1
9	I have problems with my bowels (constipation, diarrhea).	5	4	3	2	1
10	I need to urinate more than most people.	5	4	3	2	1
11	I have developed an ulcer which bothers me	5	4	3	2	1

12	I feel short of breath after mild home chores	5	4	3	2	1
13	Compared to most people, I have a very small or a very large appetite.	5	4	3	2	1
14	My weight is not ideal	5	4	3	2	1
15	I smoke tobacco.	5	4	3	2	1
16	I get sharp chest pains when I'm doing daily extraneous chores.	5	4	3	2	1
17	I lack physical energy.	5	4	3	2	1
18	When I'm resting, my heart beats more than 100 times a minute.	5	4	3	2	1
19	Because of my busy schedule I miss at least two meals during the week.	5	4	3	2	1
20	I don't really get a balanced nutrition.	5	4	3	2	1

Physical Indicators Point total _____

S/No	Particulars	Almost always	Most of the time	Some of the time	Almost never	Never
1	I have trouble falling asleep.	5	4	3	2	1
2	I take pills to get to sleep.	5	4	3	2	1

3	I have nightmares or repeated bad dreams	5	4	3	2	1
4	I wake up at least once in the middle of the night for no apparent reason.	5	4	3	2	1
5	No matter how much sleep I get, I awake feeling tired.	5	4	3	2	1

Sleep Indicators Point Total _____

S/No	Particulars	Almost always	Most of the time	Some of the time	Almost never	Never
1	I have found the best way to deal with hassles and problems is to consciously avoid thinking or talking about them.	5	4	3	2	1
2	I have trouble remembering things.	5	4	3	2	1
3	I feel anxious or frightened about problems I can't really describe.	5	4	3	2	1
4	I worry a lot.	5	4	3	2	1
5	It is important for me not to show my emotions to my family.	5	4	3	2	1
6	It is hard for me to relax at home.	5	4	3	2	1
7	It's best if I don't tell even my	5	4	3	2	1

	closest friend how I'm really feeling.					
8	I find it hard to talk when I get excited.	5	4	3	2	1
9	I feel very angry inside.	5	4	3	2	1
10	I have temper outbursts I can't control.	5	4	3	2	1
11	When people criticize me, even in friendly, constructive way, I feel offended.	5	4	3	2	1
12	I feel extremely sensitive and irritable.	5	4	3	2	1
13	My emotions change unpredictably and without any apparent reason.	5	4	3	2	1
14	I feel like I really can't trust anyone.	5	4	3	2	1
15	I feel like other people don't understand me.	5	4	3	2	1
16	I really don't feel good about myself.	5	4	3	2	1
17	Generally, I am not optimistic about my future.	5	4	3	2	1
18	I feel very tired and disinterested in life.	5	4	3	2	1

19	Impulsive behavior has caused me problems.	5	4	3	2	1
20	I have felt so bad that I thought of hurting myself.	5	4	3	2	1

Emotional Indicator Point Total _____

PERSONAL STRESS LEVELS

	Very Low	Medium	High	Very High	Danger
Physical Indicators Point Total	22.....	30.....	38.....	48.....	54+
Sleep Indicators Point Total	5.....	8.....	10.....	12.....	14+
Emotional Indicators Point Total	21.....	29.....	37.....	46.....	55+

OPEN ENDED QUESTIONS ON PERCEPTIONS OF PCID ON THE POSITIVE ATTRIBUTES ASSOCIATED WITH THE USE OF LEMON LEAVES (*CITRUS LIMON*), LEMONGRASS (*CYMBOPOGON CITRATUS*) ESSENTIAL OILS EXTRACTS AND THEIR COMBINATION FOR STRESS REDUCTION

Respondents Anonymity number:

1. What is your experience after using this aromatherapy?
2. What benefits do you believe aromatherapy provides?
3. Are there specific conditions or situations where you think it is most effective?
4. Do you have any doubts or concerns about the efficacy of aromatherapy?
5. Are you aware of any potential risks or side effects associated with aromatherapy?

Thank you for your cooperation

APPENDIX 3: PROPOSED AROMATHERAPY ADMINISTRATION PROTOCOL

NAME OF FACILITY:

SUBJECT: Aromatherapy

PURPOSE: To identify the process of using aromatherapy safely.

To provide an aromatherapy program that safely integrates the use of therapeutic essential oils into the routine use for the management of manifestation of stress by facilitation of the the body's innate healing response in a holistic environment.

RELATED REGULATIONS/LAWS: Nursing Council of Kenya Accountability for the Utilization of Integrative Therapies in Nursing Practices

DEFINITIONS:

Aromatherapy: The controlled use of essential oils to address specific stress symptoms and enhance health and well-being.

Essential Oils: Essential oils are highly concentrated extracts from the aromatic parts of herbs, flowers, fruits, trees and grasses and are known for their therapeutic properties.

Topical Application: Providing the essential oil topically through the skin by massage/touch/compress/cotton squares with dilution of essential oils to cover affected area.

Inhalation Application: Providing the essential oil using the olfactory system.

Direct Inhalation: Applying drops of the essential oil to a cotton ball and instructing the patient to smell the essential oil as needed to relieve or decrease specific symptoms or increase well-being.

Indirect Inhalation: Using a diffuser to diffuse essential oils into the patient room to relieve or decrease specific symptoms or increase well-being.

Carrier Oil: Cold pressed vegetable oil or jojoba (liquid wax) into which the essential oils are mixed before the topical application of aromatherapy by such methods as massage or touch.

Patch Testing: The process used to determine if a patient is sensitive to an essential oil before topical application is used.

POLICY:

1. Essential Oils provided by (name of facility) will be administered by a licensed healthcare professional trained in the use of essential oils.

2. Equipment List (for essential oils on cotton balls or for massage)

- Essential oils
- Carrier oils
- Cotton Balls
- Small sealable plastic bags
- Labels
- Personal Protective Equipment (PPE)

Or, Equipment List (for Inhalation Patches/Aromatherapy Inhalers)

- Inhalation Patch or Aromatherapy Inhaler.

3. Approved Locations for Application (only for topical application, not needed for Inhalation Patches/Aromatherapy Inhalers)

- Aromatherapy products used for patient care shall be used strictly in locations intended as single occupancy.
- The use of aromatherapy products can be problematic to hypersensitive people who are handling or have secondary exposure to the products. If someone experiences symptoms, discontinue use and follow the protocols identified in the (list plan).

4. Procedure for use

Responsibility	Action
	Assess patient for need and perception of problem, preferences of aroma, being touched, allergies, skin sensitivities, etc.
	Provide education about aromatherapy and explain procedure
	Obtain verbal consent
	Select essential oil or modality with patient input
	Identify method of application (application for topical) Do a patch test (not needed for inhalation patches or aromatherapy inhalers)

	Provide treatment, disposing of any waste in the trash
	Evaluate patient response
	Document

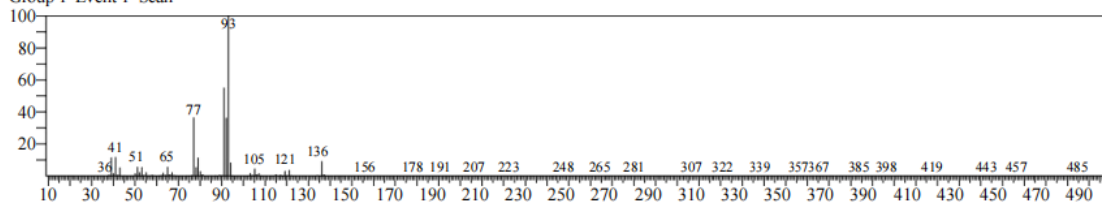
5. Procedure for Accidents (not needed for inhalation patches or aromatherapy inhalers)

Responsibility	Action
	Essential oil in eye: Irrigate eye with milk or carrier oil and then with water
	Skin reaction/Irritation: Remove essential oil with milk or carrier oil. Wash with soap and water. Pat dry and leave open to air for 10 minutes.
	Essential oil bottle dropped or oil spilled: Use a paper towel to soak up spill and collect glass if bottle is broken. Wrap in more paper and dispose of in double sealed plastic bag.

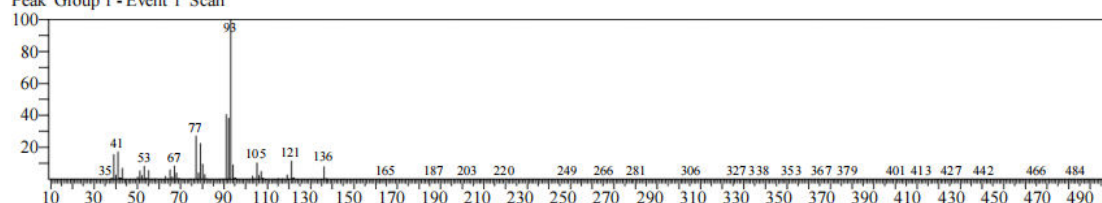
6. Documentation: Documentation includes provider, date/time, EO used, application method used, patient response

APPENDIX 4: GC-MS for *C. limon* Rt = 5.535 -7.052

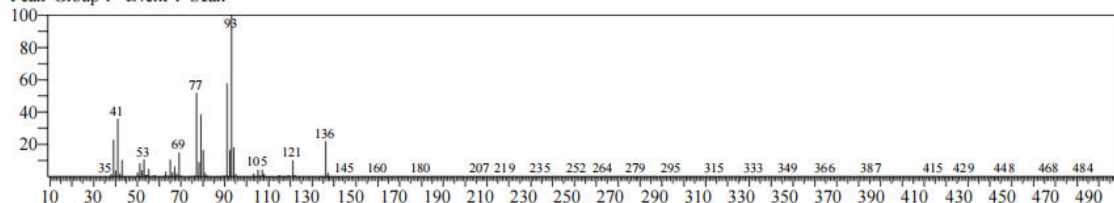
Line#:1 Retention Time:5.535(Scan#:607) Mass Peaks:254 Raw
Mode:Averaged from 5.529 to 5.541(Scans #606 to #608) Base
Peak:93.10 (Intensity 230563) Background Mode:Calculated from Peak
Group 1 Event 1 Scan



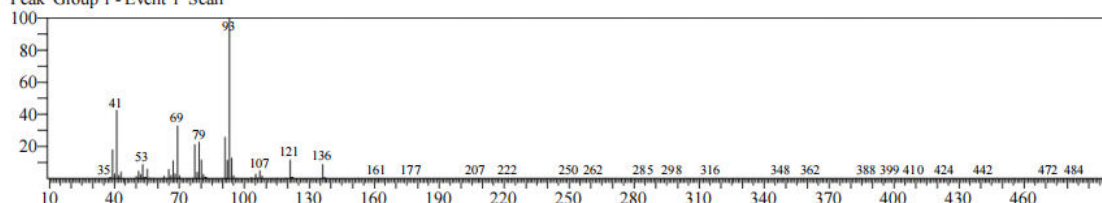
Line#:2 Retention Time:5.733(Scan#:641) Mass Peaks:308 Raw
Mode:Averaged from 5.728 to 5.739(Scans #640 to #642) Base
Peak:93.10(Intensity 717556) Back Ground Mode:Calculated from
Peak Group 1 - Event 1 Scan



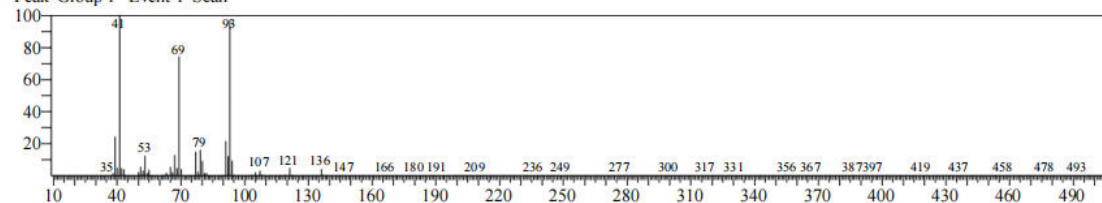
Line#:3 Retention Time:6.748(Scan#:815) Mass Peaks:318 Raw
Mode:Averaged from 6.742 to 6.754(Scans #814 to #816) Base
Peak:93.15(Intensity 8359719) Back Ground Mode:Calculated from
Peak Group 1 - Event 1 Scan



Line#:4 Retention Time:6.871(Scan#:836) Mass Peaks:284 Raw
Mode:Averaged from 6.865 to 6.877(835-837) Base
Peak:93.10(Intensity 1440742) Back Ground Mode:Calculated from
Peak Group 1 - Event 1 Scan

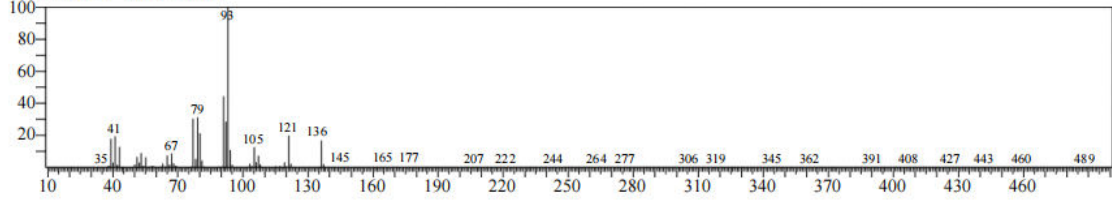


Line#:5 Retention Time:7.052 (Scan#:867) Mass Peaks:245 Raw
Mode:Averaged from 7.046 to 7.058(866-868) Base
Peak:41.10(Intensity 2019601) Back Ground Mode:Calculated from
Peak Group 1 - Event 1 Scan

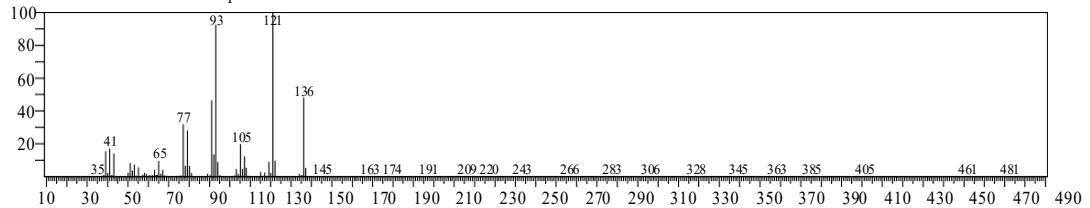


Appendix 5 : GC-MS for *C. limon* Rt = 7.618 -8.598

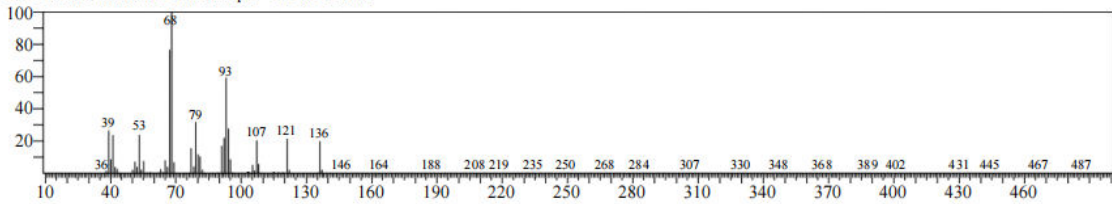
Line#:6 Retention Time:7.618(Scan#:964) Mass Peaks:272 Raw
Mode:Averaged from 7.612 to 7.623(Scan #963- #965) Base
Peak:93.10(Intensity 2072907) Back Ground Mode:Calculated from
Peak Group 1 - Event 1 Scan



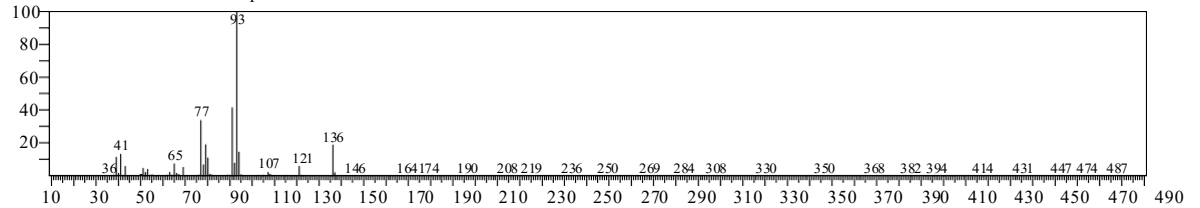
Line#:7 R.Time:7.839(Scan#:1002) MassPeaks:320
RawMode:Averaged 7.833-7.845(1001-1003) BasePeak:121.15(617801)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



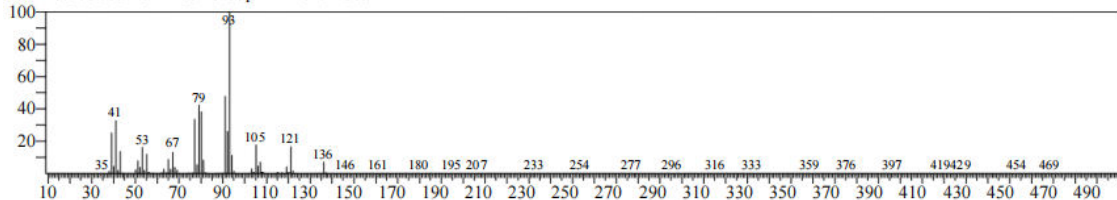
Line#:8 Retention Time:8.259(Scan#:1074) Mass Peaks:294 Raw
Mode:Averaged from 8.253-8.265(1073-1075) Base Peak:68.10(7246920)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:9 R.Time:8.300(Scan#:1081) MassPeaks:268
RawMode:Averaged 8.294-8.306(1080-1082) BasePeak:93.10(389422)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

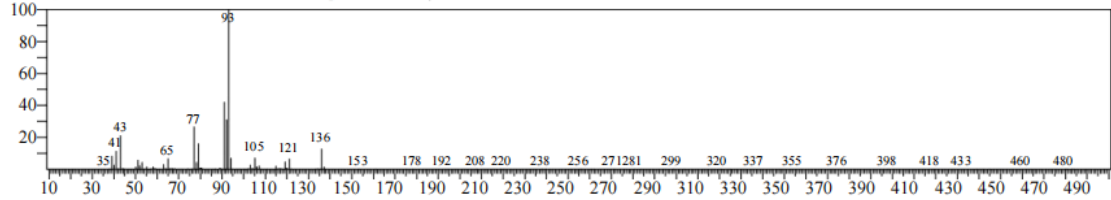


Line#:10 Retention Time:8.598 (Scan#:1132) Mass Peaks:297 Raw
Raw Mode:Averaged from 8.592-8.603(Scan #1131 to #1133) Base Peak:93.10(Intensity 2548576)
BG Mode:Calcu from Peak Group 1 - Event 1 Scan

