A COMPARATIVE CHEMISTRY OF COA® HERBAL MEDICINE AND HERBAL EXTRACTS OF AZADIRACHTA INDICA AND CARICA PAPAYA

by

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Submitted in fulfilment of the academic requirements for the degree of

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Student number: 218084368

Supervisor: Dr. Nlooto Manimbulu

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February 2019

PREFACE

The experimental work described in this dissertation was carried out in the Discipline of Pharmaceutical Chemistry, School of Health Sciences, College of Health Sciences, University of KwaZulu-Natal, Westville Campus, Durban, South Africa from March to September 2018, under the supervision of Dr. M. Nlooto and Prof. R. Karpoormath.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

I certify that the above information is correct

_____

Dr. Manimbulu Nlooto (Supervisor)

Date:

_____

Prof. Rajshekhar Karpoormath (Co-supervisor)

Date:

DECLARATION – P LAGIARISM

I Joshua Chukwufumnanya Nwabuife declare that:

1. The research reported in this thesis, except where otherwise indicated, is my original research.
2. This thesis has not been submitted for any degree or examination at any other University.
3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
4. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
    a. Their words have been re-written, but the general information attributed to them has been referenced
    b. Where their exact words have been used, then their writing has been placed in italics and inside quotation marks and referenced.
    c. This thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the thesis and in the References sections.

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LIST OF MANUSCRIPTS

A Review of The Pharmacological Importance of *Azadirachta indica* and *Carica papaya* Linn.

Joshua C. Nwabuife[1*], Rajshekhar Karpoormath[1] and Manimbulu Nlooto[1]

Journal: Indian Drugs. Manuscript No. 11658

COMPARATIVE PHYTOCHEMICAL CHARACTERIZATION USING GC-MS ANALYSIS OF COA® HERBAL MEDICINE AND TWO OF ITS CONSTITUENT PLANTS; *AZADIRACHTA INDICA* (NEEM) AND *CARICA PAPAYA* LINN. (PAWPAW) FOUND IN GHANA AND SOUTH AFRICA

Joshua C. Nwabuife[1] Akwasi Boadu[1] Olushola Bodede[1] Sima Singh[1] Elizabeth Ojewole[1] Rajshekhar Karpoormath[1] Manimbulu Nlooto[1]

Journal: South African Journal of Chemistry. Manuscript No. sajc-001838

STATEMENT

The two manuscripts above were written and submitted following the author guidelines of the Journals.

The Masters candidate performed all the experimental work described in these manuscripts, where others have made contributions it is dully acknowledged in text. The candidate drafted these manuscripts and they have all been submitted to the respective Journals.

Student signature: _____

DEDICATION

This study is dedicated to my creator and my father God Almighty for granting me the privilege to run and complete this program, kept me in good health and above all, gave me wisdom to start and finish this work.

ACKNOWLEDGEMENT

First, I want to acknowledge my father God Almighty the author and finisher of my faith, who made it possible and easy for me to run this program and without whom I do not know what I would have done to complete this work. I say may your name be PRAISED.

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To my family, words are not just enough to quantify what you have done for me. My parents Rev. Emmanuel & Deaconess Mrs. Kate Nwabuife I want to say a THUNDEROUS APPRECIATION to you and my siblings Faith, Dr. Praise and Divine what on earth can I do without you people? I pray that God would continue to preserve us to celebrate ourselves in Jesus Name, Amen.

To my mentors, Prof. Chinedum Peace Babalola, Prof. A. Adegoke, Prof. Salako, Dr. Mrs. Overah Loretta (my undergraduate mummy), DR. Olayemi Adegbolagun (my postgraduate diploma mummy) I want to say am grateful for the inspirations I have being getting from you all and it's my prayer that your oil will never run dry.

To my research group members, members of **SYNTHETIC MEDICINAL CHEMISTRY RESEARCH GROUP (SMCRG)** I want to say thank you for all the support you gave to me directly and indirectly. It is my prayer that God would bless and keep you all in Jesus Name, Amen.

To my Christian families, Redeemed Christian Church of God (Chapel of Praise), Nigeria Christian Coppers Fellowship (NCCF) KOGI STATE CHAPTER, Redeemed Christian Postgraduate Fellowship University of Ibadan (RCPGF UI), Pastor and Pastor Mrs Adejimi, Abuwa's Family. I want to say you have been good to me.

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Maduka Chisom, Mr Blessing and so many other people I would have loved to mention but because of the unending list, I must stop here.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

COA®	Center of Awareness
DMBA	Dimethylbenz(a)anthracene
DNA	Deoxyribonucleic Acid
et al.	and other people
FDA	Food and Drug Administration
g	Grams
GC-MS	Gas Chromatography – Mass Spectrometry
HBP	High Blood Pressure
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HSV-1	Herpes Simplex Virus -1
L	Liters
mg/kg	Milligram per Kilogram
MIC	Minimum Inhibition Concentration
NIST	National Institute of Standard and Technology
NRE	Neem Root Extract
μg/mL	Microgram per Milliliter
USA	United States of America

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Background

Natural products have indeed endowed man with a variety of efficacious benefit combinations which can be dated to origin of the universe. The essence of herbs in the mitigation of human indisposition cannot be overstressed. The plant kingdom is believed to be a dockyard of never-ending genesis of active compounds paramount for the prophylaxis and mitigation of countless communicable and non-communicable disease conditions of mankind. Orthodox therapeutic substances used for basic medical care necessity, in recent times, have caught the attention of researchers; the rationale for this may be explained by the increased use of chemically derived therapeutic agents having adverse effects and negative clinical outcomes. This has seen the good turn of people to natural products such as COA® herbal medicine produced in Ghana and used by people in South Africa. However, the phytochemistry of COA® herbal medicine may not be well known. This study was aimed to establish the differences and similarities of phytochemical compounds found in COA® herbal medicine and two of its constituent plants (*Azadirachta indica* and *Carica papaya* Linn.) collected in Cape Coast (Ghana), Durban and Port Shepstone (South Africa).

Method

An experimental study was conducted in the pharmaceutical chemistry laboratory, discipline of pharmaceutical sciences, School of Health Sciences and in the chemistry laboratory, School of Chemistry and Physics, University of KwaZulu – Natal. A phytochemical screening and Gas Chromatography–Mass Spectrometry (GC-MS) were carried out using hexane, ethanol, ethyl acetate and dichloromethane extracts to establish the similarities and disparities between the COA® herbal medicine and leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. collected in Ghana and South Africa. The mass spectra of the compounds found in the analyzed extracts were matched with the National Institute of Standards and Technology (NIST) library.

Results

The results of the phytochemical screening revealed the presence of alkaloids, anthraquinones, flavonoids, saponins, tannins, terpenoids and steroids, cardiac glucosides. GC–MS results revealed the presence of common phytochemical compounds such as Phyto acetate, Octadecanoic acid, Pentadecanoic acid, Stigmast-5-en-3-ol, Stigmast-5,22-dien-3-ol, in COA® herbal medicine and leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. collected in Ghana and South Africa. However, this study confirmed the differences in phytochemical compounds from leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. collected in Ghana and South Africa.

Conclusion

This study found that there were similarities between COA® herbal medicine and leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. However, differences in phytochemical compounds were observed between leaf extracts of *Azadirachta indica* and Carica papaya Linn. collected in Ghana and South Africa.

Keywords: COA® herbal medicine, Natural Products, *Azadirachta indica*, *Carica papaya* Linn, Phytochemical screening, Gas Chromatography–Mass Spectrometry

CHAPTER ONE: GENERAL INTRODUCTION

1.1. BACKGROUND

African traditional medicine (ATM) is the earliest, and conceivably the most multitudinous, of all health-giving systems[1]. Africa is the cushion of humanity with an affluent of biological and ethnic miscellany manifested by territorial dissimilarities in curative practices[1]. Although ATM was the oldest, Traditional Chinese Medicine (TCM) has gained a lot of recognition today. Nonetheless, quality control of TCM has habitually posed a tailback for their acceptance universally owing to their complications, the presence of undisclosed constituents and shortfall of quality control[2]. Environmental components are believed to have impact on the genre and contents of phytochemicals available in plants[3]. The altitude variation and several ecological components, such as temperature, atmospheric moisture, soil, active substances and solar radiation are known to be emphatically analogized to the content of some phytochemicals occurring in medicinal plants growing in a given place[3]. Sunshine duration and altitude have been remarkably and emphatically correlated to the flavonoids and antioxidant activity, while altitude was indisputably and positively harmonized with the content of total phenolic compounds [3]. The types of phytochemical and chemical constituents present in COA® herbal medicine, which may be responsible for its pharmacological activities are not yet well known; the constituents of medicinal plants collected in Cape Coast Ghana may contain similar and/or different chemical components with the same plants found in Durban and Port Shepstone, South Africa. The geographical location of the plants used in the preparation of COA® herbal medicine may have some sort of disparities and/or similarities in phytochemicals of plants from Cape Coast, Ghana compared to the same species found in Durban and Port Shepstone, South Africa. As stated above, environmental components may influence the phytochemical contents of plants in a given area [3]. Therefore, there is need for a scientific evaluation of the COA® herbal medicine to identify its bioactive compounds in comparison to the bioactive compounds found in the leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. from different geographical locations, namely Cape Coast –Ghana, and Durban and Port Shepstone – South Africa. The aim of this study was to compare the different phytochemicals and the chemistry of both COA® herbal medicine and crude extracts from *Azadirachta indica* and *Carica papaya*, Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa) using phytochemical screening methods and GC-MS.