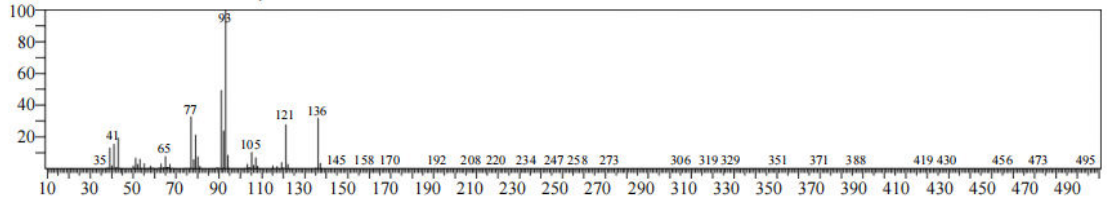


Appendix 6 : GC-MS for *C. limon* Rt = 8.813 -9.723

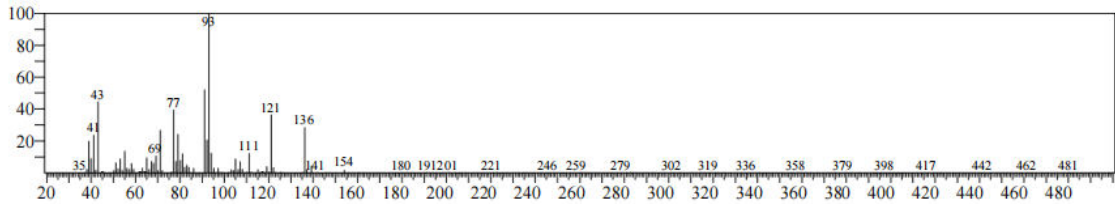
Line#:11 Retention Time:8.813(Scan#:1169) Mass Peaks:269 Raw
Mode:Averaged from 8.807-8.819(1168-1170) Base Peak:93.10(Int
36998)BG Mode:Calculated from Peak Group 1 - Event 1 Scan



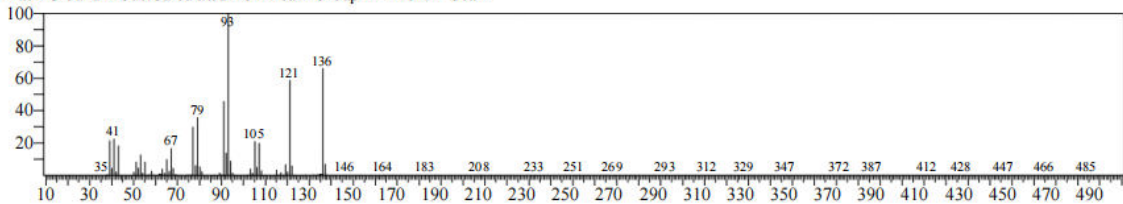
Line#:12 R.Time:8.982(Scan#:1198) MassPeaks:267
Raw Mode:Averaged from 8.977 to 8.988(Scan #1197- #1199) Base Peak:93.10(Intensity 1476616)
BG Mode:Calcalat from Peak Group 1 - Event 1 Scan



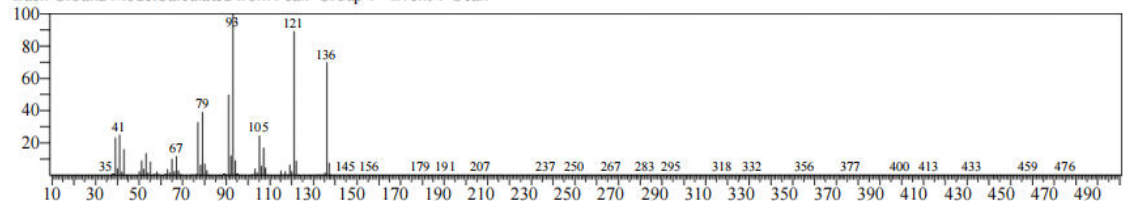
Line#:13 Retention Time:9.397(Scan#:1269) Mass Peaks:282 Raw
Mode:Averaged from 9.391 to 9.402(1268-1270) Base
Peak:93.10(Intensity 17406) BG Mode:Calculated from Peak Group 1 -
Event 1 Scan



Line#:14 Retention Time:9.595(Scan#:1303) Mass Peaks:272 Raw
Mode:Averaged from 9.589-9.601(1302-1304) Base Peak:93.10(41325)
Back Ground Mode:Calculated from Peak Group 1 - Event 1 Scan

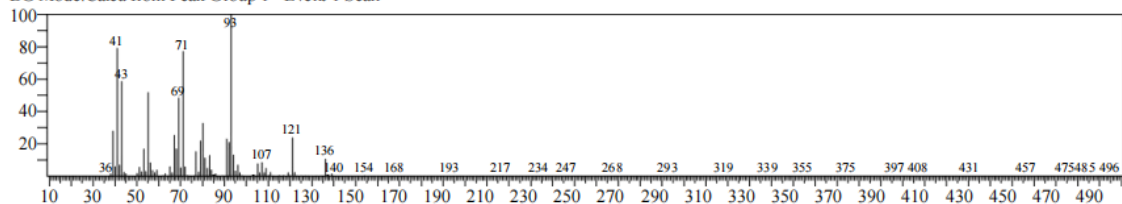


Line#:15 Retention Time:9.723(Scan#:1325) Mass Peaks:287 Raw
Mode:Averaged from 9.717-9.729(1324-1326) Base Peak:93.10(433540)
Back Ground Mode:Calculated from Peak Group 1 - Event 1 Scan

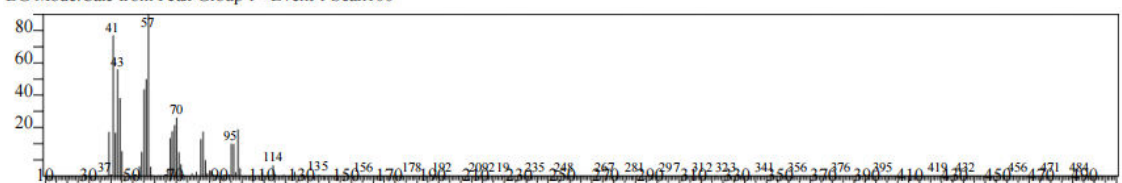


Appendix 7 : GC-MS for *C. limon* Rt = 10.155 -12.471

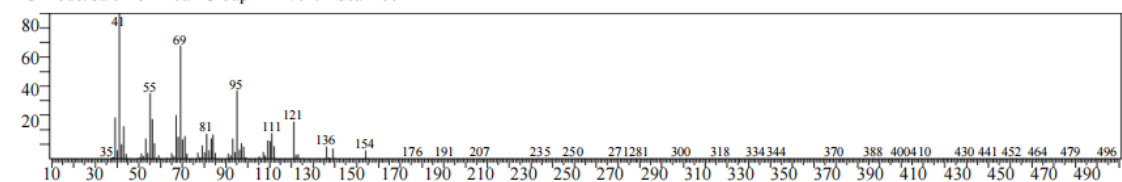
Line#:16 R. Time:10.155(Scan#:1399) MassPeaks:291
Raw Mode:Averaged from 10.149-10.161(Scan #1398- #1400) Base Peak:93.10(404174)
BG Mode:Calcu from Peak Group 1 - Event 1 Scan



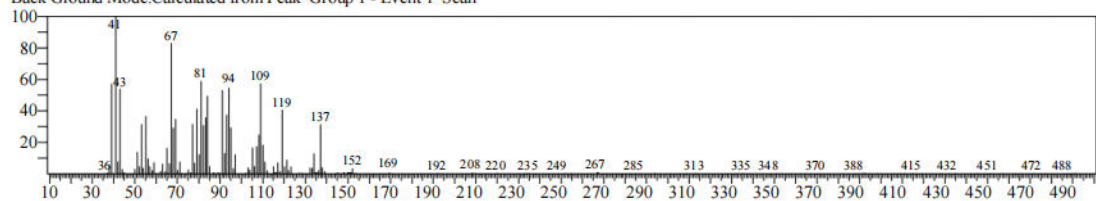
Line#:17 Retention Time:10.324(Scan#:1428) Mass Peaks:242 Raw
Mode:Averaged from 10.318-10.330(1427-1429) Base Peak:57.10(26484)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100



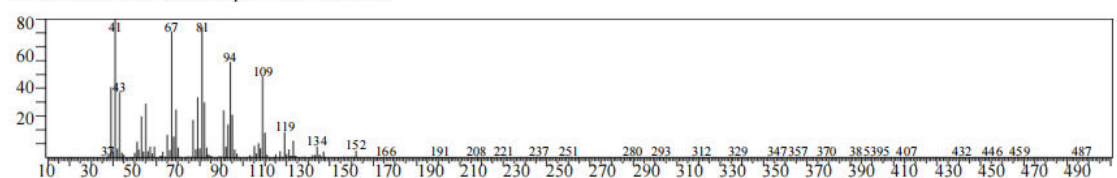
Line#:18 R. Time:11.713(Scan#:1666) MassPeaks:330
Raw Mode:Averaged from 11.707 to 11.718(1665-1667) Base Peak:41.10(2134359)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100



Line#:19 Retention Time:11.934(Scan#:1704) Mass Peaks:272 Raw
Mode:Averaged from 11.928-11.940(1703-1705) Base Peak:41.10(8313)
Back Ground Mode:Calculated from Peak Group 1 - Event 1 Scan

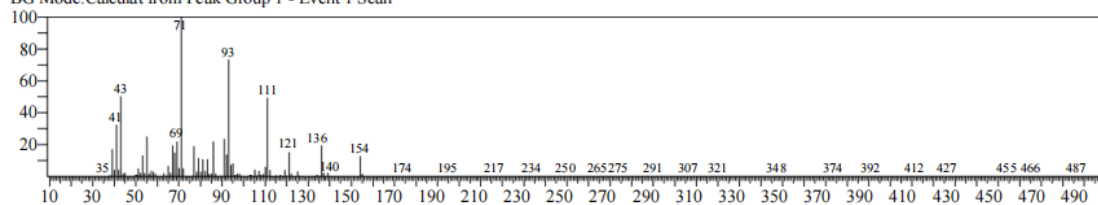


Line#:20 R. Time:12.471(Scan#:1796) MassPeaks:263
Raw Mode:Averaged from 12.465 to 12.477(Scan #1795- #1797) Base Peak:41.10(17803)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100

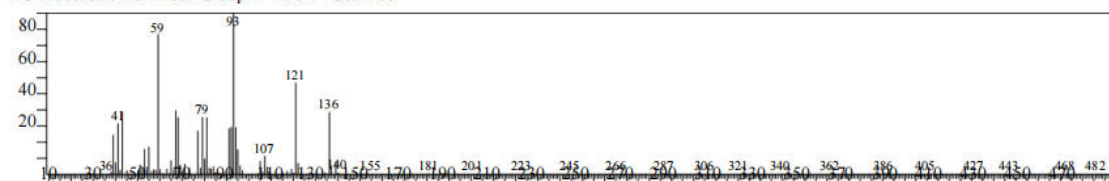


Appendix 8: GC-MS for *C. limon* Rt = 12.588 -14.192

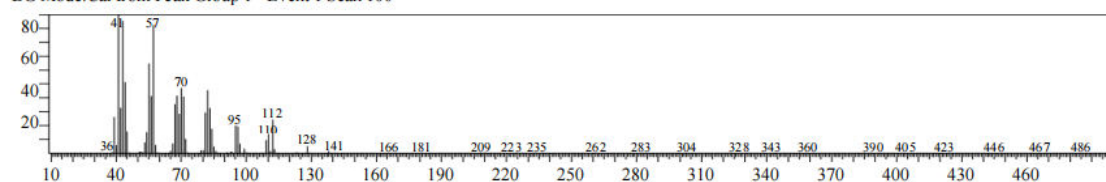
Line#:21 Retention Time:12.588(Scan#:1816) Mass Peaks:306 Raw
 Mode:Averaged from 12.582-12.593(1815-1817) Base Peak:71.10(359141)
 BG Mode:Calculat from Peak Group 1 - Event 1 Scan



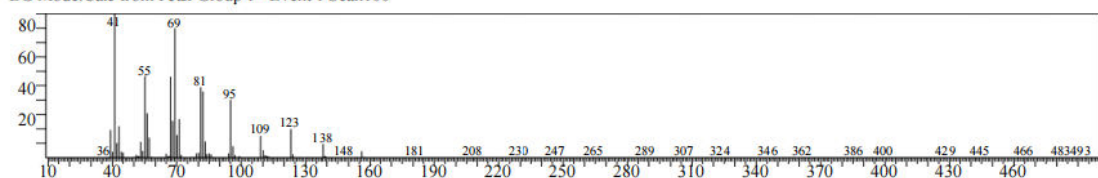
Line#:22 R. Time:13.031(Scan#:1892) MassPeaks:247
 Raw Mode:Averaged from 13.025 to 13.037(Scan #1891-#1893) Base Peak:93.10(Intensity 16417)
 BG Mode:Calc from Peak Group 1 - Event 1 Scan100



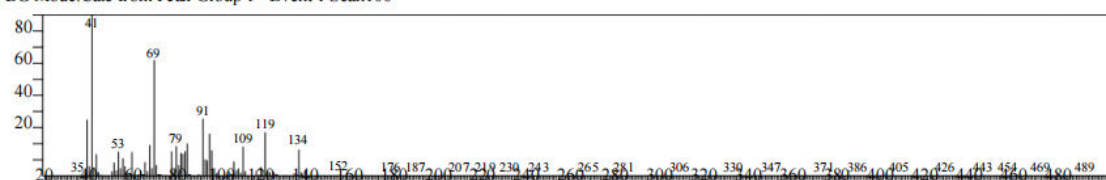
Line#:23 Retention Time:13.183(Scan#:1918) Mass Peaks:226 Raw
 Mode:Averaged from 13.177-13.188(1917-1919) Base Peak:41.10(51747)
 BG Mode:Cal from Peak Group 1 - Event 1 Scan 100



Line#:24 R. Time:13.766(Scan#:2018) MassPeaks:273
 Raw Mode:Averaged from 13.760 to 13.772(2017-2019) Base Peak:41.10(Intensity 108579)
 BG Mode:Calc from Peak Group 1 - Event 1 Scan100

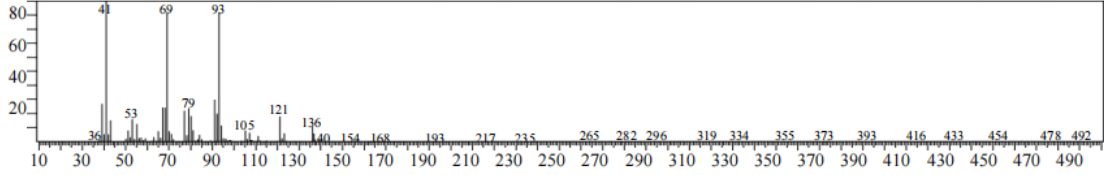


Line#:25 Retention Time:14.192(Scan#:2091) Mass Peaks:285 Raw
 Mode:Averaged from 14.186 to 14.198(2090-2092) BasePeak:41.10(353352)
 BG Mode:Calc from Peak Group 1 - Event 1 Scan100

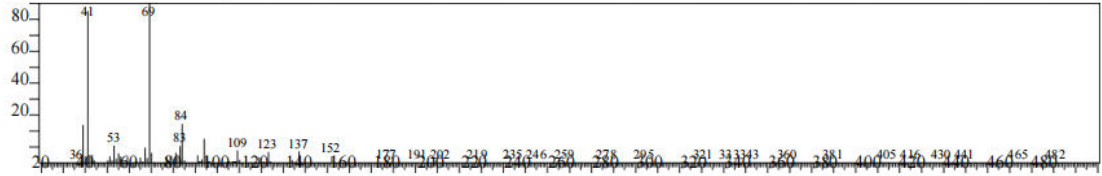


Appendix 9: GC-MS for *C. limon* Rt = 14.442 -16.321

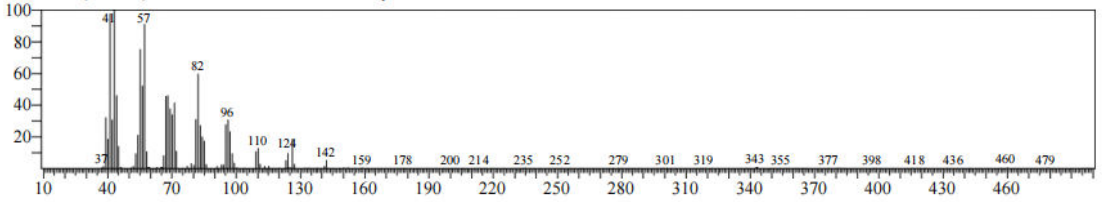
Line#:12 R.Time:14.442(Scan#:2134) MassPeaks:284
Raw Mode:Averaged from 14.437 to 14.448(2133-2135) Base Peak:41.10(Intensity 34925)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100



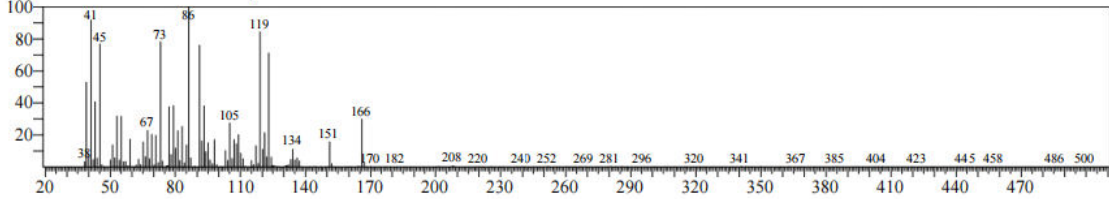
Line#:27 Retention Time:15.026(Scan#:2234) MassPeaks:257 Raw
Mode:Averaged from 15.020-15.032(Scan #2233-#2235) Base
Peak:69.10(Intensity 776083)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100



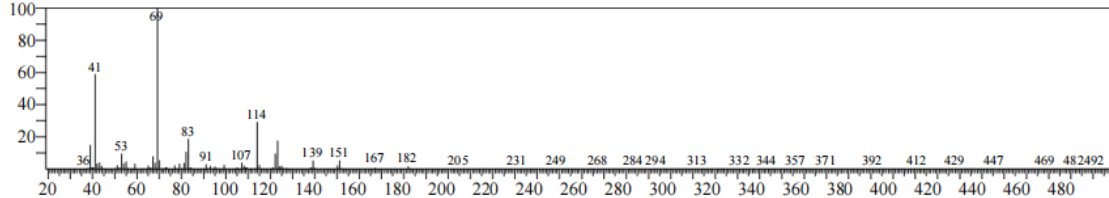
Line#:28 R.Time:15.977(Scan#:2397) MassPeaks:255
Raw Mode:Averaged 15.971-15.983(2396-2398) Base
Peak:43.10(Int9374) BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:29 Retention Time:16.181(Scan#:2432) MassPeaks:269 Raw
Mode:Averaged from 16.175-16.187(2431-2433) Base Peak:86.10(11812)
BG Mode:Calcula from Peak Group 1 - Event 1 Scan

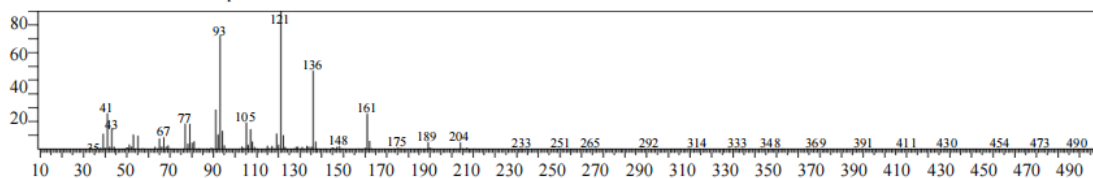


Line#:30 R.Time:16.321(Scan#:2456) MassPeaks:254
Raw Mode:Averaged from 16.315 to 16.327(2455-2457) Base Peak:69.10(Intensity 87453)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

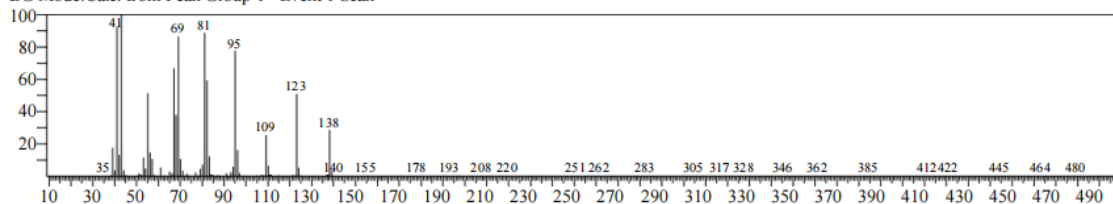


Appendix 10 : GC-MS for *C. limon* Rt = 16.589 -18.083

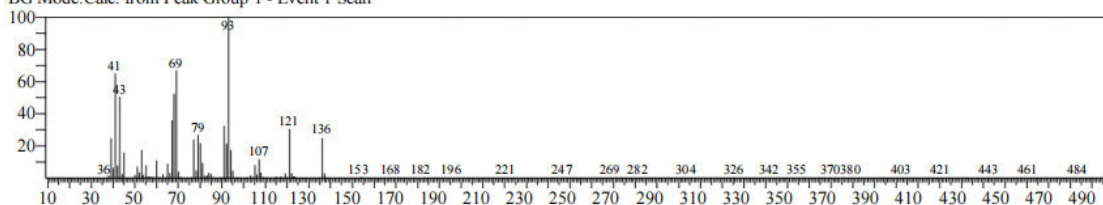
Line#:31 Retention Time:16.589(Scan#:2502) Mass Peaks:256 Raw
Mode:Averaged from 16.583 to 16.595(2501-2503) BasePeak:121.15(27112)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan100



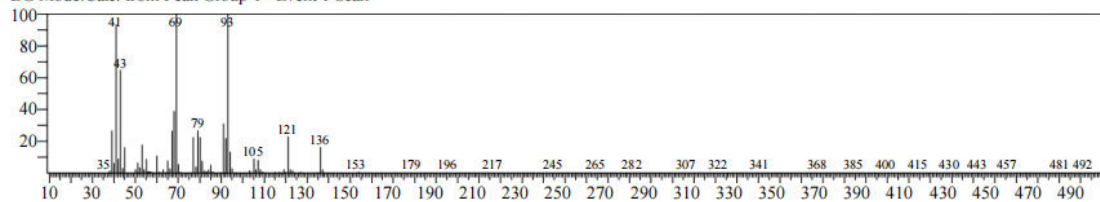
Line#:32 R.Time:16.986(Scan#:2570) MassPeaks:285
Raw Mode:Averaged from 16.980 to 16.992(2569-2571) Base Peak:43.05(119936)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



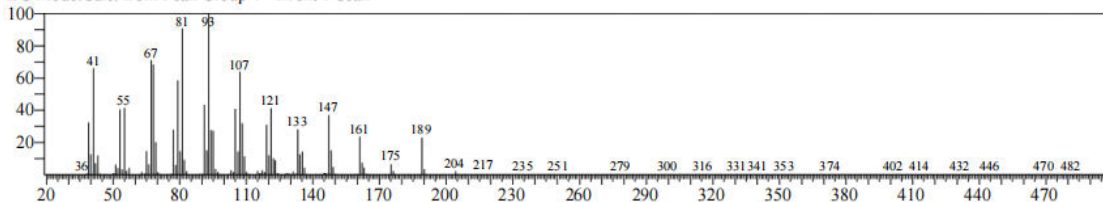
Line#:33 RetentionTime:17.254(Scan#:2616) Mass Peaks:287 Raw
Mode:Averaged from 17.248 to 17.260(2615-2617) BasePeak:93.10(251516)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:34 R.Time:17.785(Scan#:2707) MassPeaks:277
Raw Mode:Averaged from 17.779 to 17.791(2706-2708) Base Peak:93.10(Intensity 219703)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

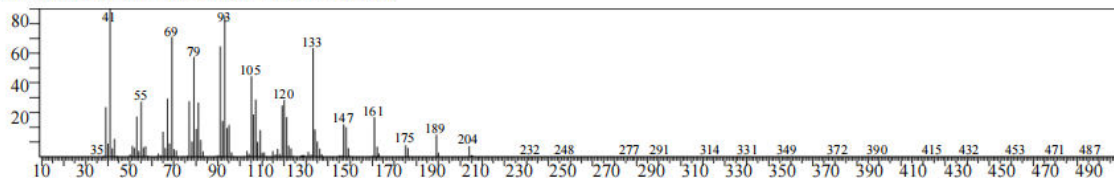


Line#:35 Retention Time:18.083(Scan#:2758) Mass Peaks:282 Raw
Mode:Averaged from 18.077-18.088(2757-2759) Base Peak:93.10(68179)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

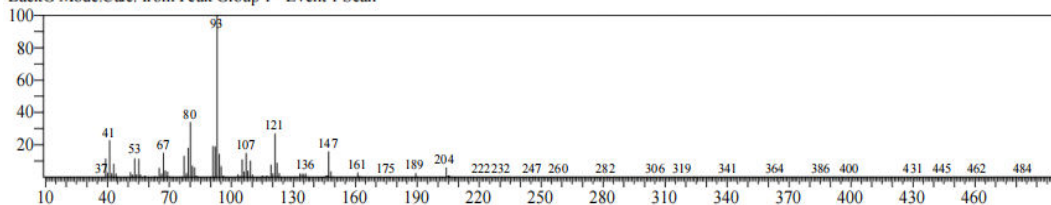


Appendix 11 : GC-MS for *C. limon* Rt = 18.934 -21.052

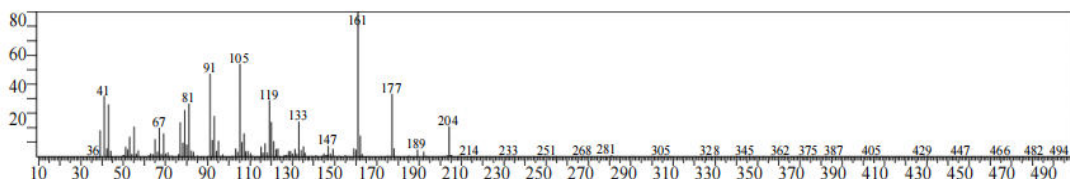
Line#:36 R.Time:18.934(Scan#:2904) MassPeaks:303
Raw Mode:Averaged from 18.928 to 18.940(2903-2905) Base Peak:41.10(Intensity 72394)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100



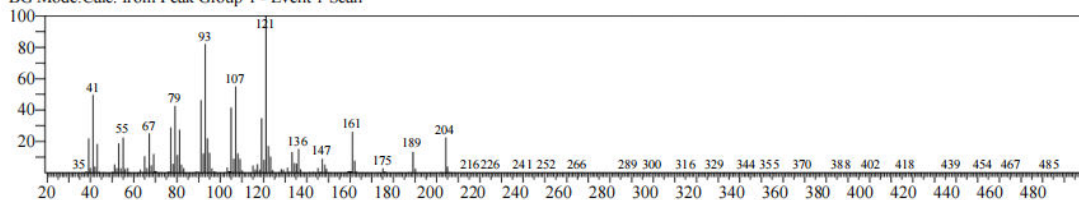
Line#:37 Retention Time:19.873(Scan#:3065) Mass Peaks:302 Raw
Mode:Averaged from 19.868-19.879(3064-3066) Base Peak:93.10(41034)
BackG Mode:Calc. from Peak Group 1 - Event 1 Scan



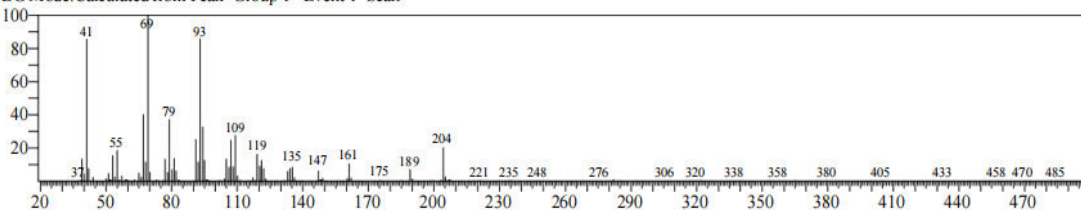
Line#:38 R.Time:20.509(Scan#:3174) MassPeaks:316
Raw Mode:Averaged from 20.503 to 20.515(3173-3175) Base Peak:161.10(Intensity 9750)
BG Mode:Calc from Peak Group 1 - Event 1 Scan100



Line#:39 R.Time:20.883(Scan#:3238) Mass Peaks:302 Raw
Mode:Averaged from 20.877-20.888(3237-3239) Base Peak:121.15(33619)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

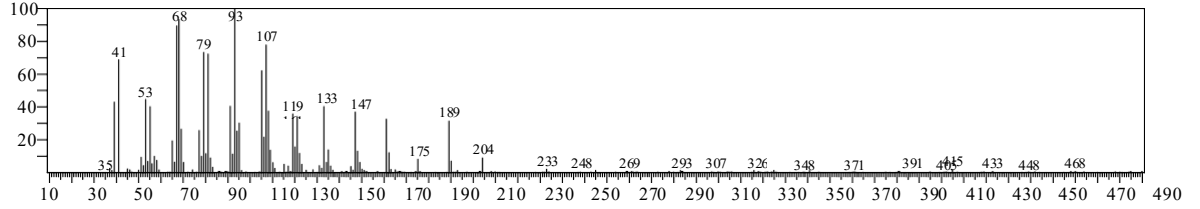


Line#:40 R.Time:21.052(Scan#:3267) MassPeaks:247
Raw Mode:Averaged 21.046 to 21.058(3266-3268) BasePeak:69.10(8144)
BG Mode:Calculated from Peak Group 1 - Event 1 Scan

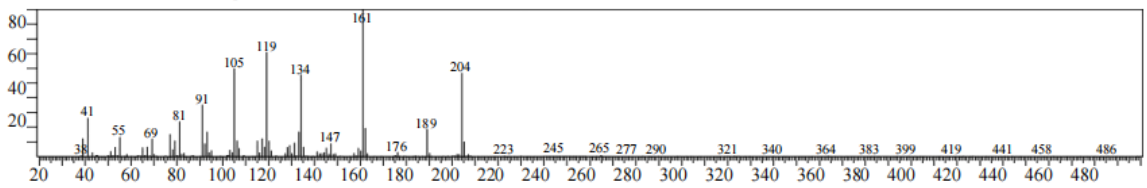


Appendix 12 : GC-MS for *C. limon* Rt = 21.192-22.469

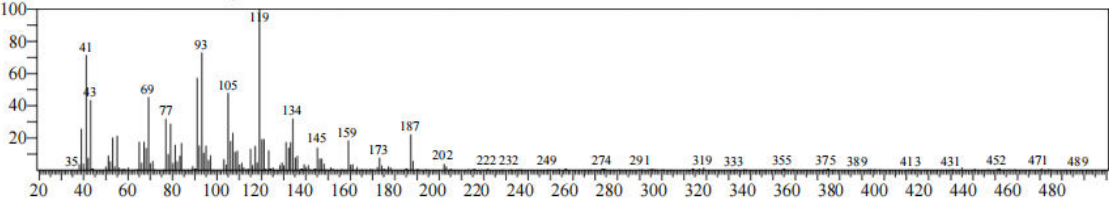
Line#:41 R.Time:21.192(Scan#:3291) MassPeaks:249
 Raw Mode:Averaged 21.186-21.198(3290-3292) BasePeak:93.10(3437)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



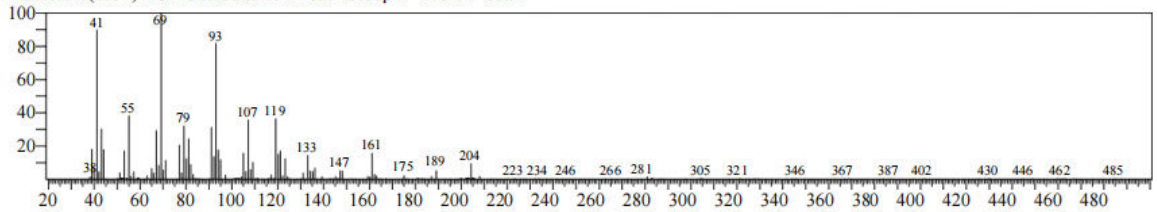
Line#:42 R.Time:21.372(Scan#:3322) MassPeaks:282
 Raw Mode:Averaged from 21.367 to 21.378(3321-3323) Base Peak:161.10(Intensity 8444)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan100



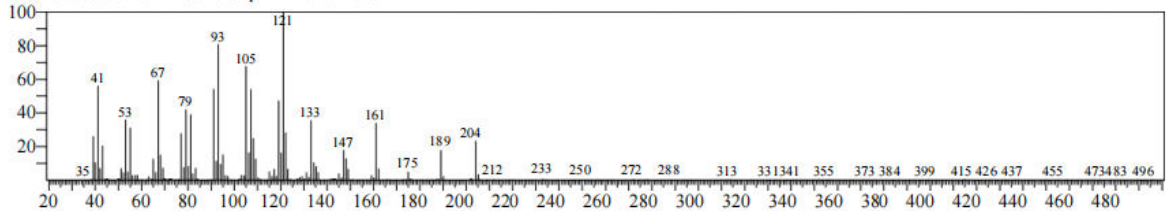
Line#:43 Retention Time:21.933(Scan#:3418) MassPeaks:272 Raw
 Mode:Averaged from 21.927-21.938(3417-3419) BasePeak:119.10(3743)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:44 R.Time:22.329(Scan#:3486) MassPeaks:273
 Raw Mode:Averaged from 22.323-22.335(3485-3487) Base
 Peak:69.10(6932) BG Mode:Calc. from Peak Group 1 - Event 1 Scan

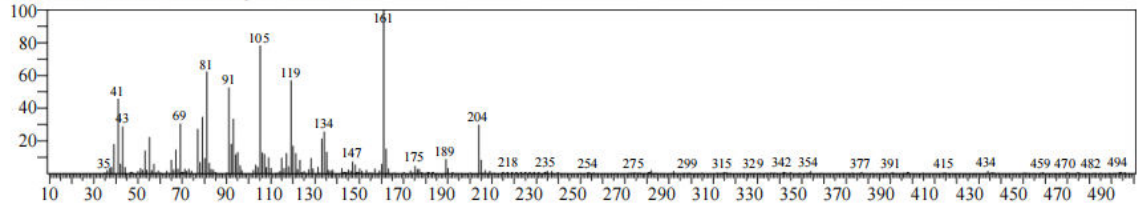


Line#:45 Retention Time:22.469(Scan#:3510) MassPeaks:279 Raw
 Mode:Averaged from 22.463 to 22.475(3509-3511) Base Peak:121.10(10183)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan

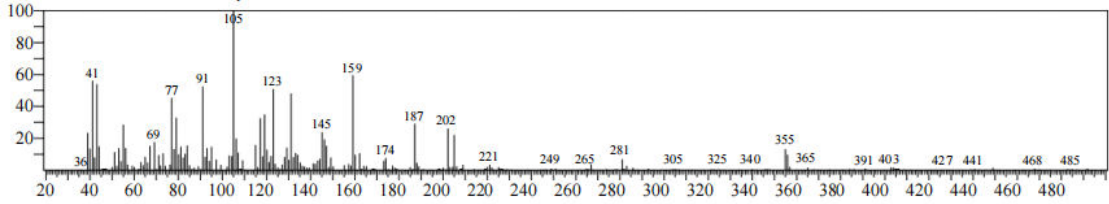


Appendix 13: GC-MS for *C. limon* Rt = 22.895-24.149

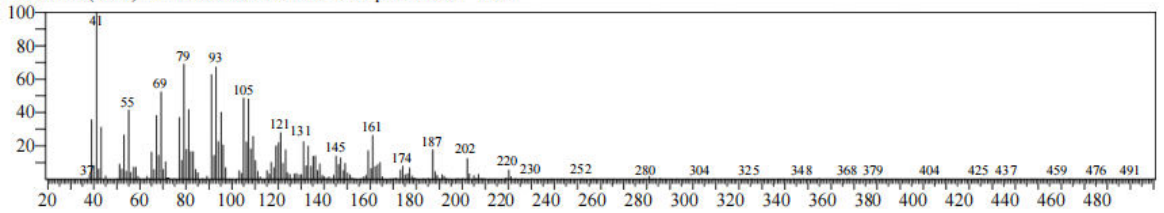
Line#:46 R.Time:22.895(Scan#:3583) MassPeaks:297
Raw Mode:Averaged from 22.889 to 22.901(3582-3584) Base Peak:161.10(Intensity 3959)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



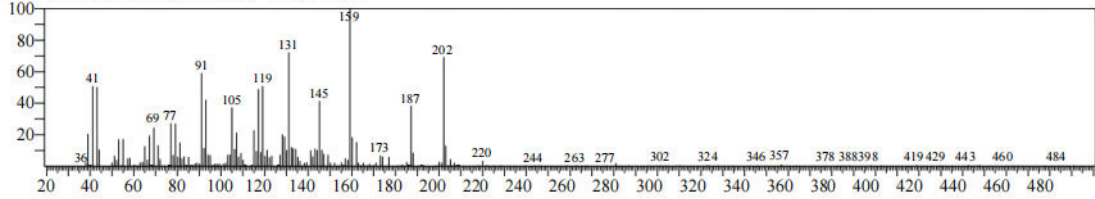
Line#:47 Retention Time:22.971(Scan#:3596) Mass Peaks:276 Raw
Mode:Averaged from 22.965-22.977(3595-3597) Base Peak:105.10(3488)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:48 R.Time:23.087(Scan#:3616) MassPeaks:276
Raw Mode:Averaged from 23.082 to 23.093(3615-3617) Base
Peak:41.10(6846) BG Mode:Calc from Peak Group 1 - Event 1 Scan

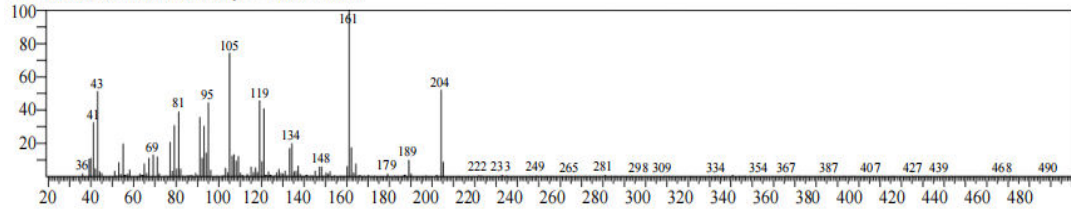


Line#:49 Retention Time:24.149(Scan#:3798) Mass Peaks:296 Raw
Mode:Averaged from 24.143-24.155(3797-3799) Base Peak:159.10(5973)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