1.2 BRIEF OVERVIEW OF THE LITERATURE

This section gives a brief overview of the literature. A full literature review is discussed in the manuscripts included in this dissertation. Chapter two presents a full review on the two constituent plants *Azadirachta indica* and *Carica papaya* Linn. Sicknesses have bedeviled humanity for length of days, but man has habitually made attempt to resolve the condition to recoup a life disrupted by these

diseases. The prior form of mitigating substances had been herbal medicines, but with the arrival of modernization which had led to superior scientific knowledge of sickness and drugs, orthodox medicines have become the principal and well endorsed products for the treatment of sicknesses in contemporary health structures[4].

In 1805, the first pharmacologically-active amalgam morphine was isolated from the opium plant by a young German pharmacist, Friedrich Sertürner[5]. Afterwards, legions of active amalgamations have been isolated from natural substances.

The evolution of new active moieties pivoting exclusively on latter-day scientific knowledge comes to sight to be approaching somewhat of a limit. In evolving new active-moieties, the pharmaceutical industry has inclined to espouse lofty-throughput synthesis and combinatorial chemistry-established drug development since the 1980s; regardless of how, the substantial attempt made in this course have not ensued in the anticipated drug productivity[6]. Some great pharmaceutical companies are experiencing substantial challenges to unfold new products. Higher up the past dozen years, growing recognition has appropriately been paid to natural products in the scout for novel drugs in integration with latter-day scientific knowledge, such as lofty-throughput selection[6].

1.3 PROBLEM STATEMENT

Center of Awareness (COA®) herbal mixture made in Ghana has been used in the mitigation of several ailments such as cancer and diabetes or as an immune booster for Human Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) patients and for their general well-being[7]. Leaf extracts of medicinal plants used to produce COA® herbal mixture were extracted from the plant leaves collected from Cape Coast, Central Region of Ghana. Following the Food and Drug Administration (FDA) report in Ghana, COA® herbal medicine contains *Vermonia amygdalina*, *Persea americana, Azadirachta indica, Carica Papaya* Linn., *Spondias mombin* and *Ocimum viride*[7]. Although headway and advances are made for the management of diseases with synthetic medicines, many African patients resort to the utilization of Traditional medicine for treatment solutions such as HIV/AIDS, cancer, diabetes[8]. COA® herbal medicine, has been ordered online by several patients as an immune booster for HIV/AIDS and as a supplement in diabetes mellitus, cancer and high blood pressure[7]. In a preliminary observational study explored in 2016 by Nlooto and Naidoo, COA® herbal medicine was said to have been administered to some HIV/AIDS patients[8]. However, phytochemical constituents present in COA® herbal medicine have not yet been fully explored. Hence, this study would help to reveal the phytochemicals present in COA® herbal medicine, with a view to ascertain the presence and availability of phytochemical constituents responsible for the pharmacological activity of COA® herbal medicine and two of its constituent plants (*Azadirachta indica, Carica Papaya* Linn.).

1.4. RESEARCH QUESTIONS, AIM, HYPHOTHESIS AND OBJECTIVES

1.4.1 Research Questions

This study was aimed to answer a general research question: "What are the different phytochemicals and chemistry found in both COA® herbal medicine and crude extracts from *Azadirachta indica* and *Carica papaya* Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa) using phytochemical screening methods and gas chromatography mass spectrometry (GC-MS)?

To answer this general research question, specific research questions have been developed as follows;

1. What is the phytochemical and chemical composition of the COA® herbal medicine compared to two of its constituent plants (*Azadirachta indica* and *Carica papaya* Linn.) using phytochemical screening methods and GC-MS?

2. What are the chemical constituents of the leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa) using phytochemical screening methods and GC-MS?

3. What are the similarities and differences in the phytochemicals and chemistry of the leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa)?

1.4.2. Aim

The aim of this study was to compare the different phytochemicals and the chemistry of COA® herbal medicine and crude extracts from *Azadirachta indica* and *Carica papaya* Linn., found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa) using phytochemical screening methods and GC-MS.

1.4.3. Hypothesis

This study assumes a null hypothesis, stating there will be no differences between phytochemicals found in COA® herbal medicine and the leaf extracts from *Azadirachta indica* and *Carica papaya* Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa). These two plants are part of the plants used in making the COA® herbal medicine.

1.4.4. Objectives

The specific objectives of the study are as follows

1. To determine the phytochemical and chemical profile of the COA® herbal medicine compared to two of its constituent plants (*Azadirachta indica* and *Carica papaya* Linn.) using phytochemical screening methods and GC-MS.

2. To establish the chemical constituents of the leaf extract of *Azadirachta indica* and *Carica papaya* Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa) using phytochemical screening methods and GC-MS

3. To compare the similarities and differences in the phytochemicals and chemistry of the leaf extracts of *Azadirachta indica* and *Carica papaya* Linn. found in Cape Coast (Ghana), Durban and Port Shepstone (South Africa) using phytochemical screening methods and GC-MS

1.5. GENERAL METHODOLOGY

1.5.1. Study design

This study is experimentally based on the phytochemical analysis of COA® herbal medicine and leaf extracts of *Azadirachta indica* and Carica *papaya* Linn. found in Cape Coast (Ghana), Port Shepstone and Durban (South Africa), using phytochemical screening methods in the Medicinal Chemistry laboratory at the College of Pharmaceutical Sciences University of KwaZulu–Natal Westville and GC-MS, at the Mass Spectrometry Laboratory, College of Chemistry University of KwaZulu Natal – Pietermaritzburg.

1.5.2. Materials:

COA® herbal medicine was purchased from a medicine retail outlet in Durban, South Africa while leaf extracts were made from leaves of the two plants (*Azadirachta indica* and Carica *papaya* Linn.) obtained from Cape Coast in Ghana, and Durban and Port Shepstone in South Africa.

1.5.3. Data Collection Technique and Instruments:

Appropriate data collection procedures were used in the collection of data. A phytochemical screening was first carried out using the ethanol fraction of COA® herbal medicine and leaf extracts of the two plants obtained from Cape Coast (Ghana), Durban and Port Shepstone (South Africa). A GC-MS fingerprinting followed the phytochemical screening for a qualitative identification of potentially bioactive chemical constituents. COA® herbal medicine and leaf extracts of plant materials were extracted and filtered using successive extraction of the leaf samples in different solvents which includes; Dichloromethane (DCM), Ethanol (EtOH), Hexane (HEX), and Ethyl Acetate (EtoAc) and filtered using Waltman filter paper respectively.

1.5.4. Plan for Data Analysis:

Results from GC-MS of the phytochemical compounds obtained were checked for duplications for phytochemical structures and /or names. In addition, the retention time and area percentages of the phytochemicals were analyzed for similarities and /or differences between COA® herbal medicine and leaf extracts of plants collected from Cape Coast-Ghana, Durban and Port Shepstone- South Africa.

1.5.5. Ethics Statement:

This study was given a class approval by the Biomedical Research Ethics committee of the University of KwaZulu-Natal under reference EXM612/18.

1.6. LAYOUT/STRUCTURE OF THE DISSERTATION:

Chapter one outlines the introduction to the topic by providing information on the background as well as a brief overview of the literature. It also contains the problem statement, the research question, aim, hypothesis and objectives of the study. Knowledge about the general methodology which includes the study design, materials, data collection technique, plan for data analysis and ethics statement were also included.

Chapter two is a review article which was prepared according to the manuscript guidelines of the journal "Indian Drugs" and is entitled: *A NARRATIVE REVIEW OF THE PHARMACOLOGICAL IMPORTANCE OF AZADIRACHTA INDICA AND CARICA PAPAYA* LINN.