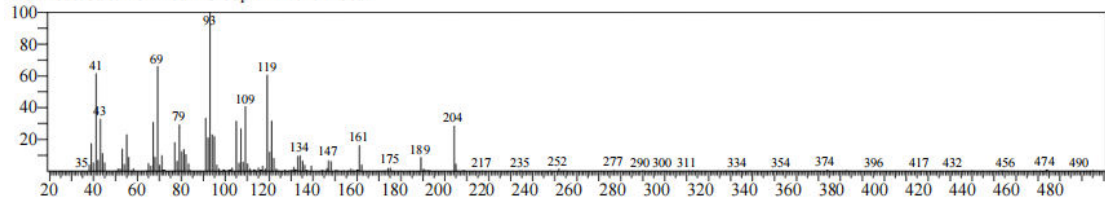


Appendix 14: GC-MS for *C. limon* Rt = 24.779-25.526

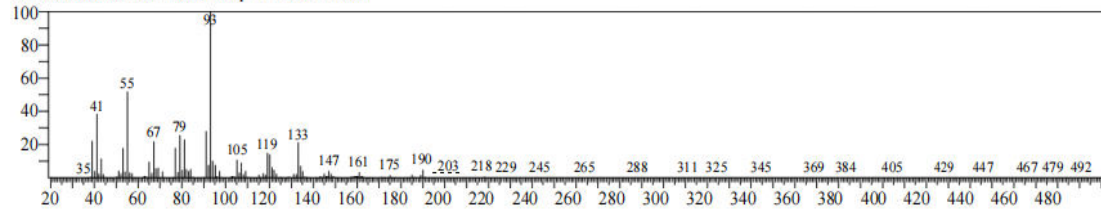
Line#:50 R.Time:24.779(Scan#:3906) MassPeaks:292
Raw Mode:Averaged from 24.773 to 24.785(3905-3907) Base Peak:161.10(Intensity 7530)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:51 R.Time:25.409(Scan#:4014) MassPeaks:251 Raw
Mode:Averaged from 25.403 to 25.415(4013-4015) BasePeak:93.10(5228)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

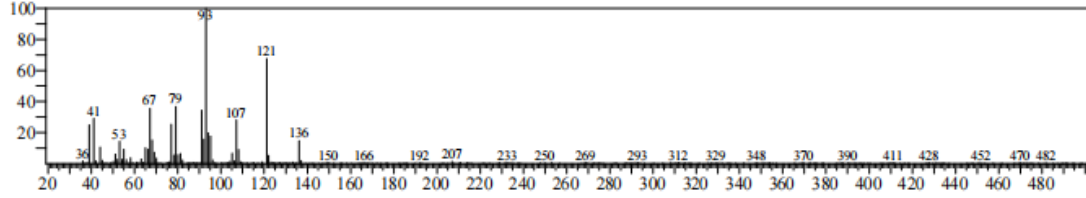


Line#:52 R.Time:25.526(Scan#:4034) MassPeaks:333
Raw Mode:Averaged from 25.520 to 25.532(4033-4035) BasePeak:93.10(Intensity 174662)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

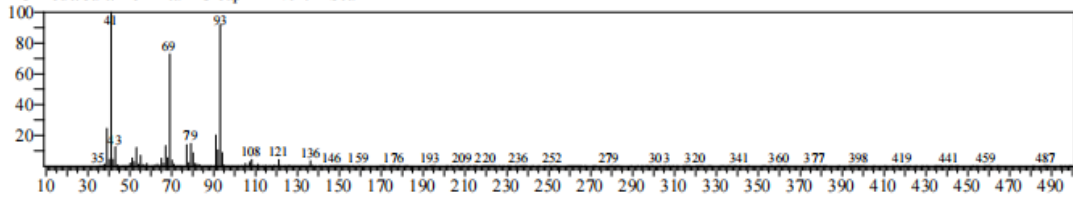


Appendix 15: GC-MS for *C. citratus* Rt = 6.165- 8.172

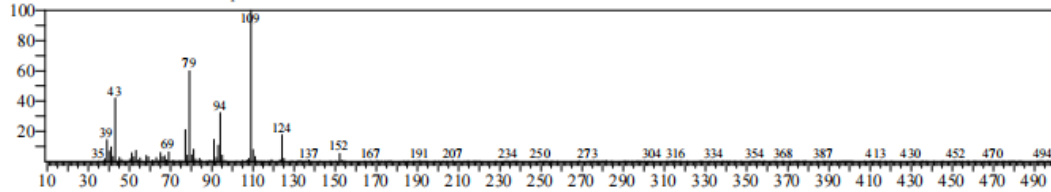
Line#1 R.Time:6.165(Scan#:715) MassPeaks:280
RawMode:Averaged 6.159-6.171(714-716) BasePeak:93.10(9647)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



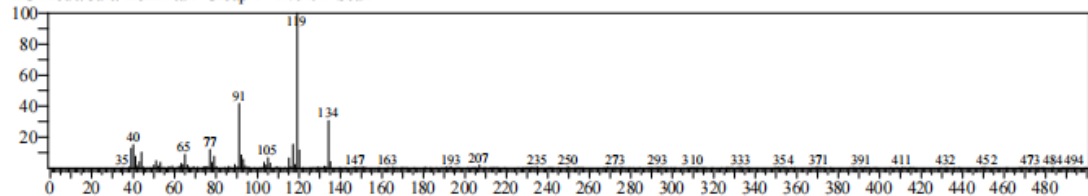
Line#2 R.Time:7.052(Scan#:867) MassPeaks:257
RawMode:Averaged 7.046-7.058(866-868) BasePeak:41.10(2192344)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



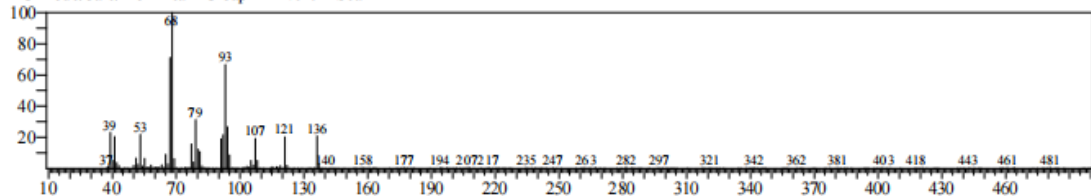
Line#3 R.Time:7.174(Scan#:888) MassPeaks:262
RawMode:Averaged 7.168-7.180(887-889) BasePeak:109.10(19411)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#4 R.Time:8.090(Scan#:1045) MassPeaks:255
RawMode:Averaged 8.084-8.096(1044-1046) BasePeak:119.10(12372)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

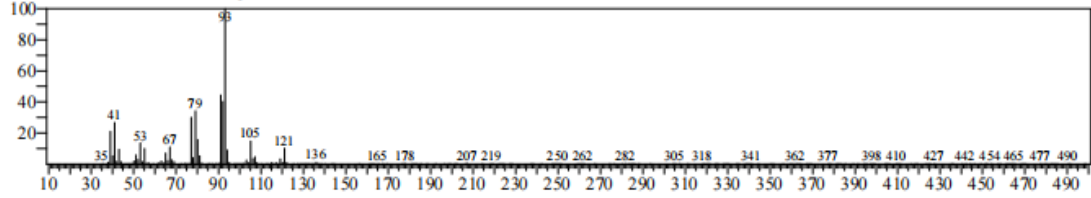


Line#5 R.Time:8.172(Scan#:1059) MassPeaks:272
RawMode:Averaged 8.166-8.178(1058-1060) BasePeak:68.10(15906)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

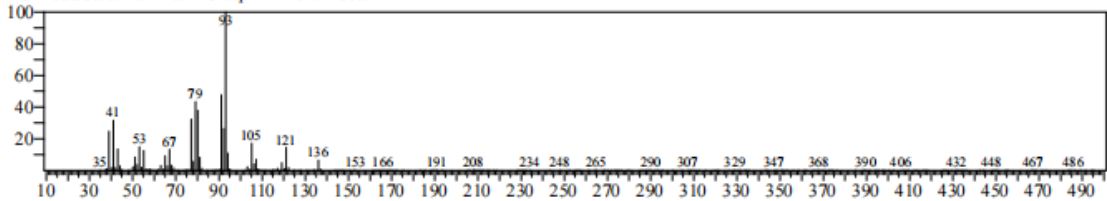


Appendix 16 : GC-MS for *C. citratus* Rt = 8.277- 10.149

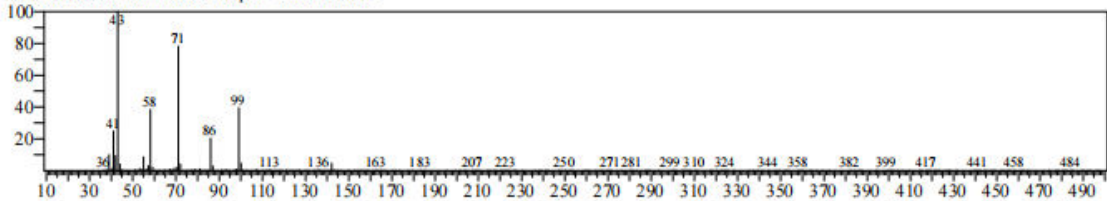
Line#:6 R.Time:8.277(Scan#:1077) MassPeaks:233
RawMode:Averaged 8.271-8.283(1076-1078) BasePeak:93.10(75816)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



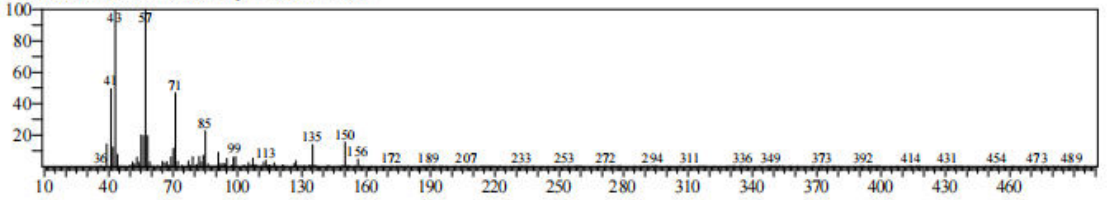
Line#:7 R.Time:8.568(Scan#:1127) MassPeaks:256
RawMode:Averaged 8.563-8.574(1126-1128) BasePeak:93.10(34473)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



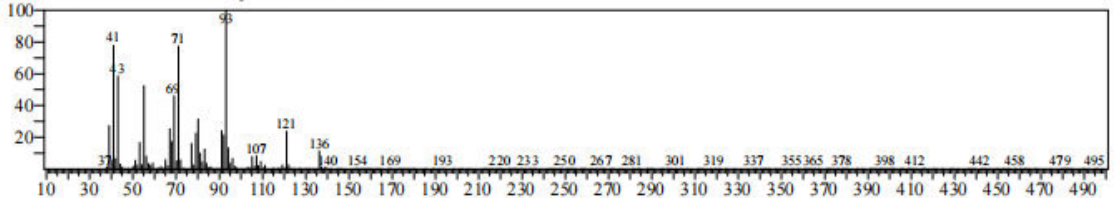
Line#:8 R.Time:9.344(Scan#:1260) MassPeaks:266
RawMode:Averaged 9.338-9.350(1259-1261) BasePeak:43.10(160556)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:9 R.Time:9.904(Scan#:1356) MassPeaks:255
RawMode:Averaged 9.898-9.910(1355-1357) BasePeak:57.10(18230)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

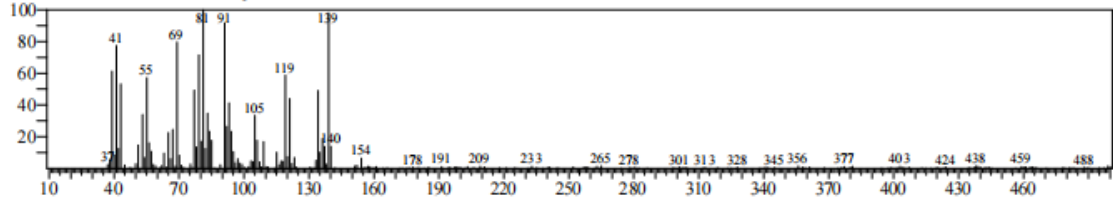


Line#:10 R.Time:10.149(Scan#:1398) MassPeaks:281
RawMode:Averaged 10.143-10.155(1397-1399) BasePeak:93.10(263107)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

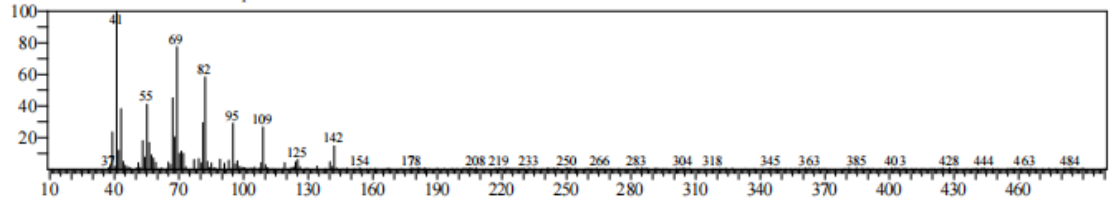


Appendix 17: GC-MS for *C. citratus* Rt = 10.902- 12.389

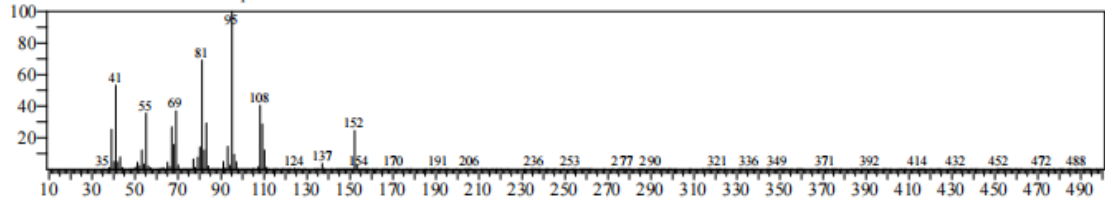
Line#: 11 R.Time: 10.902(Scan#: 1527) MassPeaks: 230
RawMode: Averaged 10.896-10.908(1526-1528) BasePeak: 81.15(3233)
BG Mode: Calc. from Peak Group 1 - Event 1 Scan



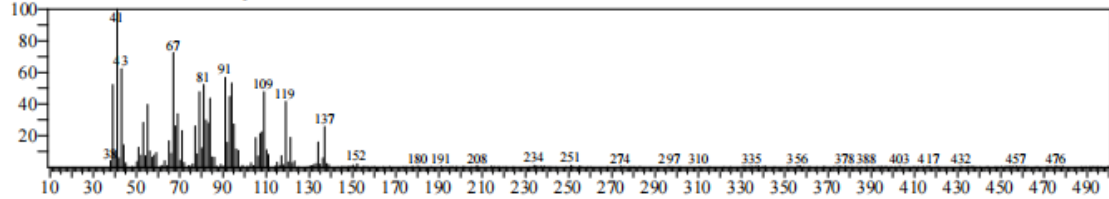
Line#: 12 R.Time: 10.995(Scan#: 1543) MassPeaks: 270
RawMode: Averaged 10.989-11.001(1542-1544) BasePeak: 41.10(7049)
BG Mode: Calc. from Peak Group 1 - Event 1 Scan



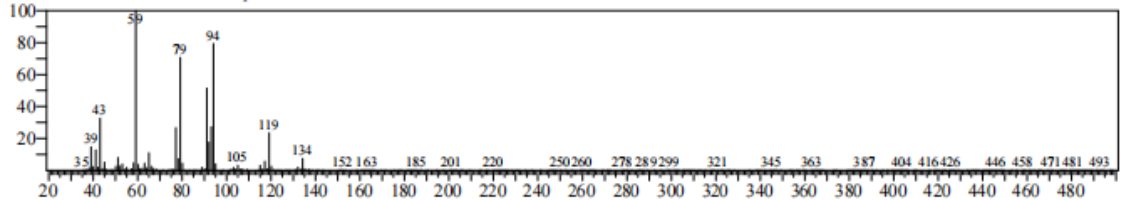
Line#: 13 R.Time: 11.730(Scan#: 1669) MassPeaks: 274
RawMode: Averaged 11.724-11.736(1668-1670) BasePeak: 95.10(563279)
BG Mode: Calc. from Peak Group 1 - Event 1 Scan



Line#: 14 R.Time: 11.928(Scan#: 1703) MassPeaks: 254
RawMode: Averaged 11.922-11.934(1702-1704) BasePeak: 41.10(6651)
BG Mode: Calc. from Peak Group 1 - Event 1 Scan

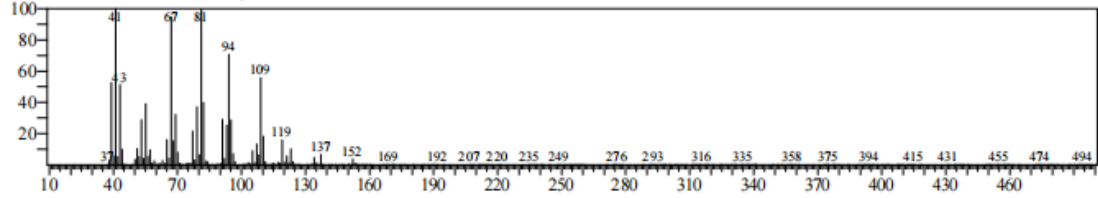


Line#: 15 R.Time: 12.389(Scan#: 1782) MassPeaks: 289
RawMode: Averaged 12.383-12.395(1781-1783) BasePeak: 59.10(149697)
BG Mode: Calc. from Peak Group 1 - Event 1 Scan

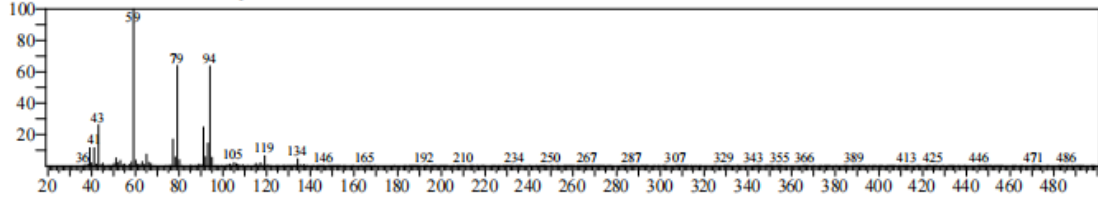


Appendix 18 : GC-MS for *C. citratus* Rt = 12.465- 14.518

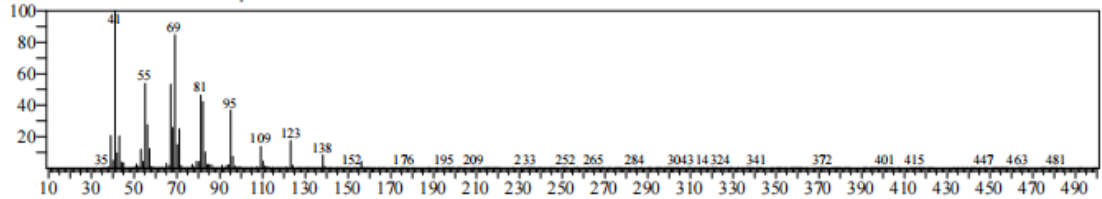
Line#:16 R.Time:12.465(Scan#:1795) MassPeaks:274
RawMode:Averaged 12.459-12.471(1794-1796) BasePeak:41.10(23090)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



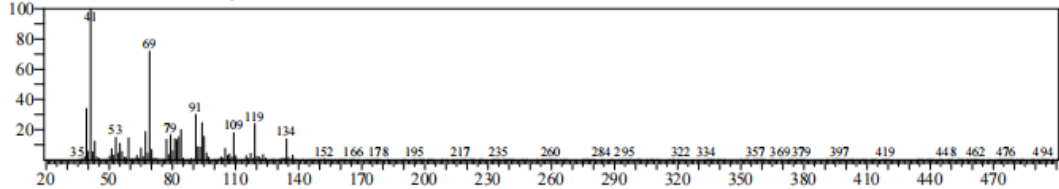
Line#:17 R.Time:13.130(Scan#:1909) MassPeaks:280
RawMode:Averaged 13.124-13.136(1908-1910) BasePeak:59.10(195184)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



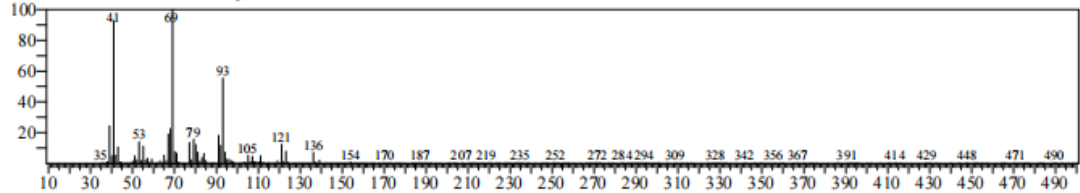
Line#:18 R.Time:13.801(Scan#:2024) MassPeaks:308
RawMode:Averaged 13.795-13.807(2023-2025) BasePeak:41.10(794524)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:19 R.Time:14.221(Scan#:2096) MassPeaks:296
RawMode:Averaged 14.215-14.227(2095-2097) BasePeak:41.10(936717)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

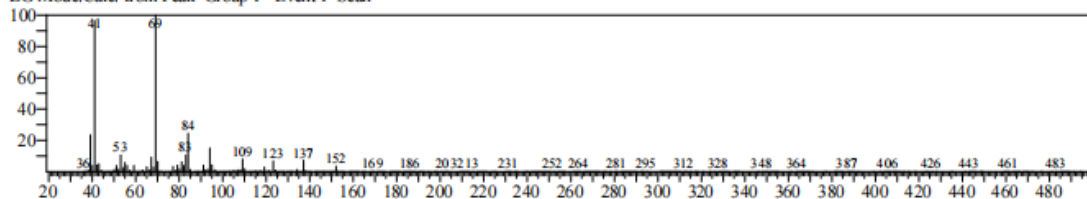


Line#:20 R.Time:14.518(Scan#:2147) MassPeaks:296
RawMode:Averaged 14.512-14.524(2146-2148) BasePeak:69.10(1873358)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

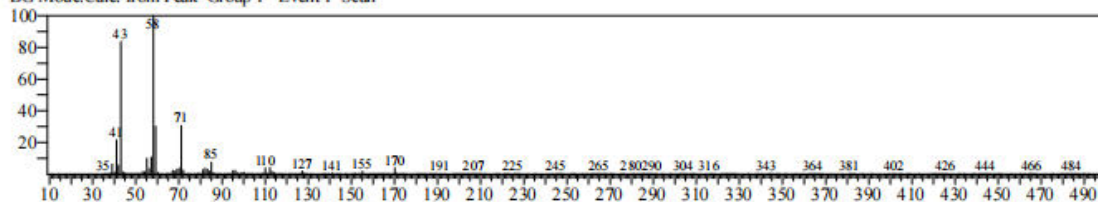


Appendix 19: GC-MS for *C. citratus* Rt = 15.061- 17.377

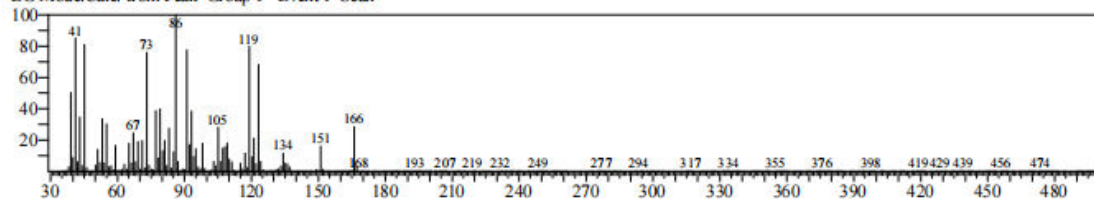
Line#:21 R.Time:15.061(Scan#:2240) MassPeaks:312
RawMode:Averaged 15.055-15.067(2239-2241) BasePeak:69.10(1848247)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



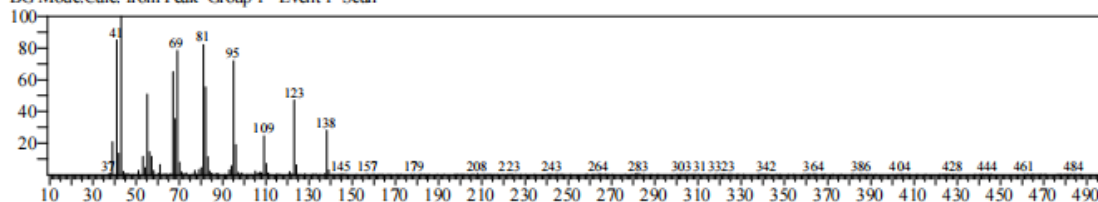
Line#:22 R.Time:15.545(Scan#:2323) MassPeaks:284
RawMode:Averaged 15.539-15.551(2322-2324) BasePeak:58.10(118675)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



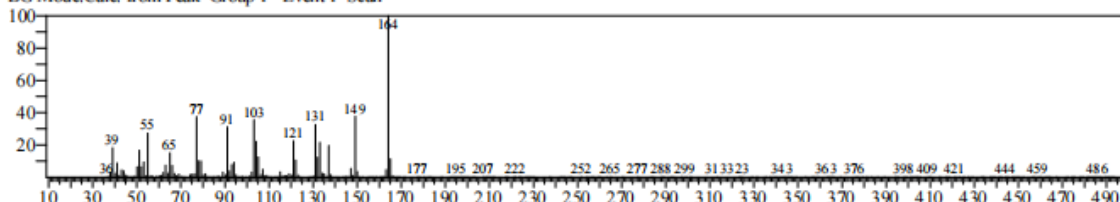
Line#:23 R.Time:16.204(Scan#:2436) MassPeaks:312
RawMode:Averaged 16.198-16.210(2435-2437) BasePeak:86.10(82699)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:24 R.Time:16.992(Scan#:2571) MassPeaks:265
RawMode:Averaged 16.986-16.997(2570-2572) BasePeak:43.05(15047)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

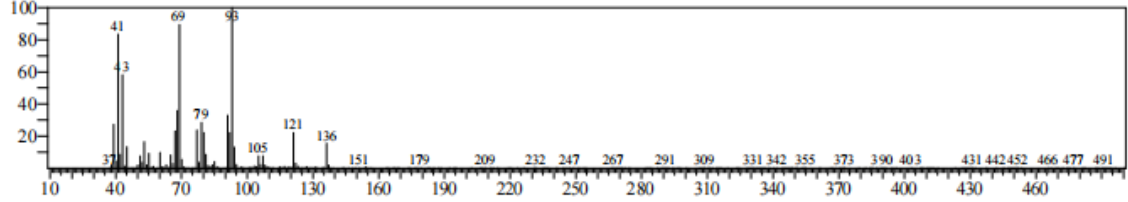


Line#:25 R.Time:17.377(Scan#:2637) MassPeaks:277
RawMode:Averaged 17.371-17.383(2636-2638) BasePeak:164.10(69119)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

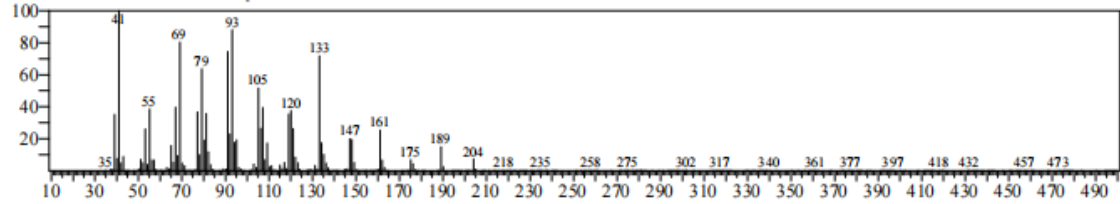


Appendix 20 : GC-MS for *C. citratus* Rt = 17.779- 18.809

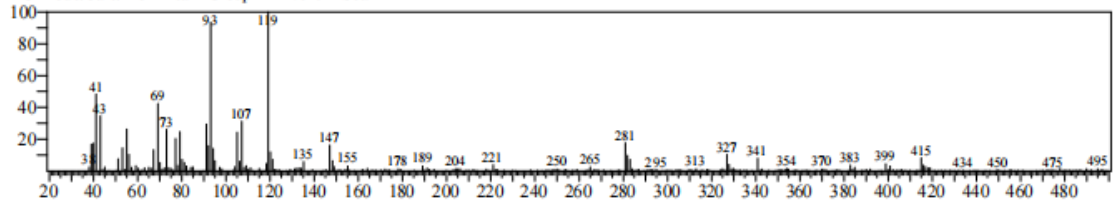
Line#:26 R.Time:17.779(Scan#:2706) MassPeaks:271
RawMode:Averaged 17.773-17.785(2705-2707) BasePeak:93.10(35489)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



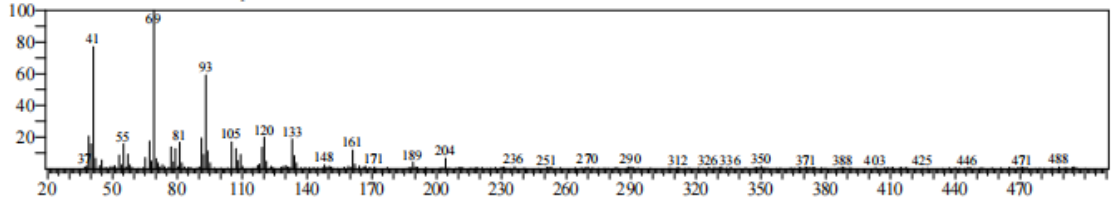
Line#:27 R.Time:18.934(Scan#:2904) MassPeaks:303
RawMode:Averaged 18.928-18.940(2903-2905) BasePeak:41.10(32839)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



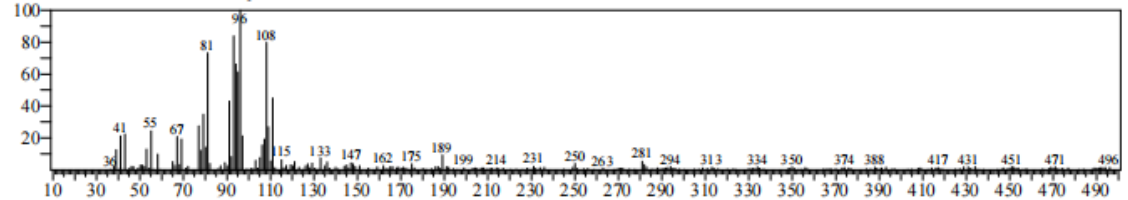
Line#:28 R.Time:19.162(Scan#:2943) MassPeaks:299
RawMode:Averaged 19.156-19.168(2942-2944) BasePeak:119.10(3992)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:29 R.Time:19.593(Scan#:3017) MassPeaks:257
RawMode:Averaged 19.587-19.599(3016-3018) BasePeak:69.10(3777)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

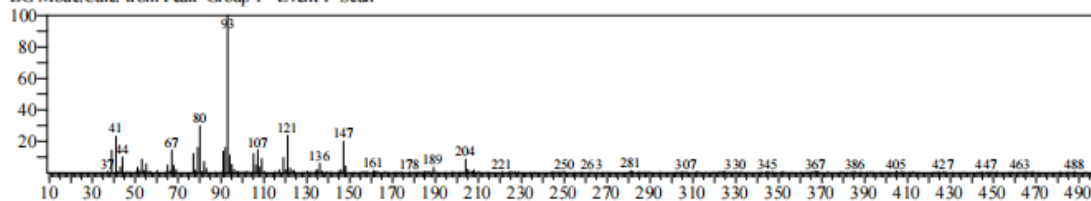


Line#:30 R.Time:19.809(Scan#:3054) MassPeaks:263
RawMode:Averaged 19.803-19.815(3053-3055) BasePeak:96.15(2553)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

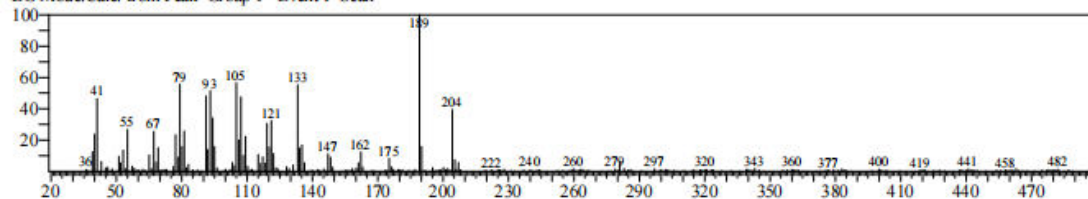


Appendix 21: GC-MS for *C. citratus* Rt = 19.873- 21.197

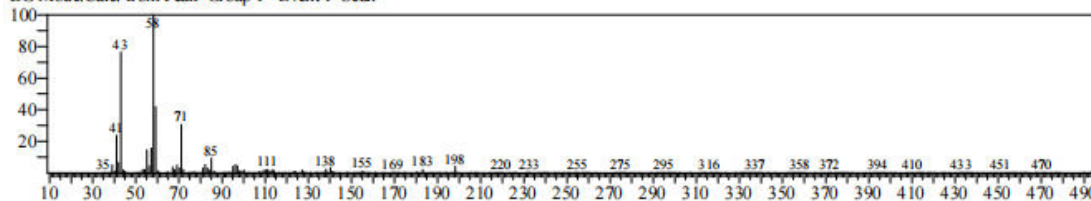
Line#:31 R.Time:19.873(Scan#:3065) MassPeaks:260
RawMode:Averaged 19.868-19.879(3064-3066) BasePeak:93.10(6298)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



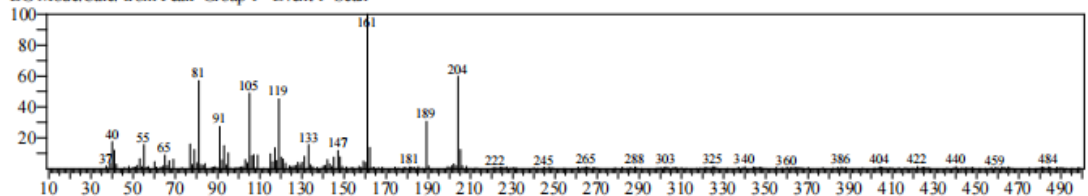
Line#:32 R.Time:20.585(Scan#:3187) MassPeaks:289
RawMode:Averaged 20.579-20.591(3186-3188) BasePeak:189.10(3500)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



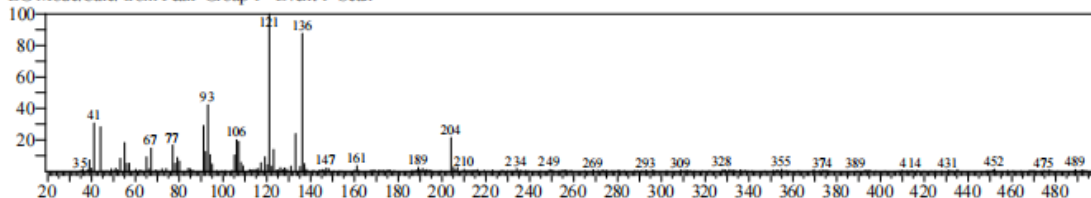
Line#:33 R.Time:20.760(Scan#:3217) MassPeaks:290
RawMode:Averaged 20.754-20.766(3216-3218) BasePeak:58.10(49378)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:34 R.Time:20.848(Scan#:3232) MassPeaks:280
RawMode:Averaged 20.842-20.853(3231-3233) BasePeak:161.10(3949)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

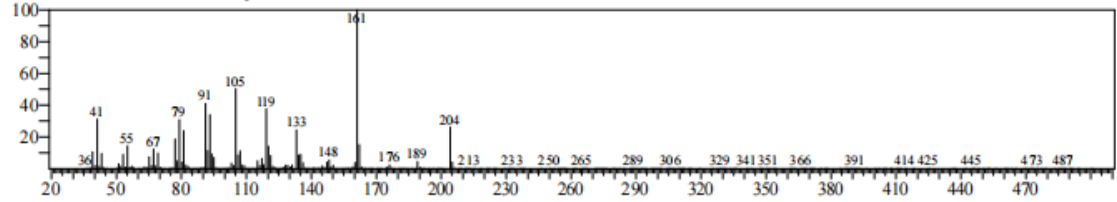


Line#:35 R.Time:21.197(Scan#:3292) MassPeaks:248
RawMode:Averaged 21.192-21.203(3291-3293) BasePeak:121.15(3925)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

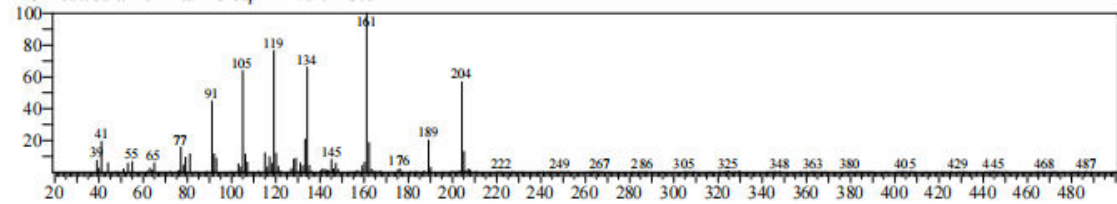


Appendix 22: GC-MS for *C. citratus* Rt = 21.308- 22.189

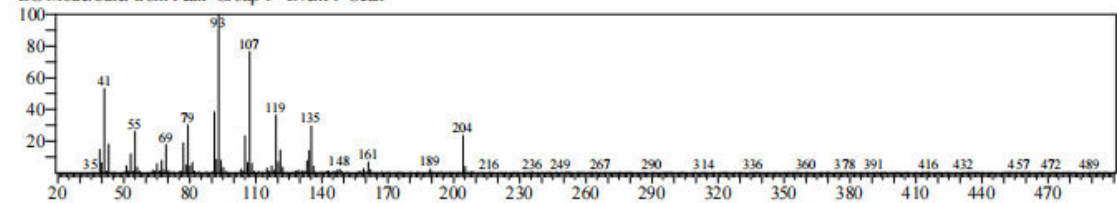
Line#:36 R.Time:21.308(Scan#:3311) MassPeaks:296
RawMode:Averaged 21.302-21.314(3310-3312) BasePeak:161.10(138107)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