Chapter three is a research article which was prepared according to the manuscript guidelines of the "South African Journal of Chemistry" and is entitled: *COMPARATIVE PHYTOCHEMICAL CHARACTERIZATION USING GC-MS ANALYSIS OF COA® HERBAL MEDICINE AND TWO OF ITS CONSTITUENT PLANTS AZADIRACHTA INDICA (NEEM) AND CARICA PAPAYA* LINN. *(PAWPAW) FOUND IN CAPE COAST (GHANA), DURBAN AND PORT SHEPSTONE (SOUTH AFRICA).*

Chapter four is the synthesis and discussion of the findings of this study.

The appendices are also attached at the end of this thesis.

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CHAPTER 2

Manuscript 1

A NARRATIVE REVIEW OF THE PHARMACOLOGICAL IMPORTANCE OF *Azadirachta indica* and *Carica papaya* Linn.

Submitted to *Indian Drugs*

Manuscript No. 11658

Following the introduction in chapter one, an extensive review was written on the pharmacological importance of two of the constituent plants (*Azadirachta indica* and *Carica papaya* Linn.) that were used in the production of COA® herbal medicine. A manuscript was written and submitted following the guidelines of the journal "Indian Drugs."

CHAPTER TWO: A NARRATIVE REVIEW OF THE PHARMACOLOGICAL IMPORTANCE OF *AZADIRACHTA INDICA* AND *CARICA PAPAYA* LINN.

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ABSTRACT

Nature has indeed privileged man with a good origin of efficacious and health benefit combinations since the traceable origin of the universe. The significance of herbs in the mitigation of human malady cannot be overemphasized. The plant kingdom is believed to harbor a never-ending origin of active compounds crucial for the mitigation of numerous communicable diseases. In addition, the pharmacologically active ingredients of these plants are said to boast of the edge of being in combination with multitudinous other substances which may come to sight as to be inactive and these harmonious pieces help to avail the plant with safety and coherence which can be regarded to be much more supercilious to that of its scientifically distinguished and pure active piece. This paper focuses on the various medicinal and pharmacological uses of these two plants *Azadirachta indica* and *Carica papaya* Linn.

Keywords; Azadirachta Indica, Carica Papaya linn, Medicinal Importance, Pharmacological Properties.

2.0 INTRODUCTION

Since antiquated times, the use of freely available combinations (druglike molecule) from variable origins such as plants, animals, unicellular/multicellular organisms, and saltwater organisms by humans as physic to mitigate and nurse diseases cannot be overemphasized. Petrified records have it that, the human application of naturally cultivated plants as physic could be dated rear at minutest period of 60,000 years[1].

Natural products are said to be unique in their chemical diversity, which contributes to the differences in their bioactive properties as drug-like components. These products are leading sources for the development of new lead compounds and/or scaffolds. Their ability is correlated with their complicacy of a well-structured three-dimensional chemical and steric properties, which presents them with a lot of fore deal in terms of their effectiveness as well as their ability to be selective of molecular targets[2]. Natural products are believed to continuously undergo usefulness towards meeting the various urgent needs for the development of efficient moieties and will keep on frolicking a decisive function over uncovering new moieties for the cure of disparate human sicknesses, especially some critically known diseases[3]. The application of some locally made combinations for bioactive function modification has also gained a large recognition. Afterwards, a lot of them have been favorably used for the uncovering of different new active moieties and have implied a large influence on chemicobiology[4].

2.1 Azadirachta Indica (Neem Plant)

Azadirachta indica is said to be a quick-spring green retaining well known plant commonly grown in India, African and American continent[5]. It is said to have been used in whole-body healing for over four millenniums because of its healing properties. *Azadirachta indica* is also known as 'arista' in Sanskrit which can be interpreted to mean 'good, complete and long-living[6]. It springs more around areas of South-eastern Asia and Western part of Africa; with a smaller number of it having been recently sowed in the Carribbean and many Central American nations, including Mexico. *Azadirachta indica* is known to be harmless to humans and animals in general and to valuable arthropods and annelid worms. Hence it has been consented to by the United States Environmental Protection Agency to be considered as nutriment crop[7]. Neem is known to be the most flexible and multifaceted plant of the tropical areas, having high prospects. It is said to also contain paramount important non-wood products (leaves, bark, flowers, fruits, seed, gum, oil and neem cake) compared to other plant.

Azadirachta indica is a plant traceable to the meliaceae family and an evergreen plant of great medicinal importance found in a lot of tropical countries[8]. It is known for its medicinal use in the cure of allergenic, dermatic, feedent, fungal, inflammatory, pyorrhoeic, scabic, cardiac, diuretic, diseases and for its use as insecticide, larvicide, nematicide and spermicide amongst other biological potential uses. All these

properties of *Azadirachta indica* have found large applications, hence causing it to be regarded as a green treasure[9].

Bioactive combinations separated from various parts of *Azadirachta indica* include: azadirachtin, meliacin, gedunin, salanin, nimbin, valassin and so numerous more derivatives of these combinations. Meliacin is known to be the crucial combination accountable for the harsh properties of *Azadirachta indica* seed oil. *Azadirachta indica* seed equally seats tignic acid (5-methyl-2-butanic acid) which is said to be liable for its peculiar smell noticed in the oil**.** These combinations are believed to belong to phytochemicals known as triterpenes (Limonoids). They are to a small degree tending to mix with water but are known to freely combine with or dissolve in lipids and easily dissolving in organic liquids such as alkanols, ketones and alkanoates[10].

2.2. Taxonomical Classification

The taxonomic classification of neem is as follows[6]:

Kingdom:	Plantae,
Order:	Rutales,
Suborder:	Rutinae,
Family:	Meliaceae,
Subfamily:	Melioideae,
Tribe:	Melieae,
Genus:	Azadirachta,
Species:	Indica

2.3. Vernacular Names[11]

Bengali:	Nim, Nimgachh,
Guajarati:	Danujhada, Limbado, Limbra, Limdo,
Hindi: Nim,	Nimb,
Sanskrit: Arista,	Nimba, Nimbah, Picumarda,

English: Indian Lilac, Margosa tree, Neem tree,

Kannada: Bemu, Bevinamara, Bivu, Kaybevu,

Punjabi: Bakam, Drekh, Nim

2.4. Medicinal Use of *Azadirachta indica* (Neem)

All parts of *Azadirachta indica* have been reported to be used medicinally for centuries. Below are the various medicinal uses of the different parts of the plant.

Table 2. 1: **Medicinal uses of the Various Parts of *Azadirachta Indica* Plant**[9].

PLANT SEGMENTS	MEDICINAL APPLICATIONS
The Leaf	Leprosy, Sight troubles, Epistaxis, Gastroenteric worms, Anorexia, Excess secretion of bile, Skin problems.
The Bark	Analgesic properties used as Alternatives and curing of Fever.
The Flowers	Bile clampdown, removal of gastroenteric worms and Mucus.
The Fruits	Used to cure piles, Urine disarray, Epistaxis, Mucus, Eye troubles, Diabetes, injuries and Leprosy.
The Twigs	Used to cure cough, Asthma, Piles, Phantom tumour, Spermatorrhoea, Headstrong urine disarray, Diabetes.
The Viscous Secretion	Used unsympathetically to skin problems such as; Ringworms, Scabies, Injuries and Ulcers.
The Seed Paste	Leprosy and Intestine worms.
The Viscous liquid	Leprosy and gastroenteric worms in the intestines.
The Root, Bark, Leaf, Flower and Fruit combined	Blood disease, Bile plague, Tingling, Epidermal ulcer, Burns sensation, Leprosy, etc.

2.5. Pharmacological Properties of *Azadirachta indica* (Neem)

2.5.1. Antibacterial Activity:

Ghonmode *et al.,* (2013) evaluated the antimicrobial potential of herbal option as inner tooth irritants and then juxtaposed it with an already known calibre irritant sodium hypochlorite. The results confirmed that leaf extracts of the neem and grape seed extracts showed zones of inhibition which suggested that they had antimicrobial activity. Furthermore, leaf extracts were said to have shown significantly greater zone of inhibition compared to 3% sodium hypochlorite[12]. Another scrutiny was conveyed to access the antimicrobial potential of the bark, leaf, seed and fruit of *Azadirachta indica*

(neem) on unicellular microorganisms secluded from the buccal cavity of an adult and out-come had it that, the rear surface and leaf extracts exhibited antibacterial properties in opposition to every of the strains of the sample unicellular microorganism used. Furthermore, seed and fruit extracts showed antibacterial activity only at higher concentrations[11].