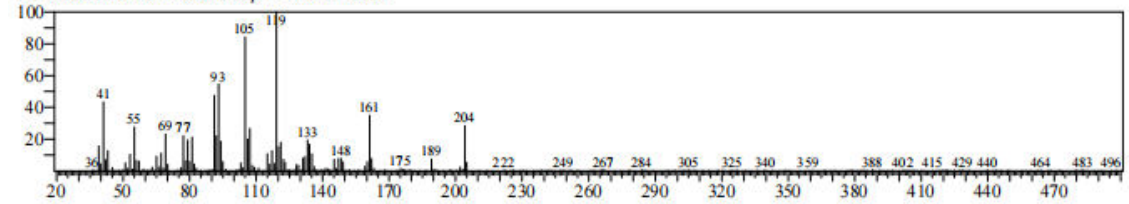
Line#:37 R.Time:21.372(Scan#:3322) MassPeaks:228
RawMode:Averaged 21.367-21.378(3321-3323) BasePeak:161.10(10144)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



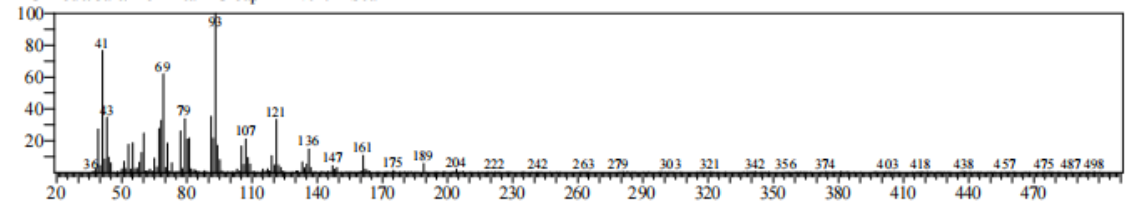
Line#:38 R.Time:21.512(Scan#:3346) MassPeaks:276
RawMode:Averaged 21.507-21.518(3345-3347) BasePeak:93.10(14271)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:39 R.Time:21.863(Scan#:3406) MassPeaks:285
RawMode:Averaged 21.857-21.868(3405-3407) BasePeak:119.15(7791)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

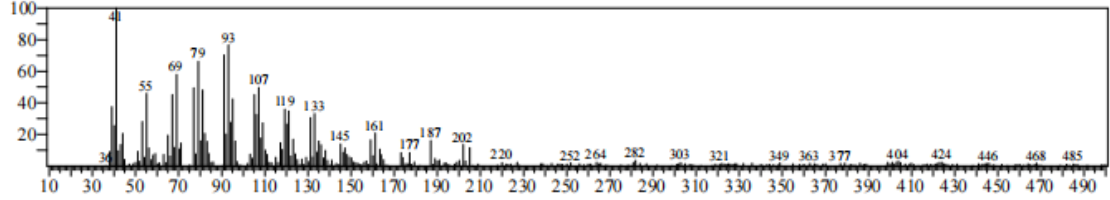


Line#:40 R.Time:22.189(Scan#:3462) MassPeaks:294
RawMode:Averaged 22.183-22.195(3461-3463) BasePeak:93.15(12353)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

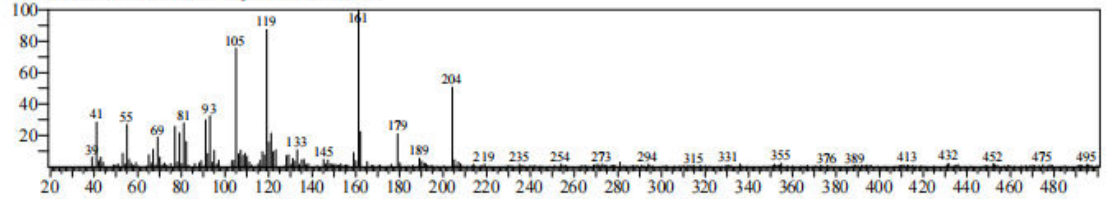


Appendix 23: GC-MS for *C. citratus* Rt = 23.093- 24.826

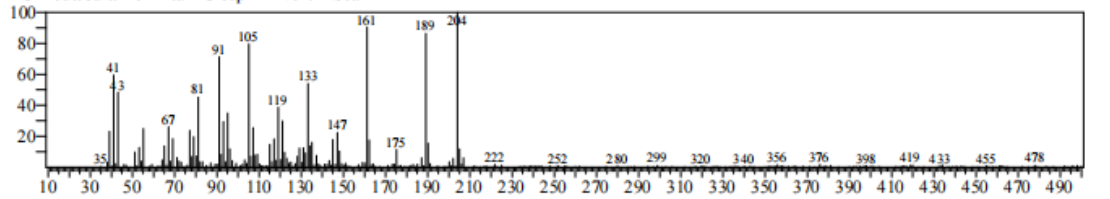
Line#:41 R.Time:23.093(Scan#:3617) MassPeaks:293
RawMode:Averaged 23.087-23.099(3616-3618) BasePeak:41.10(2031)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



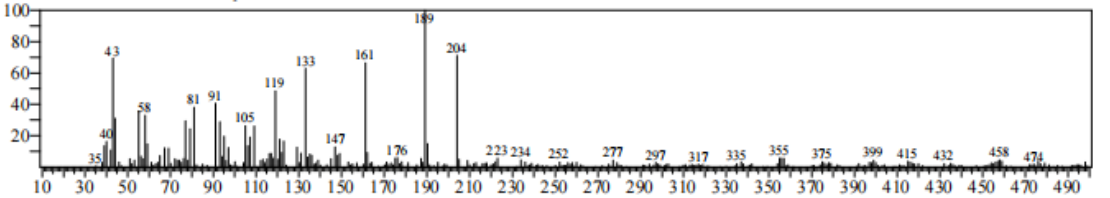
Line#:42 R.Time:23.817(Scan#:3741) MassPeaks:281
RawMode:Averaged 23.811-23.823(3740-3742) BasePeak:161.15(2644)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



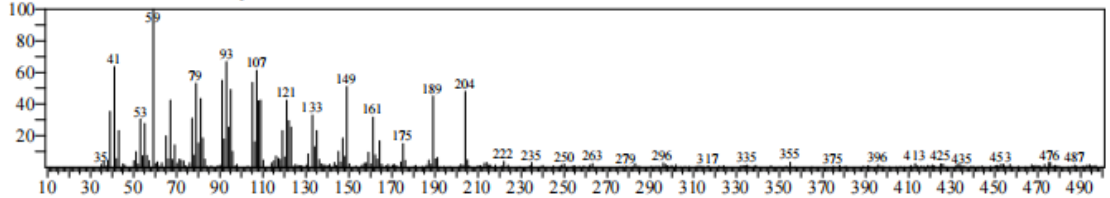
Line#:43 R.Time:24.073(Scan#:3785) MassPeaks:287
RawMode:Averaged 24.067-24.079(3784-3786) BasePeak:204.10(3516)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:44 R.Time:24.231(Scan#:3812) MassPeaks:278
RawMode:Averaged 24.225-24.237(3811-3813) BasePeak:189.10(1298)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

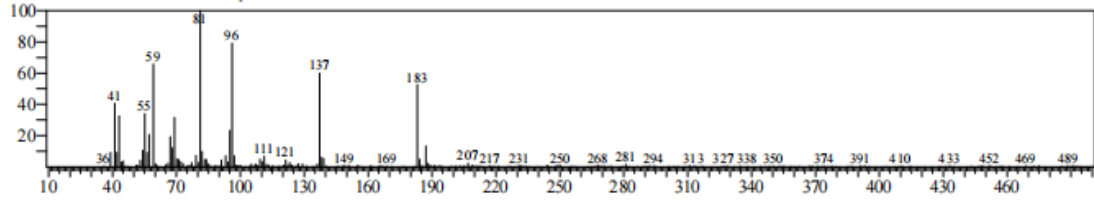


Line#:45 R.Time:24.826(Scan#:3914) MassPeaks:279
RawMode:Averaged 24.820-24.832(3913-3915) BasePeak:59.10(1907)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

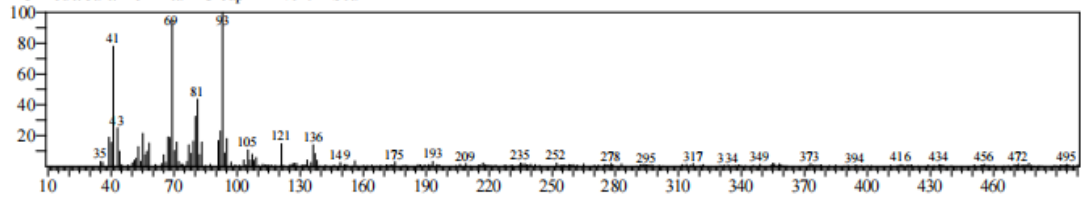


Appendix 24: GC-MS for *C. citratus* Rt = 27.888- 28.973

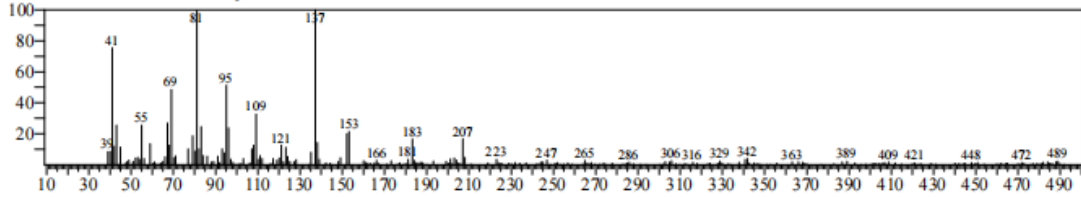
Line#:46 R.Time:27.888(Scan#:4439) MassPeaks:257
RawMode:Averaged 27.883-27.894(4438-4440) BasePeak:81.10(7119)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



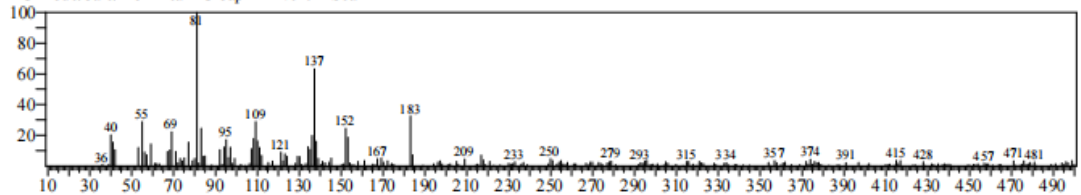
Line#:47 R.Time:28.303(Scan#:4510) MassPeaks:263
RawMode:Averaged 28.297-28.308(4509-4511) BasePeak:93.15(2752)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



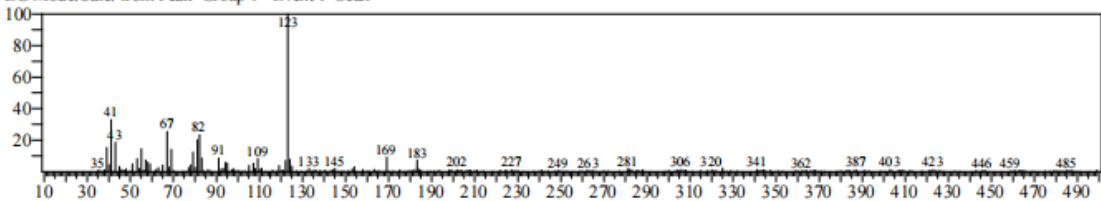
Line#:48 R.Time:28.594(Scan#:4560) MassPeaks:247
RawMode:Averaged 28.588-28.600(4559-4561) BasePeak:137.15(1656)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:49 R.Time:28.839(Scan#:4602) MassPeaks:246
RawMode:Averaged 28.833-28.845(4601-4603) BasePeak:81.15(1157)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

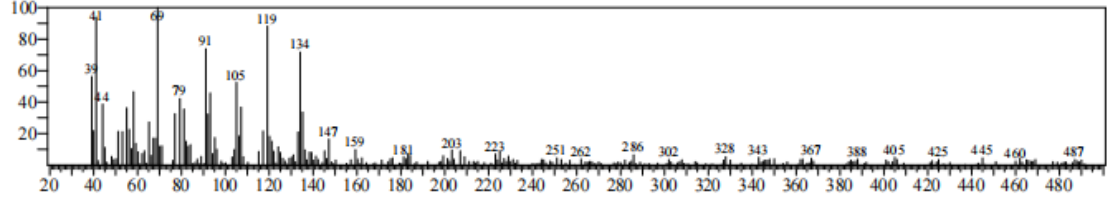


Line#:50 R.Time:28.973(Scan#:4625) MassPeaks:283
RawMode:Averaged 28.968-28.979(4624-4626) BasePeak:123.15(3714)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

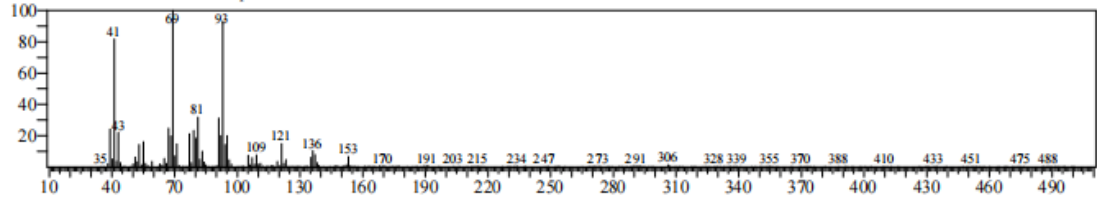


Appendix 25 : GC-MS for *C. citratus* Rt = 29.294- 30.671

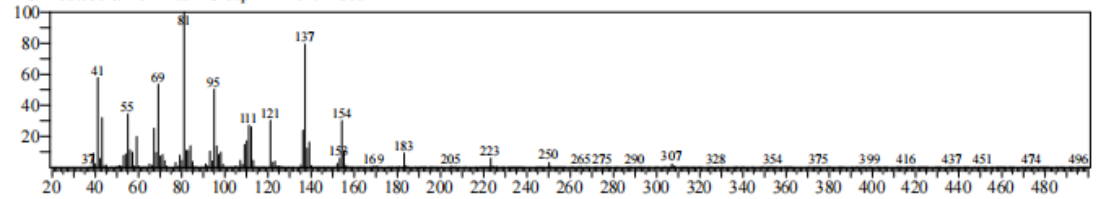
Line#:51 R.Time:29.294(Scan#:4680) MassPeaks:263
RawMode:Averaged 29.288-29.300(4679-4681) BasePeak:69.15(1015)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



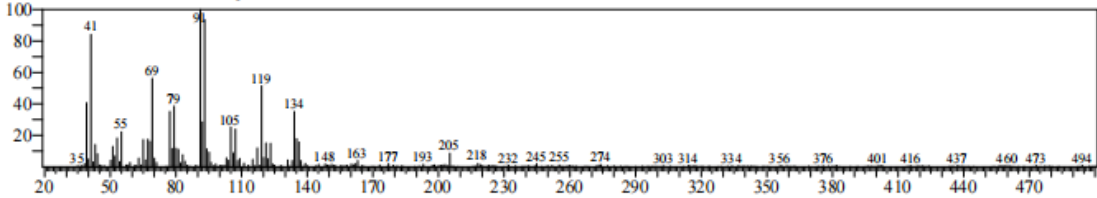
Line#:52 R.Time:29.539(Scan#:4722) MassPeaks:273
RawMode:Averaged 29.533-29.545(4721-4723) BasePeak:69.10(13348)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



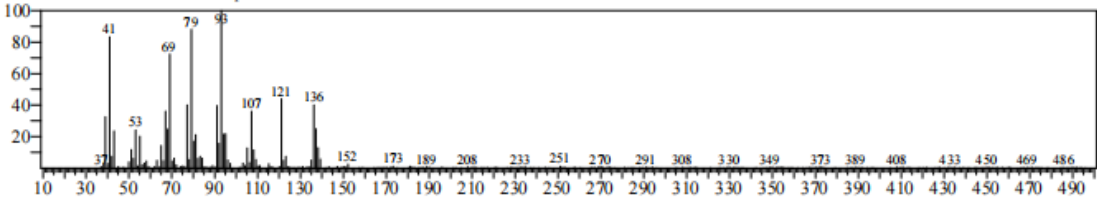
Line#:53 R.Time:30.216(Scan#:4838) MassPeaks:320
RawMode:Averaged 30.210-30.222(4837-4839) BasePeak:81.10(81131)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:54 R.Time:30.589(Scan#:4902) MassPeaks:295
RawMode:Averaged 30.583-30.595(4901-4903) BasePeak:91.10(5968)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

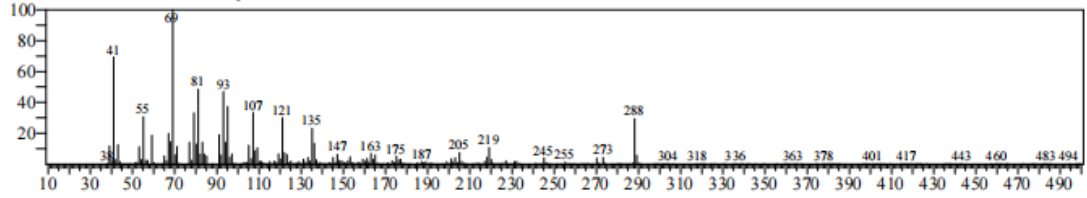


Line#:55 R.Time:30.671(Scan#:4916) MassPeaks:284
RawMode:Averaged 30.665-30.677(4915-4917) BasePeak:93.10(8172)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

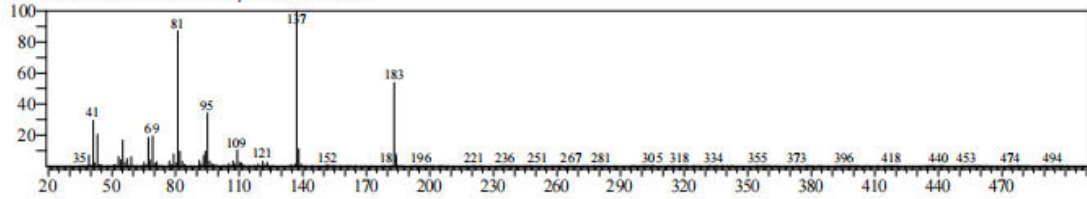


Appendix 26: GC-MS for *C. citratus* Rt = 30.741- 31.423

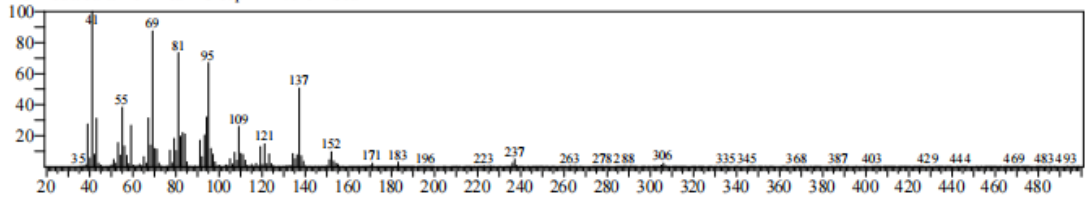
Line#:56 R.Time:30.741(Scan#:4928) MassPeaks:312
RawMode:Averaged 30.735-30.747(4927-4929) BasePeak:69.10(26922)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



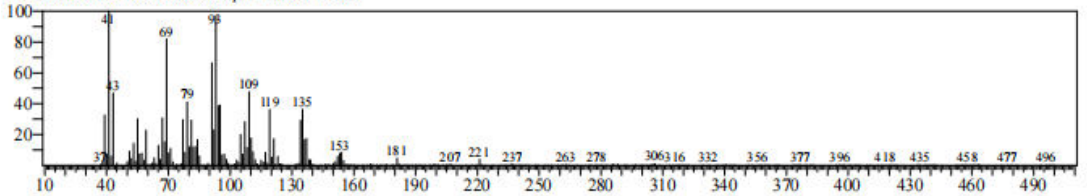
Line#:57 R.Time:30.805(Scan#:4939) MassPeaks:276
RawMode:Averaged 30.799-30.811(4938-4940) BasePeak:137.15(52556)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



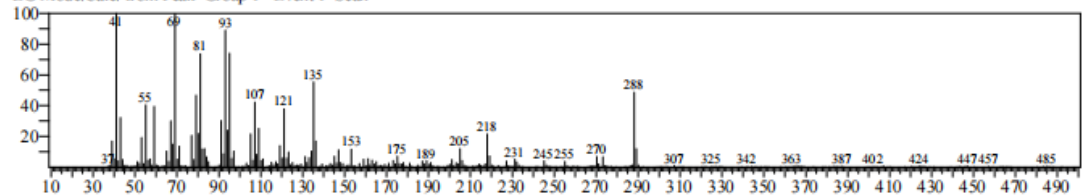
Line#:58 R.Time:31.050(Scan#:4981) MassPeaks:343
RawMode:Averaged 31.044-31.056(4980-4982) BasePeak:41.10(433990)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:59 R.Time:31.231(Scan#:5012) MassPeaks:293
RawMode:Averaged 31.225-31.237(5011-5013) BasePeak:41.10(18514)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

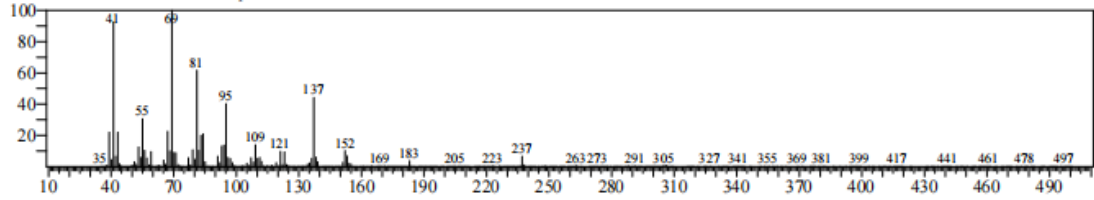


Line#:60 R.Time:31.423(Scan#:5045) MassPeaks:309
RawMode:Averaged 31.418-31.429(5044-5046) BasePeak:41.10(7798)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

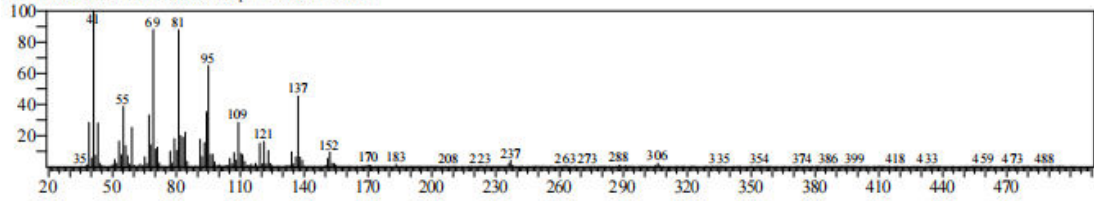


Appendix 27 : GC-MS for *C. citratus* Rt = 31.598- 32.170

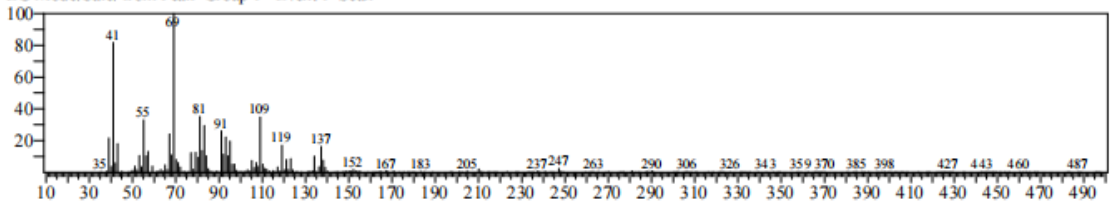
Line#:61 R.Time:31.598(Scan#:5075) MassPeaks:357
 RawMode:Averaged 31.593-31.604(5074-5076) BasePeak:69.10(860113)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



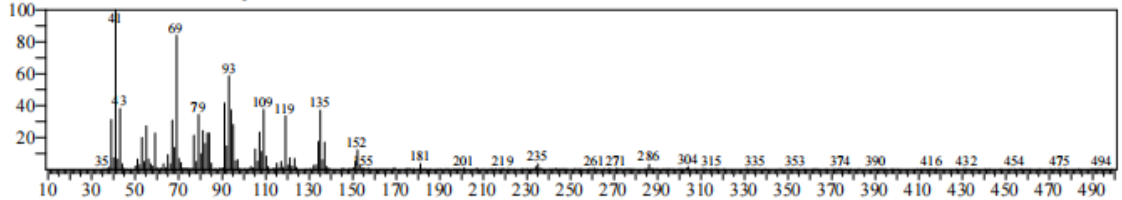
Line#:62 R.Time:31.779(Scan#:5106) MassPeaks:334
 RawMode:Averaged 31.773-31.785(5105-5107) BasePeak:41.10(210376)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



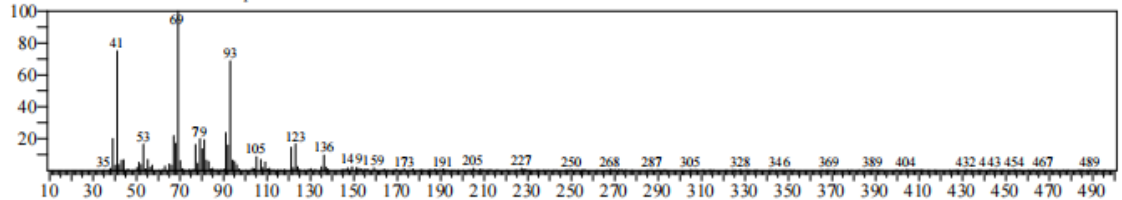
Line#:63 R.Time:31.913(Scan#:5129) MassPeaks:261
 RawMode:Averaged 31.907-31.919(5128-5130) BasePeak:69.10(26506)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:64 R.Time:32.042(Scan#:5151) MassPeaks:292
 RawMode:Averaged 32.036-32.047(5150-5152) BasePeak:41.10(24454)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan

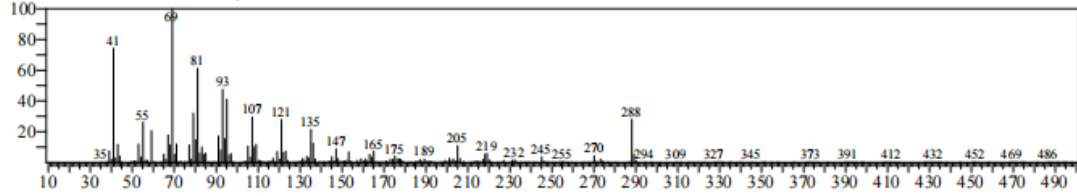


Line#:65 R.Time:32.170(Scan#:5173) MassPeaks:275
 RawMode:Averaged 32.164-32.176(5172-5174) BasePeak:69.10(14925)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan

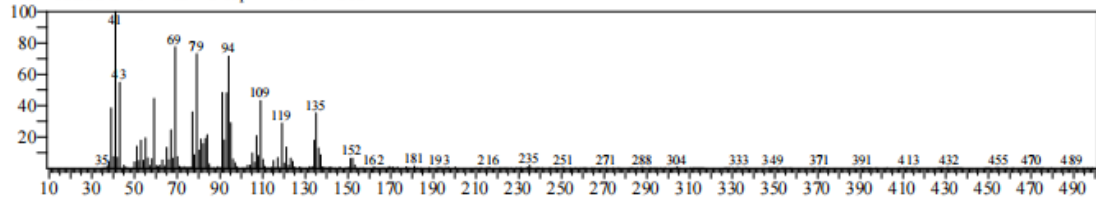


Appendix 28: GC-MS for *C. citratus* Rt = 32.263- 32.707

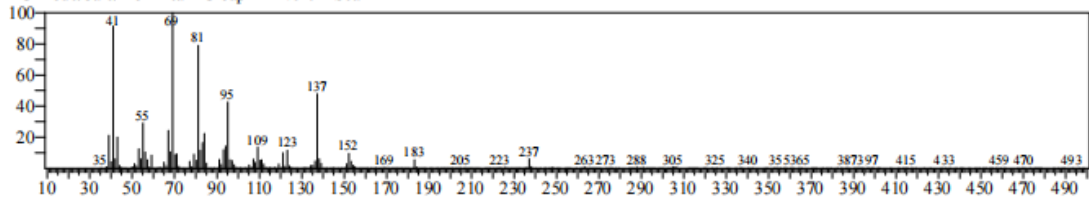
Line#:66 R.Time:32.263(Scan#:5189) MassPeaks:286
 RawMode:Averaged 32.258-32.269(5188-5190) BasePeak:69.10(37281)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



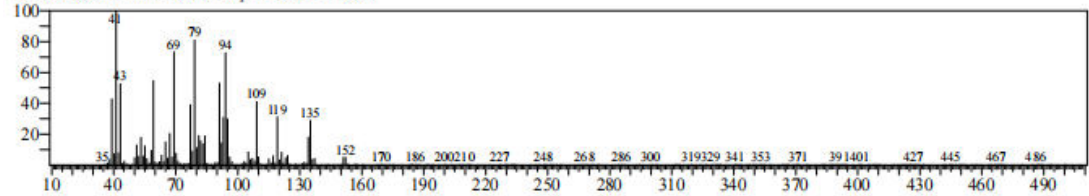
Line#:67 R.Time:32.368(Scan#:5207) MassPeaks:272
 RawMode:Averaged 32.362-32.374(5206-5208) BasePeak:41.10(26641)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



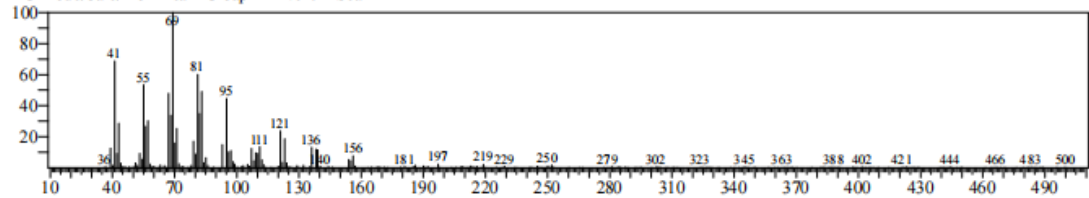
Line#:68 R.Time:32.520(Scan#:5233) MassPeaks:340
 RawMode:Averaged 32.514-32.526(5232-5234) BasePeak:69.10(443353)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:69 R.Time:32.590(Scan#:5245) MassPeaks:256
 RawMode:Averaged 32.584-32.596(5244-5246) BasePeak:41.10(77194)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan

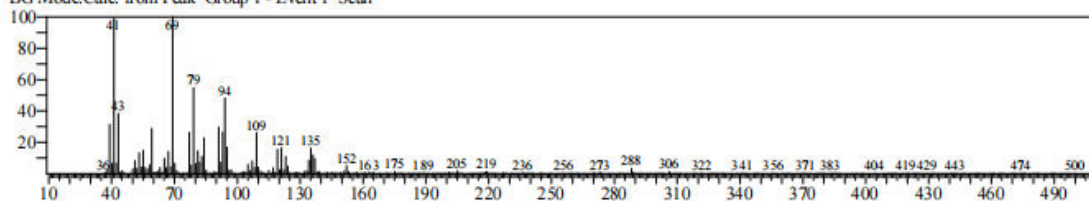


Line#:70 R.Time:32.707(Scan#:5265) MassPeaks:247
 RawMode:Averaged 32.701-32.712(5264-5266) BasePeak:69.10(11987)
 BG Mode:Calc. from Peak Group 1 - Event 1 Scan

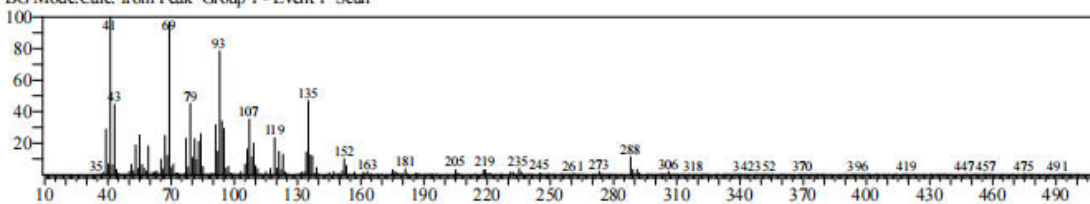


Appendix 29 : GC-MS for *C. citratus* Rt = 32.888- 33.483

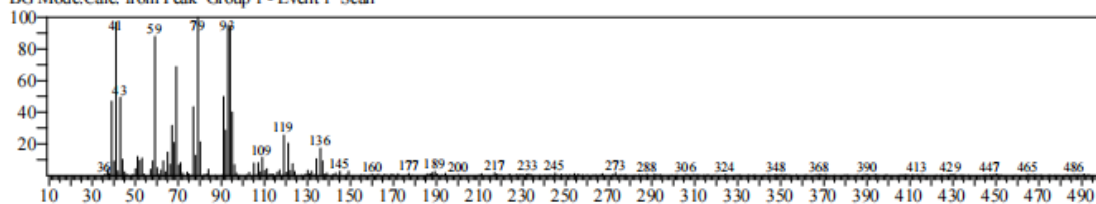
Line#:71 R.Time:32.888(Scan#:5296) MassPeaks:332
RawMode:Averaged 32.882-32.893(5295-5297) BasePeak:69.10(54971)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



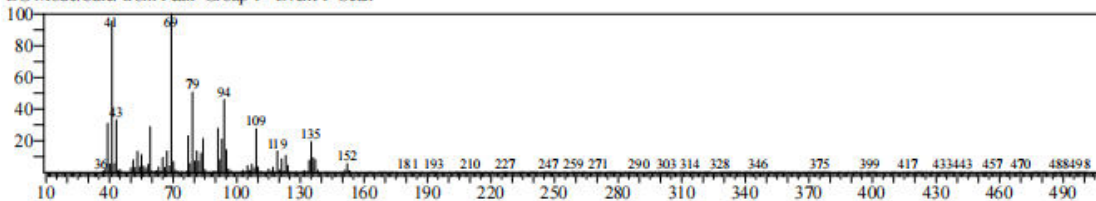
Line#:72 R.Time:33.039(Scan#:5322) MassPeaks:308
RawMode:Averaged 33.033-33.045(5321-5323) BasePeak:41.10(35222)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



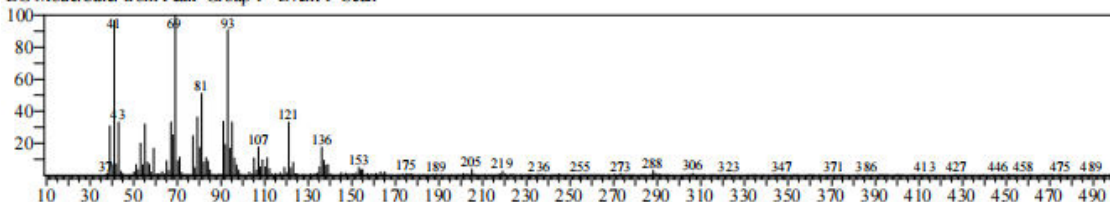
Line#:73 R.Time:33.121(Scan#:5336) MassPeaks:269
RawMode:Averaged 33.115-33.127(5335-5337) BasePeak:79.10(7144)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:74 R.Time:33.220(Scan#:5353) MassPeaks:301
RawMode:Averaged 33.214-33.226(5352-5354) BasePeak:69.10(194569)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

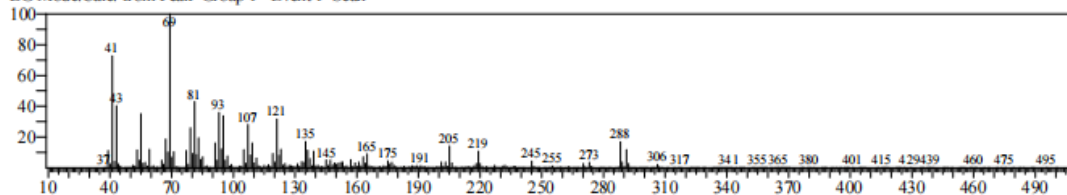


Line#:75 R.Time:33.483(Scan#:5398) MassPeaks:334
RawMode:Averaged 33.477-33.488(5397-5399) BasePeak:69.10(228100)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

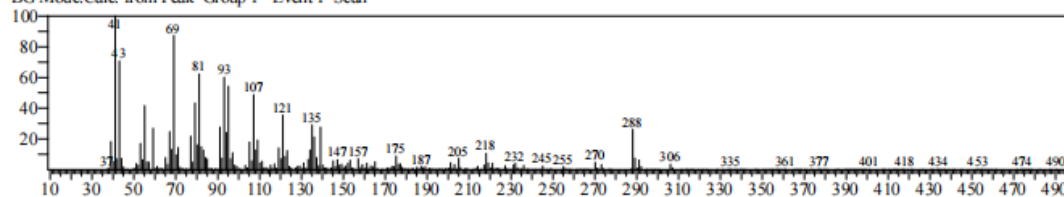


Appendix 30: GC-MS for *C. citratus* Rt = 33.576- 34.083

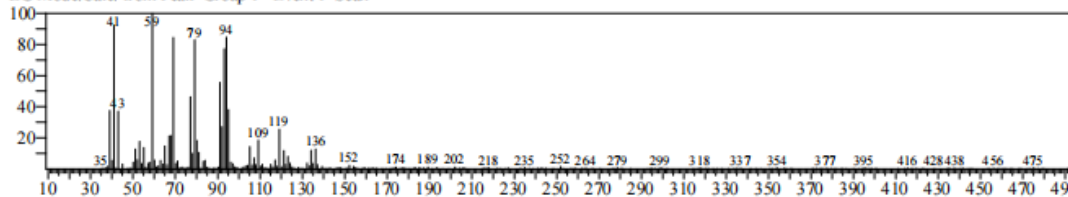
Line#:76 R.Time:33.576(Scan#:5414) MassPeaks:362
RawMode:Averaged 33.570-33.582(5413-5415) BasePeak:69.10(100392)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