2.5.2. Antifungal Activity:

In a study to evaluate the efficacy of various extracts of neem leaf on seed borne fungi *Aspergillus* and *Rhizopus*, Mondali *et al.*, (2009) confirmed through the result obtained that the growth of both fungal species was significantly inhibited and controlled with both alcoholic and water extract[13]. Furthermore, alcoholic extract of *Azadirachta indica* leaf was said to be highly effective when compared to the aqueous fraction for decreasing the growth of both fungal species[14]. In another investigation, the antimicrobial role of aqueous extracts of neem cake in the impediment of spore development against three sporulating fungi such as *C. lunata, H. pennisetti* and *C. gloeosporioides* f. sp. *Mangiferae* was reported[15]. Also, another study was undertaken to examine the antifungal potential of *Azadirachta indica* L. over *Alternaria solani* Sorauer and results confirmed that ethyl acetate extract of *Azadirachta indica* was found to be the greatest in functionality in reducing fungal development which gave an MIC of 0.19 mg and it happened to be more functional than fungicide (metalaxyl + mancozeb) as the fungicide was said to have shown a minimum inhibition concentration MIC of 0.78mg[16].

2.5.3. Antiulcer Activity:

The antiulcer potential was obtained using nimbidin in the prevention of aspirin, indomethacin, serotonin-induced stomach injury or streets and cysteamine instigated small intestine sore or histamine[11]. Leaf extract of *Azadirachta indica* (Neem) showed antiulcer effect with the inhibition of mucus depletion and most cell defragmentation as possible mechanism. Bandyopadhyay *et al*, isolated the phenolic glycoside which is an active compound, with its characterization and mechanism of action being under study. Consequently, *Azadirachta indica* potentially provides additional choice for a constructive antiulcer agent and which is safe[17].

2.5.4. Antiviral Activity:

Leaf extracts of neem *Azadirachta indica* have shown viricidal activity against coxsackievirus virus B-4 as propagated via virus deactivation and yield reduction assay apart from interference at the early event of its reproducing cycle[11]. In another experiment, results showed that *Azadirachta indica* bark extract was said to have significantly blocked the entry of Herpes Simplex Virus -1 into the functional unit of the organism at concentrations tending towards 50 to 100 μg/mL[18]. Furthermore, blocking potential of *Azadirachta indica bark extract* was noticed when it was preincubated alongside the virus excluding the target cells which suggested a direct anti-HSV-1 potential of *Azadirachta indica* bark[19].

2.5.5. Antimalarial Activity:

To evaluate the antimalarial activity of neem plant, Akin-Osanaiya *et al.* (2013), treated *Plasmodium berghei* infected albino mice using leaf and stem bark extracts of *Azadirachta indica* plant and results revealed that *Azadirachta indica* leaf and stem bark extracts decreased the level of parasitaemia in infested mice with about 51–80% and 56–87%, respectively[20]. Similarly, Udeinya *et al.* (2008), in yet another investigation based on raw acetone/water (1/1) extract of *Azadirachta indica* leaves checked the activity potential on the asexual and sexual forms of malaria parasite *Plasmodium falciparum*, and the results *in vitro* showed that, in a discrete 72-hour cultures of the asexual parasites and mature gametocytes treated, parasite numbers was reduced to below 50% of that of the known standard cultures, which was 8.0% and 8.5% parasitaemia, respectively[21].

2.5.6. Anti-Inflammatory, Antipyretic and Analgesic Properties:

Trichloromethane fraction of neem stem rare surface extract showed effectiveness over carrageenan – instigated paw edema in mouse ear swelling. Inflammatory stomatitis suffered by children is said to be treated using the bark extract[11]. Neem leaf extract was delineated to have produced remarkable analgesic effect, at amount of 250mg and 500mg/kg body weight[22]. Antipyretic properties have been delineated in *Azadirachta indica* viscous liquid. A methanol fraction of neem leaf extract showed this effect when it is administrated into male rabbits. Antipyretic and Anti-inflammatory properties of various extracts have also been reviewed[9].

2.5.7. Male Antifertility Properties:

The *Azadirachta indica* seed viscous liquid and leaf extracts used as robust contraceptive was said to have significantly prevented spermatogenesis, reduced sperm movement, count and stoppage of fertility. No Indicative or important influence on the loss of libido or potency. Furthermore, it was said to possess abortifacient and anti-implantation effect[10]. Vagina biopsy reveals no harmful effect, and the studies of radio-isotope indicated a non-antiovulatory and non-absorptive effect in the vagina. This research enabled neem oil formulation ―sensual which is used as a powerful contraceptive in India[9].

2.5.8. Anticancer Activity:

Azadirachta indica contains biologically energetic combinations that act pivotal part in the prophylaxes of cancer evolution and advancement. Although the actual molecular procedure in this vista remain yet to be completely understood, based on experimentation, it was considered that neem constituent ingredients act a pivotal part in the variation of various cell signalling cause of actions[23].

Kumar *et al.*, in a study in 2009 performed an investigation of the cytotoxic effects of nimbolide found in leaves and flowers on human choriocarcinoma (BeWo) cells and out-come showed that use of nimbolide ensued in amount- and time-reliant prevention of development of BeWo cells which gave IC50 figures of 2.01 and 1.19 μM at the 7^{th} and 24^{th} hour, respectively[24]. In another study, Priyadarsini

et al., made effort to assess the chemo preventive capability of the limonoids, azadirachtin, and nimbolide and results showed that azadirachtin and nimbolide prevented the development of Dimethylbenz(a)anthracene (DMBA)-induced high blood pressure (HBP) carcinomas through catalysing multiple mechanisms such as prophylaxes of procarcinogen actuation and oxidative DNA damage, increasing of antioxidant and carcinogen detoxification enzymes, and stoppage of tumour invasion and angiogenesis[25].

2.5.9. Antidiabetic Activity:

In a study carried out to evaluate the 70% alcoholic neem root bark extract (NRE) as a potential for anti-diabetes, the results showed that neem root bark extract exhibited a statistically significant result in a dose of 800mg/kg[26]. Another experiment was performed to examine the pharmacological hypoglycaemic exploit of *Azadirachta indica* in diseased rats and the out-come showed that neem extract of 250mg/kg demonstrated significantly less glucose level as juxtaposed to the control group and *Azadirachta indica* remarkably reduced the sugar level on the 15th day in diseased rats[27]. Joshi *et al.*, (2011) in an *in vivo* diabetic murine model study, investigated anti-diabetic properties using *A. indica*, and *B. spectabilis* trichloromethane, methane alcohol, and aqueous extracts, and the out-come showed that *A. indica* trichloromethane extract and *B. spectabilis* aqueous, methanol extracts exhibited a superior oral sugar forbearance potential and remarkably decreased the level of gastric glucosidase venture[28]. Akter *et al.*, (2013) suggested from a study that leaf extracts of *Azadirachta indica* and *Andrographis paniculata* showed a potential antidiabetic venture and can possibly serve as a probable origin for cure of diabetes mellitus[29].

2.5.10. Role of Neem in Dentistry:

A study carried out to assess the effectiveness of neem based on mouth wash, regarding its antigingivitic effect confirmed that *Azadirachta indica* mouth rinse is also effective in the reduction of periodontal indices as chlorhexidine[30]. Another study carried out to evaluate the possible antimicrobial properties of organic extracts of neem against three different bacterial strains causing dental problems showed that petroleum ether and chloroform extract had strong potential antimicrobial activity against *S. mutans*. Chloroform extract showed strong activity against *Streptococcus salivarius* and third strain *Fusobacterium nucleatum* also showed high sensitivity to both ethanol and water extract[31].