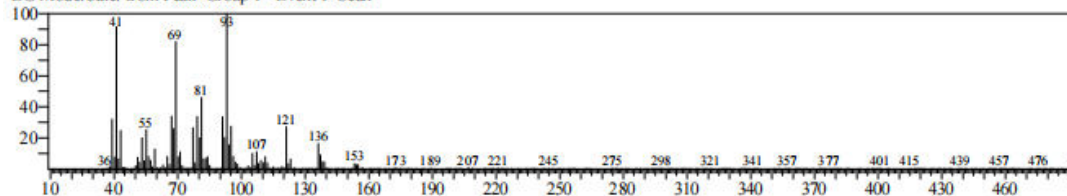
Line#:77 R.Time:33.634(Scan#:5424) MassPeaks:341
RawMode:Averaged 33.628-33.640(5423-5425) BasePeak:41.10(24007)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



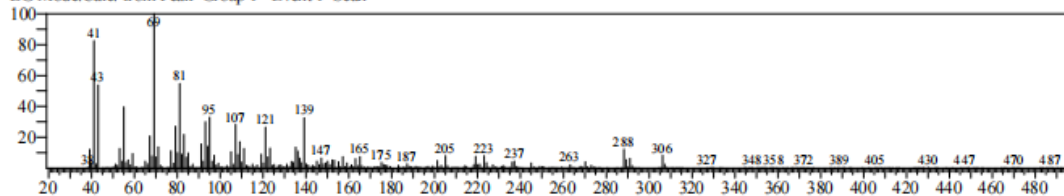
Line#:78 R.Time:33.803(Scan#:5453) MassPeaks:287
RawMode:Averaged 33.797-33.809(5452-5454) BasePeak:59.10(10256)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



Line#:79 R.Time:33.908(Scan#:5471) MassPeaks:293
RawMode:Averaged 33.903-33.914(5470-5472) BasePeak:93.10(63505)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

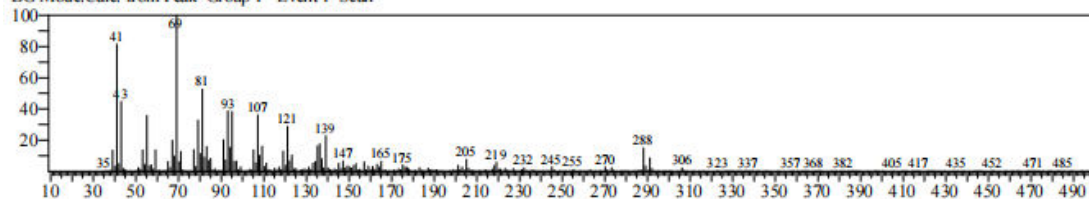


Line#:80 R.Time:34.083(Scan#:5501) MassPeaks:335
RawMode:Averaged 34.078-34.089(5500-5502) BasePeak:69.10(19693)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan

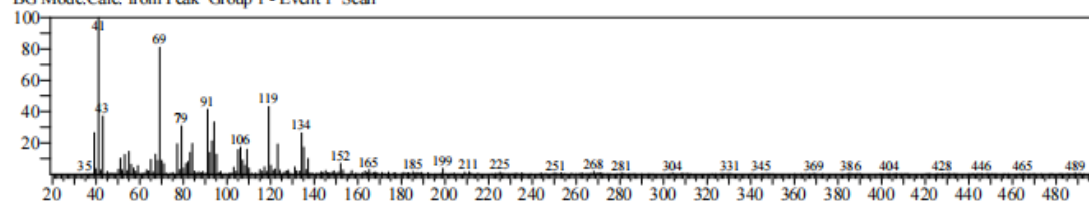


Appendix 31: GC-MS for *C. citratus* Rt = 34.340- 34.929

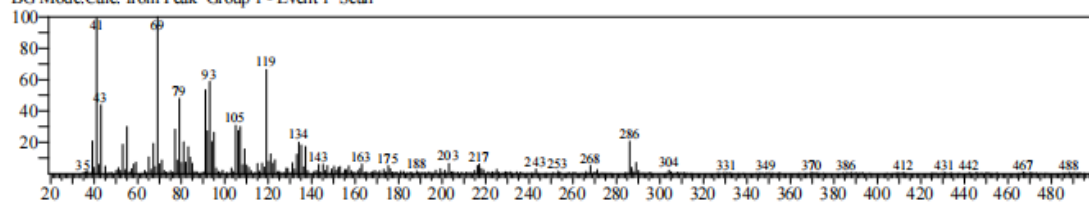
Line#:81 R.Time:34.340(Scan#:5545) MassPeaks:360
RawMode:Averaged 34.334-34.346(5544-5546) BasePeak:69.10(155520)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



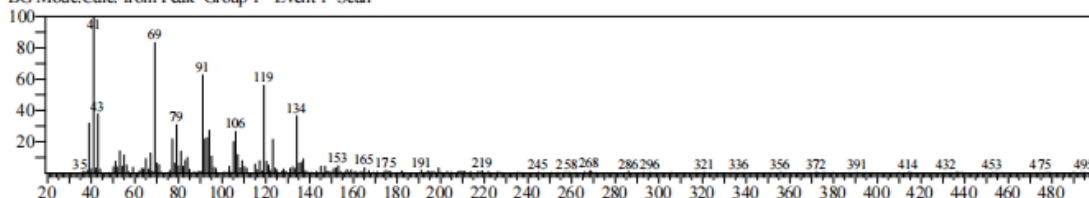
Line#:82 R.Time:34.527(Scan#:5577) MassPeaks:303
RawMode:Averaged 34.521-34.532(5576-5578) BasePeak:41.10(10470)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



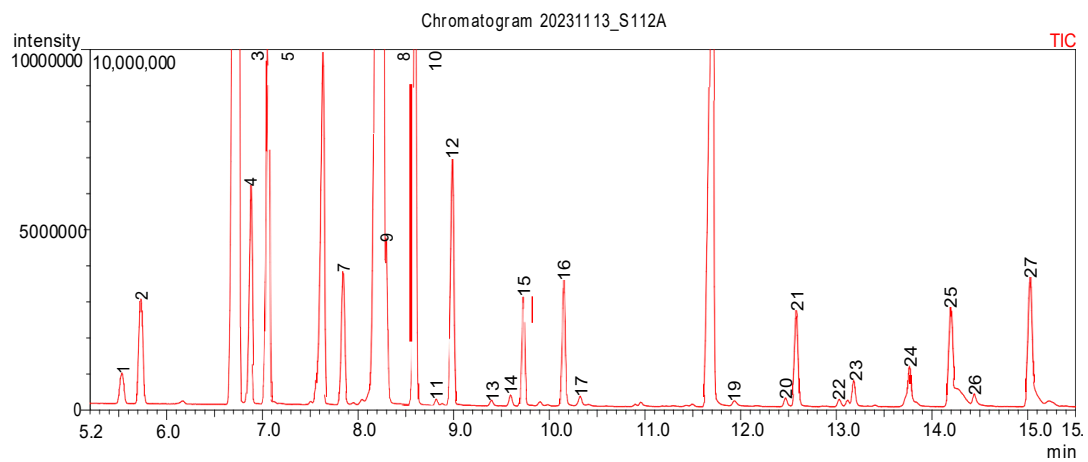
Line#:83 R.Time:34.836(Scan#:5630) MassPeaks:321
RawMode:Averaged 34.830-34.842(5629-5631) BasePeak:69.10(7713)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



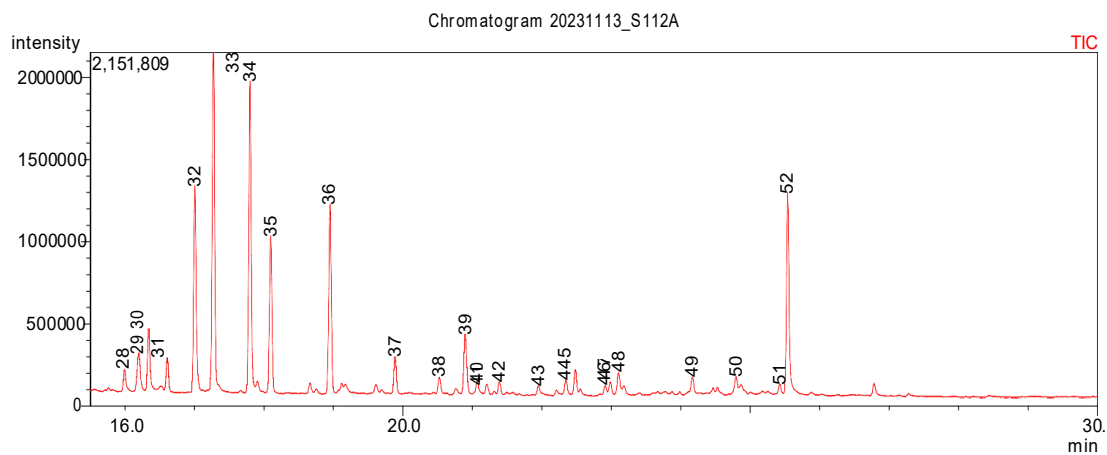
Line#:84 R.Time:34.929(Scan#:5646) MassPeaks:296
RawMode:Averaged 34.923-34.935(5645-5647) BasePeak:41.10(9081)
BG Mode:Calc. from Peak Group 1 - Event 1 Scan



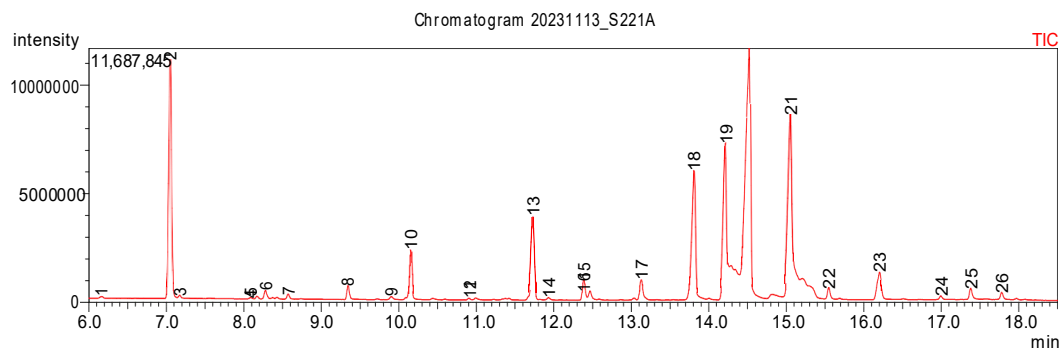
Appendix 32: Total Ion Content Chromatogram (TIC) for GC-MS of C .limon 0-15min



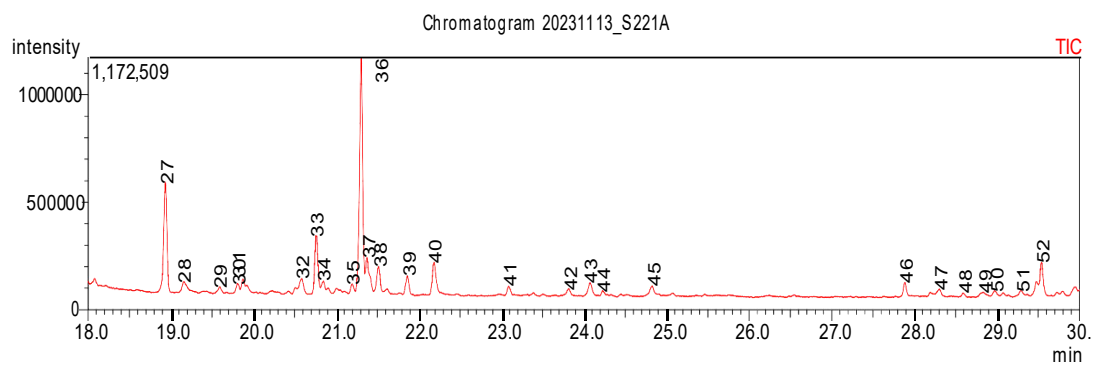
**Appendix 33 : Total Ion Content Chromatogram (TIC) for GC-MS of C .limon
16- 30 min**



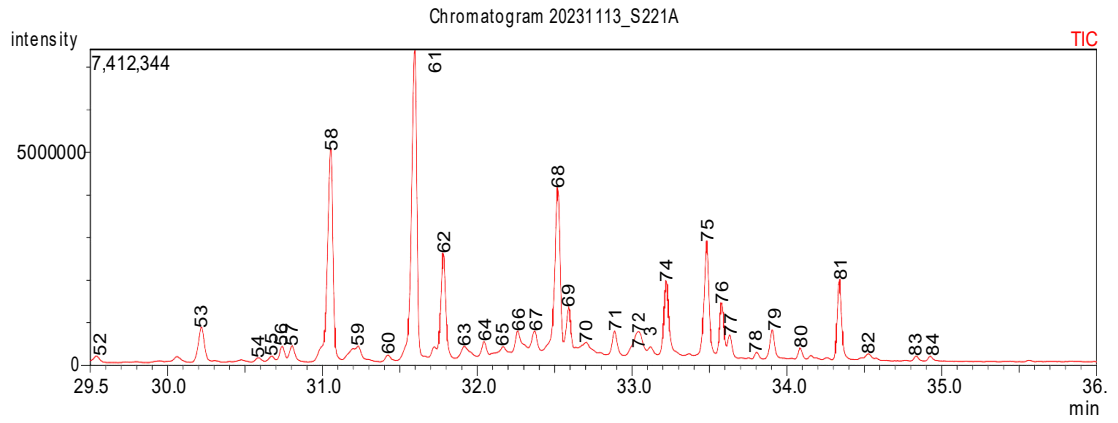
Appendix 34: Total Ion Content Chromatogram (TIC) for GC-MS of C .citratrus
0- 18min



**Appendix 35 : Total Ion Content Chromatogram (TIC) for GC-MS of C .citratrus
18- 30min**



**Appendix 36 : Total Ion Content Chromatogram (TIC) for GC-MS of C .citratrus
29.5- 36min**



Appendix 37: LIST OF SUBCOUNTIES IN KAKAMEGA COUNTY

1. Ikolomani
2. Lurambi
- 3. Shinyalu**
4. Malava
5. Lugari
- 6. Lumakanda**
7. Navakholo
8. Mumias East
- 9. Matungu**
10. Mumias West
11. Butere
- 12. Khwisero**

APPENDIX 38: APPROVAL LETTER FROM DPS



MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
Fax: 056-30153
E-mail: director@dps@mmust.ac.ke
Website: www.mmust.ac.ke

P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

29th September, 2021

Sharon Jepchumba Kosgey,
HNR/H/01-52483/2018,
P.O. Box 190-50100,
KAKAMEGA.

Dear Mr. Kosgey,

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your Ph.D. Proposal entitled: *"Effectiveness of Lemon and Lemon Grass Combination as Aromatherapy on Stress Reduction among Parents of Children with Intelligence mental Disability in Kakamega County, Kenya"* and appointed the following as supervisors:

1. Prof. John Okoth - SONMAPS, MMUST
2. Dr. Benard Juma - SONMAPS, MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director of Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Nursing & Midwifery Graduate Studies Committee and Chairman, Department of Nursing Research, Education & Management and Graduate Studies Committee. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of three years from the date of registration to complete your Ph.D. thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely,

Prof Stephen Odebero, Ph.D, FIEEP
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

APPENDIX 39: APPROVAL LETTER FROM IERC



MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY
Tel: 056-31375
Fax: 056-30153
E-mail: ierc@mmust.ac.ke
Website: www.mmust.ac.ke

P. O. Box 190,
50100,
Kakamega,
KENYA

Institutional Ethics and Review Committee (IERC)

REF: MMU/COR: 403012 Vol 5 (01)

Date: December 16th, 2021

To: Sharon Jepchumba

Dear Madam,

RE: EFFECTIVENESS OF LEMON AND LEMONGRASS COMBINATION AS AROMATHERAPY ON STRESS REDUCTION AMONG PARENTS OF CHILDREN WITH MENTAL DISABILITY (PCID) IN KAKAMEGA COUNTY, KENYA.

This is to inform you that *Masinde Muliro University of Science and Technology Institutional Ethics and Review Committee (MMUST-IERC)* has reviewed and approved your above research proposal. Your application approval number is MMUST/IERC/039/2021. The approval period is *December 16th, 2021-December 16th, 2022*.

This approval is subject to compliance with the following requirements;

- i. Only approved documents including informed consents, study instruments, MTA will be used.
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *MMUST-IERC*.
- iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *MMUST-IERC* within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to *MMUST-IERC* within 72 hours
- v. Clearance for export of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days upon completion of the study to *MMUST-IERC*.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://research-portal.nacosti.go.ke> and also obtain other clearances needed.






Yours Sincerely,

Prof. Gordon Nguka
Chairperson, Institutional Ethics and Review Committee

Copy to:

- The Secretary, National Bio-Ethics Committee
- Vice Chancellor
- DVC (PR&I)

APPENDIX 40: RESEARCH LICENSE

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 305897	Date of Issue: 30/June/2023
RESEARCH LICENSE	
	
<p>This is to Certify that Ms. Sharon Kogey of Masinde Muiro University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kakamega on the topic: EFFECTIVENESS OF LEMON AND LEMONGRASS COMBINATION AS AROMATHERAPY ON STRESS REDUCTION AMONG PARENTS OF CHILDREN WITH MENTAL DISABILITY (PCID) IN KAKAMEGA COUNTY, KENYA for the period ending : 30/June/2024.</p>	
License No: NACOSTI/P/23/26771	
305897	
Applicant Identification Number	Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
	Verification QR Code
	
<p>NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.</p>	
See overleaf for conditions	

Appendix 41: Research Authorization Letter Kakamega County

REPUBLIC OF KENYA
COUNTY GOVERNMENT OF KAKAMEGA



OFFICE OF THE GOVERNOR
COUNTY SECRETARY AND HEAD OF PUBLIC SERVICE

Telephone: 056-31850/31852/31853
Website: www.kakamega.go.ke
E-mail: countysecretary@kakamega.go.ke

County Government of Kakamega
P.O. Box 36-50100
KAKAMEGA

When replying please Quote

Ref No: CGK/OCS/GEN.CRR./04/VOL.5/216

Date: 5th December, 2023

Sharon Jepchumba Kosgey
Masinde Muliro University of Science & Technology
P. O. Box 190-50100
KAKAMEGA

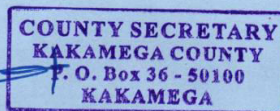
RE: RESEARCH AUTHORIZATION

The above subject matter refers.

Following your authorization letter Ref. No. NACOSTI/P/23/26771 dated 30th June, 2023 by NACOSTI to undertake research on "Effectiveness of Lemon and Lemongrass combination as Aromatherapy on Stress Reduction among Parents of Children with Mental Disability (PCID) in Kakamega County" for the period ending 30th June, 2024, I am pleased to inform you that you have been authorized to carry out the research on the same in Kakamega County.

It is therefore expected that you shall forward a copy of the thesis to this office.

Thank you.



Dr. Lawrence Omuhaka, CBS
County Secretary and Head of Public Service

Copy to: H.E. the Governor

Appendix 42: Data collection Photos