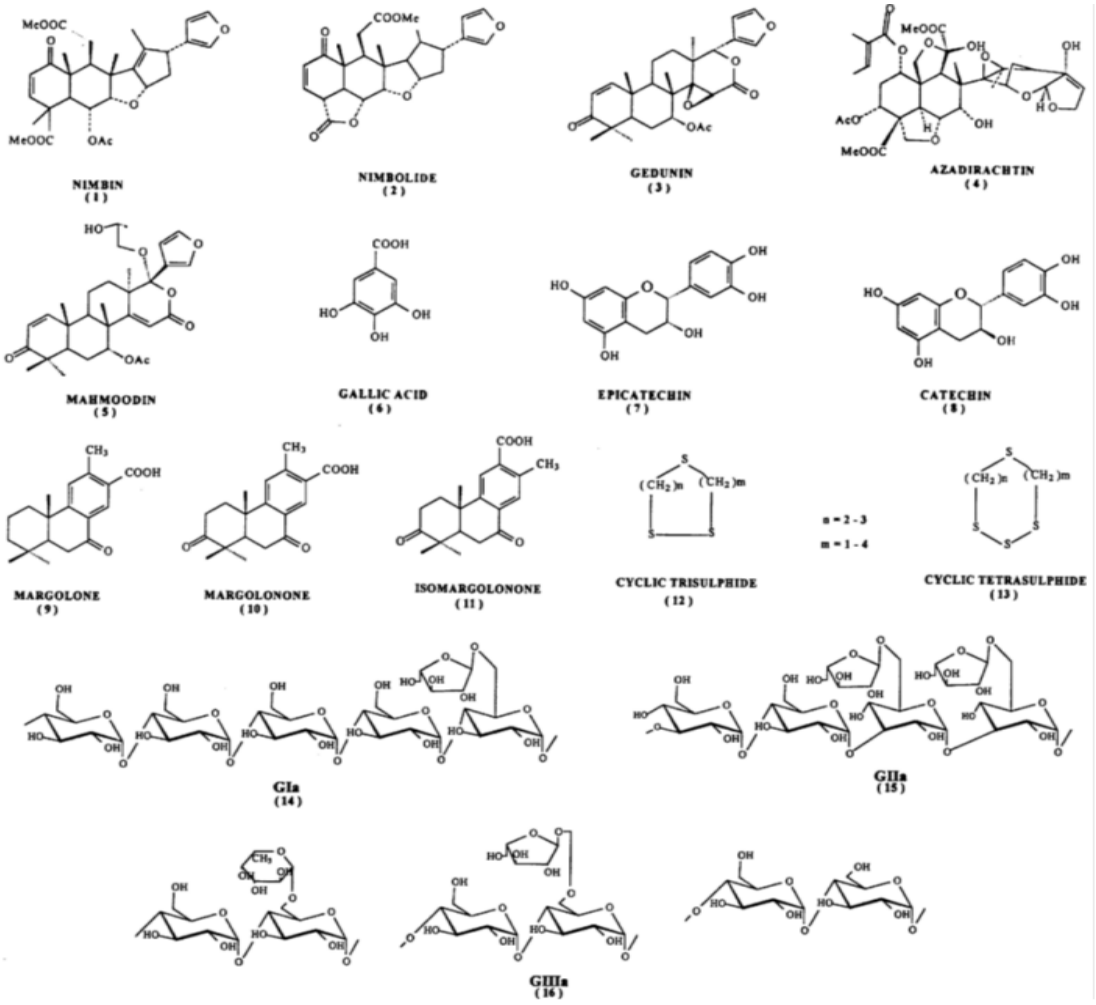

Figure 2. 1 Structures of some of the pharmacologically active compounds of NEEM[11]

2.6. Carica Papaya Linn. (Pawpaw Plant)

Carica papaya Linn. (Caricaceae) is known to be a quick-spring, temporary, tropical tree plant, grown because of the fruit, papain, pectin, and its antibacterial importance[32]. Today pawpaw is a plant that is planted widely in tropical and subtropical low-lying regional areas throughout the universe and was traded at almost $200 million in the year 2009[33].

Pawpaw is said to be the third prevalently grown tropical crop globally, with Brazil and India being noted as the greatest promoters but Mexicans are the major exporter[33]. Papaya trees when cultivated, grows quickly, giving birth to matured fruits no further than a space of 9–12 months after it was planted. Commercially, it is believed that a bulk of 1,500–2,500 trees per 10,000 square metres of *Carica papaya* Linn. can give birth to between 125,000 and 300,000 lbs per hectare, yearly[34]. Among other familiar fruits, pawpaw is classified as the number one nutritional result because of its number of vitamins, potassium, folate, niacin, thiamine, riboflavin, iron and calcium, and fibre content[35]. Besides, major parts of the plant (such as; fruits, stems, leaves and roots) are used for a compendious medicinal

accomplishment and enzyme (papain) fabrication[36]. Mercenary purposes to produce papain is tailored towards protein digestion; majorly used as a beef softener, in fermentation industry for production of beer, and the cosmetics industry for the dermal cure of swelling and blemish[37]. *Carica papaya* Linn. contains a biologically active compound known as papain which is employed for the curative purpose of arthritis. The level of active combinations present in *Carica papaya* Linn. differs in the fruit, latex, leaves, and roots. Since, all chunk of papaya tree is of lucrative importance; it is cultivated on merchandising scale[38].

2.7. Taxonomical Classification:

Carica papaya Linn can be said to be classified taxonomically as follows[39]:

Kingdom:	Plantae,
Class:	Magnoliopsida,
Superorder:	Rosanae,
Order:	Brassicales,
Family:	Caricaceae,
Genus:	Carica L,
Species:	Carica papaya L

2.8. Nutritional Value of Carica Papaya:

Nutritional values of Carica papaya Linn. has been reported to help arrest the oxidation of cholesterol. Pawpaw is known to be copious in iron and calcium, serve as a viable origin of vitamins A, B and G and known to be an eminent origin of (5R)-[(1S)-1,2-dihydroxyethyl]-3,4-dihydroxyfuran-2(5H)-one (ascorbic acid). The extracts of *Carica papaya* Linn. are said to consist of some phytochemicals such as; terpenoids, alkaloids, flavonoids, carbohydrates, glycosides, saponins, and steroids, etc[40].

Papaya can be said to be a fruit for the common man, which possesses a great health/food worth, contains rock-bottom fat and an endowed source of natural vitamins and minerals[41]. The advantageous rock-bottom fat content (32 Kcal / 100 g of ripe fruit) accolades it as perfect and sort after fruit by the overweight individuals that may be undergoing weight reduction control. Pawpaw contains economical carotene content when juxtaposed to other fruits with the likes of apples, guava and plantains, which aids in the prevention of vandalism by free radicals. Immature *Carica papaya* Linn. fruit is said to be consumed as vegetable and is devoid of carotene but rather is a rich source of different types enzymes[41].

Papain which is an enzyme of papaya plant, has an excellent aid in digestion of proteinous food at acidic, basic and neutral medium. Those people with celiac diseases, who lack the ability normally to absorb wheat protein gliadin, tolerates it, when being nursed with raw papain. *Carica papaya* Linn. reserves the ability of slow cooking meat. The information is utilized by preparing meat with fresh pawpaw to temper and make it absorbable[42]. The brewed pawpaw is said to have a potential nutraceutical importance as an antioxidant. It is said to improve the antioxidant protection level in aged patients in the absence of any noticeable antioxidant shortcoming with a dose of 9g/day through the mouth. The pawpaw lipase which is a hydrolase enzyme, when firmly joined to the aqueous insoluble fraction of the raw papain, is said to be appraised as a "naturally immobilized" biocatalyst[42].

2.9. Medicinal Uses of Carica Papaya:

The different chunk of pawpaw plant has been delineated to be of medical importance in the care of diverse human diseases[43]. The water containing seed extract fraction of the unready but matured fruit of *Carica papaya* Linn. was proven to own a nephron defensive venture why the ripe matured fruits are being said to be employed as surface ulcer covering aid in Jamaica[44].

In another study carried out in 2007, report has it that seeds of *Carica papaya* Linn demonstrated together, antimicrobial and antihelmintic effect[45]. *Carica papaya* Linn. plants constitute of some freely available combinations in its leaf, bark and twig tissues which has been found to possess activities of an anti-tumor as well as a pesticidal properties[46]. The seed has been found to be active against gastroenteric worms when masticated, while the root when masticated, and the sap digested, it helps in the treatment of cough, bronchitis, and sundry types of respiratory diseases. Also, an immature fruit has been said to be proven as a cure for ulcer and lack of orgasm[47]. Freshly gotten green papaya leaf is said to act as an antiseptic, while the brown and dried papaya leaf has also been said to be the best tonic and helps in the purification of the blood. It also helps in the cleansing of the intestines from bacteria (as only a disease-free intestine can absorb the necessary vitamins and minerals, particularly the cyanocobalamin) [48]. Mastication of the seeds of a juicy pawpaw has again been reported to help in clearing nose congestions[49].

The matured fresh fruits of *Carica papaya* Linn. has been said to have a restorative worth based on its ability to prevent the growth of disease-causing microorganisms. The drink made from the pawpaw plant leaf is said to promote absorption and helps in the cure of diseases like the long-lasting hyperacidity, overweight, arteriosclerosis, increase in blood pressure and ill-performance of the heart[50].

2.10. PHARMACOLOGICAL ACTIVITIES OF CARICA PAPAYA

2.10.1. Anthelmintic Properties:

The latex of *Carica papaya* Linn. was said to have shown anthelmintic activity against Heligmosomoides polygyrus in an experimentally induced mouse, which then suggested its probable use as an anthelmintic agent over powerful gastric nematode that are of human hosts[39]. The plant extracts of *Carica papaya* Linn. is said to possess a quantity relying out-come on the egg, larvae and imago adult worms of Trichostrongylus colubriformis and its Alcoholic fraction tincture showed prospective anti-parasitic action in vitro, which is said to also have a consequential impact on the eggs, larvae and adult of Haemonchus contortus[39].

2.10.2. Antifungi Activities:

Kumar *et al.,* (2013) in a study of the Antifungal activity potential of *Carica papaya* Linn. carried out a study of the plants extract against some pathogenic fungi such as; Aspergillus niger, A. flavus, Candida albicans and Microsporum fulvum. They distinguished a significant addition in the rate of development hinderance of these microbes as the concentration of the extract was increased[51]. Again, in another study, the antifungal capability potential of C. papaya Linn viscous matter tested against Candida albicans was reported. *Carica papaya* Linn. latex sap was observed to hinder the development potential of Candida albicans on addition to a culture of Candida albicans through in the development period[39]. It also established the synergistical action with the combination of C. papaya Linn latex (0.41 mg protein/ml) and fluconazole (2 μg/ml) on the reticence of the development of C. albicans[39].

2.10.3. Antioxidant Activity:

The main group of phytochemical compounds established as a free source of antioxidants and is known to impact the sum of antioxidant activities of plant matter includes; polyphenols, carotenoid and some traditional antioxidant vitamins such as (5R)-[(1S)-1,2-dihydroxyethyl]-3,4-dihydroxyfuran-2(5H)-one and alpha-tocopherol[52]. Several studies have been conducted and it is believed that phenolic combinations are known to be the prominent bioactive phytochemicals to be of health benefit to humans and these combinations were said to be observed as being present in *Carica Papaya* Linn. plant[53].

Mehdipour, et al. (2006) in a relative survey of the antioxidant activity prospects of *Carica papaya* Linn. sap and alpha-tocopherol inquired the toxicity and antioxidant activity potentials of dried *Carica papaya* Linn. juice in vitro and in vivo. The in vitro results of the antioxidant activity of papaya revealed that, the greatest antioxidant activity 80% was noted at concentration of 17.6 mg/ml [54]. In the in vivo studies, it was observed that the levels of blood fatty acids peroxidation were noticeably reduced following the application of some amount of *Carica papaya* Linn. sap (100, 200, 400 mg/kg/day) to 35.5, 39.5 and 40.86% of the control individually, when juxtaposed to the worth of 28.8% for alpha-tocopherol[54]. Also, the sum of antioxidant strength of the blood grew remarkably through the help of

amount of *Carica papaya* Linn. juice (100, 200, 400 mg/kg/day) to 11.11, 23.58 and 23.14% of the control, respectively while the worth for alpha-tocopherol was said to be increased by 18.44%. The findings therefore revealed the haven and anti- oxidative tension activity capacity of *Carica papaya* Linn. sap, which could be commensurable with already known standard antioxidant (Vitamin E) [54].

In 2007, a survey revealed that, the hexane fraction of C. papaya Linn seed homogenate proved to be positively powerful in the slowing down of superoxide initiation and apoptosis in H2-60 cells[55]. Also, in another study in 2009, it was observed that the aqueous fraction of *Carica papaya* Linn. seed extract of unripe but matured fruits showed nephro-protection[56].

2.10.4. Cancer:

Papaya is said to stop the growth of some cancer cells. The fiber released from the fruit binds to the cancer-causing cell and keeps the cancer cell away from the healthy cells why the nutrients from the papaya provides synergistic protection for the cells which is free from radical damage[57]. Men who consume a fruit that is rich in lycopene such as *Carica papaya* Linn., tomatoes and guava are less likely to be infected with prostate cancer compared to individuals who do not consume this food[57].

2.10.5. Antimicrobial activity:

The seed part of papaya plant has been reported for its antimicrobial potency over an anaerobic, flagellated protozoan parasite known to be the causative agent of trichomoniasis. This survey suggested that, employment of *Carica papaya* Linn. seed in the treatment of urinary and genital malfunction such as trichomoniasis with care avoiding harmful effect was successful[58]. In another study, the seed and paste of *Carica papaya* Linn. was reported to have shown bacteriostatic activity over several enteropathogenesis such as Bacillus subtilis, Escherichia coli, Salmonella typhi, Proteus vulgaris, Pseudomonas aeruginosa, Enterobacter cloacae, Klebsiella pneumoniae, etc using agar cup plate method[59]. Yet in another study, the purified extracts obtained from ripe and unripe fruits of *Carica papaya* Linn. also was said to have produced a very remarkable antimicrobial out-put on S. aureus, Bacillus cereus, E. coli, P. aeruginosa and Shigella flexneri[39].

2.10.6. Anticoagulant Effect:

Injection of some of the *Carica papaya* Linn. plant constituent such as papain in an animal like dog, helps to improve the prothrombin and coagulation in the animal by threefold. It has also been said that papain abolish dead tissues in long-standing injuries, burns and ulcers. Papain is said to inclusively be of merchant purpose because of its uses in the brewery, food and textile industries[40].

2.10.7. Anti-Inflammatory Effects:

Protein enzymes contained in papaya plant such as papain and chymopapain, and some vitamins which act as an antioxidant nutrient also established to be present in papaya such as; vitamin C, vitamins E,

and beta-carotene, minimizes the intensity of some of already known medical states like asthma, osteoarthritis, rheumatoid arthritis, etc[40].

2.10.8. Promote Lung Health:

Vitamin, which is essential to the body are gotten from fruits, such as papaya, and has been found to assist in making sure the lung stays healthy and sound. Hence people who smokes or are exposed to a secondary smoke can have a longer life span from eating Carica papaya[40].

2.10.9. Anti-HIV – 1 Activity:

Khaled *et al.*, (2013) in a study to evaluate the Phytochemical and antiHIV-1 activity of Carica papaya Linn. Carried out a study on the polar extracts of the aerial parts of Carica papaya Linn. The methanolic and aqueous fractions of Carica papaya was said to have been used in this study for their activity against HIV-1 and was carried out with the syncytia formation assay. The result of the study showed that, the polar extracts Carica papaya Linn had an out-come as anti-HIV-1 agent, with the tinctures giving an intimation of 5.51 and 7.13 when juxtaposed to the accepted combination used[60].

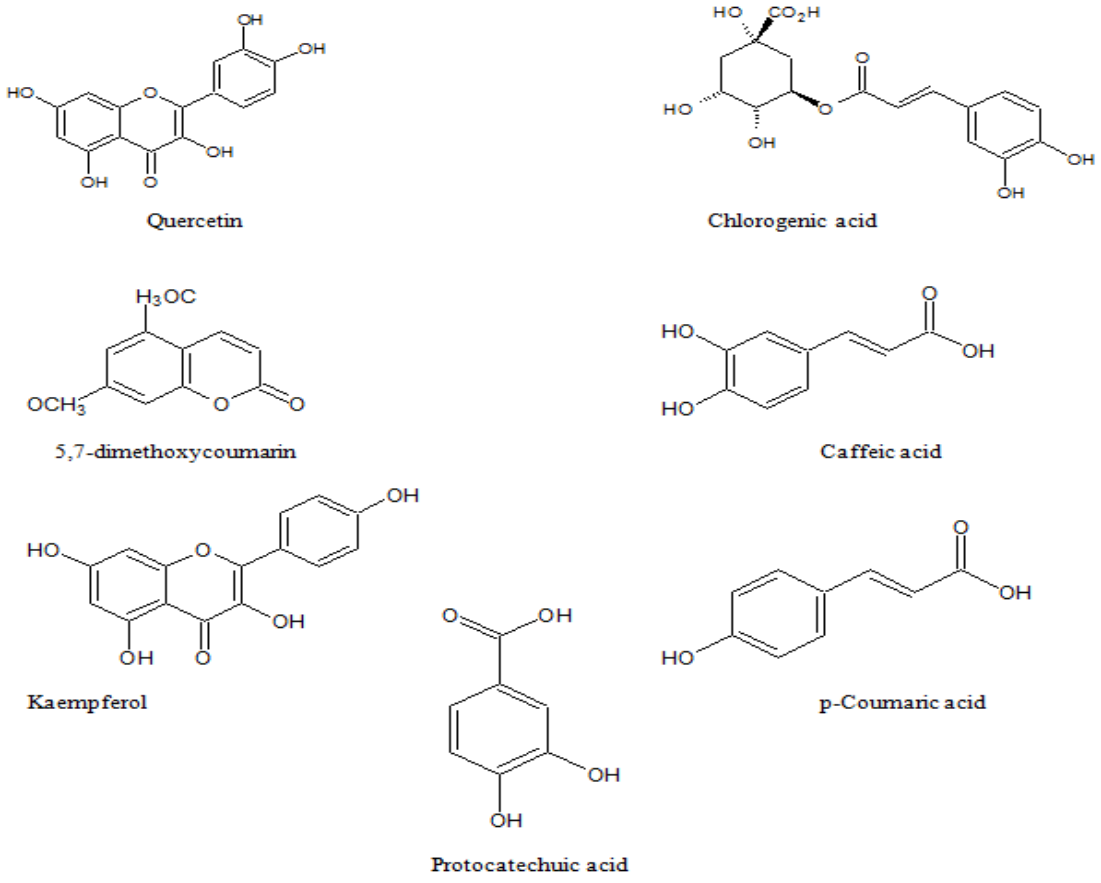

Figure 2. 2 Compounds from *Carica papaya* leaf extract[61].

CONCLUSION

Medicinal plants such as Neem and pawpaw are widely used because of their various medicinal properties. Owing to their versatile characteristics they can be regarded as 'The Village pharmacy' or 'Doctor tree'. Neem is considered as a plant with a more promising feature compared to other plants and thus is believed to eventually benefit everybody on this earth in one way other. Papaya on the other hand is considered as the common man's food which is rich in natural vitamins[41]. An extensive research should be undertaken to further explore more possible pharmacological relevance of neem and papaya for their better economic and therapeutic utilization.

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CHAPTER 3

Manuscript 2

COMPARATIVE PHYTOCHEMICAL CHARACTERIZATION USING GC-MS ANALYSIS OF COA® HERBAL MEDICINE AND TWO OF ITS CONSTITUENT PLANTS; *AZADIRACHTA INDICA* (NEEM) AND *CARICA PAPAYA* LINN. (PAWPAW) FOUND IN GHANA AND SOUTH AFRICA

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Following the extensive literature review in chapter two, a comparative phytochemical characterization was carried out using the COA® herbal medicine and two of its constituent plants (*Azadirachta indica* and *Carica papaya* Linn.) used in its production to determine their phytochemical similarities and differences. A manuscript was written and submitted following the guidelines of the "South African Journal of Chemistry."

CHAPTER THREE: COMPARATIVE PHYTOCHEMICAL CHARACTERIZATION USING GC-MS ANALYSIS OF COA® HERBAL MEDICINE AND TWO OF ITS CONSTITUENT PLANTS; *AZADIRACHTA INDICA* (NEEM) AND *CARICA PAPAYA* LINN. (PAWPAW) FOUND IN GHANA AND SOUTH AFRICA

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Abstract

COA® herbal medicine like every other herbal drug, was manufactured in Ghana and is said to be used for the curative purposes of different ailments. Hence, this present study was carried out to validate that fact by characterizing COA® herbal medicine for the presence of phytochemicals and the chemistry using hexane, ethanol, ethyl acetate and dichloromethane extracts and to compare it with two of its constituent plants *Azadirachta indica* (Neem) and *Carica papaya* Linn. (Pawpaw). COA® herbal medicine, *Azadirachta indica* (Neem) and *Carica papaya* Linn. (Pawpaw) were screened for the presence of alkaloids, anthraquinones, flavonoids, saponins, terpenoids and steroids, tannins, and cardiac glucoside by standard qualitative test procedures and further this study was extended by analyzing the potent bioactive compounds in the hexane, ethanol, ethyl acetate and dichloromethane extract fractions using Gas Chromatography–Mass Spectrometry (GC-MS) analysis while the mass spectra of the compounds found in the extract was matched with the National Institute of Standards and Technology (NIST) library. Results revealed the presence alkaloids, anthraquinones, flavonoids, terpenoids and steroids, saponins, tannins and cardiac glucoside. GC-MS results confirmed the presence of therapeutically potent compounds in COA® herbal medicine with some of them contained in two of its constituent plants and some differences and similarities in both plants with respect to locations.

Keywords: COA®, *Azadirachta indica*, *Carica papaya* Linn., Phytochemicals, GC-MS analysis.

3.1. INTRODUCTION

African traditional medicine (ATM) is the earliest, and conceivably the most multitudinous, of all health-giving systems[1]. Africa is the cushion of humanity with an affluent of biological and ethnic miscellany manifested by territorial dissimilarities in curative practices[1]. ATM make use of natural products and are of great importance. Considering their incomparable chemical diversity and novel mechanisms of action, natural products have continued to play a pivotal role in many drug development and research programs. As a successful example of drug development from natural products, artemisinin and its analogs are presently in wide use for the anti-malaria treatment [2].

Herbal medicine has been comprehensively authorized by the powerfully engaged persons of the orthodox medicines based on their reduced consequential out-come and tariff [3]. It has been gauged that four billion humans which accounts for 80% of total inhabitants of the earth employ herbal physic for some areas of basic health management [3]. Herbal medicine unfortunately has little or no real scientific basis, standardized references, quality control measures, so doctors cannot guide their patients regarding proper usage or potential toxicity [4].

Azadirachta indica (Neem) is known for its medicinal use in the cure of allergenic, dermatic, feedent, fungal, inflammatory, pyorrhoeic, scabic, cardiac and diuretic diseases[5] why *Carica papaya* Linn. (Pawpaw) has been known to possess anthelmintic[6], antioxidant[7], antimicrobial[6] activities amongst others. Drugs made available freely to humanity are thought about to be less harmful and disadvantage free when contrasted to the synthetically manufactured ones.

Centre of Awareness (COA®) herbal medicine is manufactured in Ghana. The COA® herbal medicine has indications that it contains *A. Indica, V. Amygdalina, C. Papaya* Linn.*, S. Mombin, O. Viride (scent leaf) and P. Americana Mill (Avocado),* in which their leaves were fermented, and the process of distillation used to obtain the herbal medicine. The COA® herbal medicine claims to possess anti-diabetic, anti-cancerous, antiviral and antihypertensive activities among others. COA® herbal medicine, have been ordered online by several patients as, immune boosters for human immunodeficiency virus and acquired immunodeficiency syndrome (HIV/AIDS), and as treatments in diabetes mellitus, cancer, high blood pressure [8]. This study tends to characterize COA® herbal medicine and two of its constituent plants *Azadirachta indica* (Neem) and *Carica papaya* Linn. (Pawpaw) cultivated in Cape Coast in Ghana, Durban and Port Shepstone South Africa for the similarities and differences in the presence of phytochemicals and their chemistry.

Available temperature statistics project an averagely warm climatic condition in Ghana. It also revealed that the temperature in all zones in Ghana are rising, and rainfall has been reducing from year to year. Cape coast and other parts of Ghana is said to be experiencing a continual decrease in the amount of

rainfall yearly [9]. Durban in South Africa on the other hand, although known to have a warm weather and clear skies, is thought about to have an average increase in the amount of rain fall every year[10]. Hence there is constant rise in sea water level [10.] Port Shepstone South Africa on the other hand, although known to have a warm weather and clear skies, is thought about to have an average increase in the amount of rain fall every year. Hence there is constant rise in sea water level [10].

Azadirachta indica (Neem) is known to be grown and too often accustomed to the parched regions of the tropics and the subtropics and seems less appropriate to spread in cool temperate areas [11] while *Carica papaya* Linn. (Pawpaw) is a plant that is habitually cultured in tropical parts of the world and springs best in a well-drained, sufficiently aerated and prolific biological matter soil [12].

Climatic change has been known to infer a noticeable effect on the life cycle, distribution and phyto-chemical composition in general of the world's vegetative habitat, which includes the medicinal and aromatic plants. The variation in temperatures and humidity patterns that are associated with this climatic change has its effect on the rate of precipitation and therefore plant's origination, flowering, fruiting, phyto-chemical constituent and in situ competition with other species [13].

3.2. EXPERIMENTALS

3.2.1. Reagents and Equipments: All reagents used were of GC analytical grade. Hexane (Honeywell, Israel), Ethanol Absolute (Merck, South Africa), Dichloromethane (Merck, South Africa), Ethyl acetate (Associated Chemical Enterprise, South Africa), Chloroform (Merck, Germany), Ammonia (Merck, Germany), Glacial Acetic Acid (Merck, Germany), Hydrochloric Acid (Sigma-Aldrich, USA), Acetic Anhydride (Aldrich, New Germany), Tetraoxosulphate vi (Sigma-Aldrich, USA).

Rotatory evaporator (Heidolph, USA), Analytical balance (Radwag Wagi Elektroniczne, Poland), Stirrer (Lasec, China), GC–MS (Perkin Emler, UK), Filter Paper (Macherey-Nagel, Germany).

3.2.2. Plant Collection: Plant materials were collected from cape coast latitude 5°06'52.1" N, longitude 1°17'13.3" W Ghana, latitude 30° 44' 36.4" S, longitude 30° 26' 30.2" E Port Shepstone (for *Carica papaya* Linn.) and Durban botanical garden latitude -29° 50' 28.79" S, longitude 31° 00' 14.40" E South Africa (for *Azadirachta indica*) and authenticated by Prof. Himansu Baijnath from the School of Life Sciences, University of KwaZulu-Natal - Westville Campus. The leaves were picked from the branches and then air dried for 2weeks, after which fine powders of the leaves were obtained using electric blender. These finely powdered leaves were then kept at room temperature for further use.

3.2.3. Preparation of COA® Extracts: 5L of COA® herbal medicine was concentrated using rotatory evaporator and then the concentrated herbal mixture was then serially extracted using solvents of

increasing polarity which includes; hexane, dichloromethane, ethyl acetate and ethanol respectively. 500ml of these solvents where used [14].

3.2.4. Preparation of Plant Extracts: 30g of powdered leaves were weighed for both Ghanaian and South African plant samples of *Azadirachta indica* (Neem) and *Carica Papaya* Linn. (Pawpaw), using an analytical balance and then transferred into a separate round bottom flask. Serial exhaustive extraction method which involves successive extraction with solvents of increasing polarity from a non-polar (hexane) to a more polar solvent (ethanol) under a thorough shaking condition for 6hours to ensure that a wide polarity range of compound could be extracted was used [14]. 500ml each of hexane, dichloromethane, ethyl acetate and ethanol were used for the serial exhaustive extraction. After which, the various extracts were then dried using rotatory evaporator and kept for further studies.

3.2.5. Phytochemical Screening: Ethanol fractions for COA® and plants extracts were used for the preliminary phytochemical screening.

3.2.5.1. Alkaloid test: Extracts of both plants were dissolved individually in dilute Hydrochloric acid and filtered. The filtrates were then put into 3 test tubes (2ml each) for each plant (Ghana and South Africa). One of the test tubes for each plant served as a control, while the other two test tubes where used for Mayer and Wagner test. The same was done for COA®. On addition of these two reagents, a yellowish precipitate for Mayer's reagent and brown/reddish precipitate for Wagner's reagent, indicated the presence of alkaloids [14].

3.2.5.2. Anthraquinones test: Extracts of both plants were reconstituted in a test tube and to a 3ml of the extracts, 3ml of 5% dilute tetraoxosulphate vi was added, boiled in a water bath and then filtered. Filtrate was then shaken with equal volume of chloroform shared into two equal parts and kept standing for 5mins. The lower chloroform layer was then shaken with half of its volume with dilute ammonia. The same was done for COA®. The formation of rose pink to red colour of the ammoniacal layer indicated the presence of anthraquinones [15]

3.2.5.3. Flavonoids test: Extracts of both plants were reconstituted in test tubes (2 for each plant) and to a 2ml of one portion of the extracts for each plant, few drops of sodium hydroxide solution was added. The same was done for COA®. Formation of intense yellow colour which becomes colourless on addition of dilute acid, indicated the presence of flavonoids [14].

3.2.5.4. Saponins test: Extracts of both plants were reconstituted using distilled water and 10ml portion was then shaken in a graduated cylinder for 15 minutes. COA® was made in water so the 10ml portion was taken and shaken for 15 minutes just like the plants. Formation of 1 cm layer of foam indicated the presence of saponins [14].

3.2.5.5. Tannins test: Extracts of both plants were reconstituted and filtered. 2ml of the filtrate for both plants were measured into four test tubes with one from each plant serving as a control. 2ml of $FeCl_3$ was then added to one portion of each plants and the formation of blue-black precipitate indicated the presence of Tannins. The same was done for COA® [16].

3.2.5.6. Terpenoids and Steroids test: Extracts of both plants were reconstituted and treated with chloroform. The solutions were then divided into two test tubes and one of each was used as a control. To these solutions, few drops of acetic anhydride were added, boiled and cooled. Concentrated sulphuric acid was added through the sides of one of the test tubes for each plant. The same was done for COA®. Formation of brown ring at the junction of two layers and the greenish upper layer indicated the presence of triterpenoids and steroids [14].

3.2.5.7. Cardiac Glycoside test: Extracts of both plants were reconstituted and 2ml of each plant was measured and placed inside two test tubes. One of the test tubes served as a control. 3 ml of glacial acetic acid and 1 drop of 5% ferric chloride were added to the other test tube. Carefully 0.5 ml of concentrated sulphuric acid was added by the sides of the test tube. The same was done for COA®. Formation of a green – blue colour in the acetic acid layer indicated the presence of cardiac glycosides [14].

3.2.5.8. GC-MS Analysis: Fractions of the hexane, dichloromethane, ethyl acetate and ethanolic extract of COA® and both plants were used.

Specifications: Analysis by GC–MS using PerkinEmler Gas Chromatography (Clarus 580) equipped with MSD mass spectrometer (Clarus SQ8S) instrument with built–in auto sampler. Column: Elite-5MS (30 m x 0.25 mm id x 0.25 μm). The oven temperature to be programmed from 37 to 320°C at a rate of 18-25°C/min and held for 0.5 and 1.85 mins at 18 and 320 °C, respectively. The injector temperature: 250°C and MS Ion Source temperature: 280°C with full scan and solvent delay of 0–2.30 min. MS Scan Range was m/z 35 – 500 in 0.10 sec. One microliter of the samples was injected in helium (He) carrier gas at split flow of 20 ml/min.

3.3. RESULTS

The results for the qualitative phytochemical screening of the ethanol extracts of COA® herbal medicine and two of its constituent plants from both locations (Ghana and South Africa) are shown in Table 3.1 while the results for the GC-MS of COA® herbal medicine with comparison to two of its constituent plants from both location (Ghana and South Africa), similarities and differences in the phytochemical constituents of two of its constituent plants with regards to location (Ghana and South Africa) showing the presence of specific chemical compounds with their names, retention time, molecular formula and weight are shown in Table 3.2 – 3.19, 4.1 – 4.17 and 5.1 – 5.18 below.

Table 3.1 presents the qualitative phytochemical screening of COA® herbal medicine, *Azadirachta indica and Carica papaya* Linn. in ethanol which showed the presence of alkaloid, anthraquinones, flavonoids, saponins, tannins, terpenoids and steroids and cardiac glucoside.

Table 3. 1: Results of Qualitative Phytochemical Screening

Phytochemical test	COA® Herbal Medicine	*Azadirachta indica* Durban (South Africa)	*Azadirachta indica* Cape Coast (Ghana)	*Carica Papaya* Cape Coast (Ghana)	*Carica Papaya* Port Shepstone (South Africa)
Alkaloid test	+	+	++	+	+
Anthraquinones test	+	+	++	+	+
Flavonoids test	+	+	++	+	+
Saponins test	+	+	++	+	+
Tannins test	+	+	++	+	+
Terpenoids and Steroids test	+	+	++	+	+
Cardiac glucoside test	+	+	++	+	+

Legend: + (present with light colour), ++ (present with thick colour)

Tables 3.2 to 3.6 present the GC-MS results in hexane for COA® herbal medicine and two of its constituent plants from both locations (Ghana and South Africa). Heptadecane, Phytol acetate, l-(+)-Ascorbic acid 2,6-dihexadecanoate, Octadecanoic acid Stigmasta-5,22-dien-3-ol, (3.beta.,22E) and Stigmast-5-en-3-ol, (3.beta.,24S) were some of the major findings.

Table 3. 2: Hexane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – HEXANE					NEEM – HEXANE Retention Time (Mins)		PAWPAW–HEXANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
2.663	Dimethylformamide	1.07	C_3H_7NO	73	–	–	–	–
3.625	4-Hydroxybutanoic acid	0.17	$C_4H_8O_3$	104	–	–	–	–
4.047	m-Hydroxybenzonitrile	0.31	C_7H_5NO	119	–	–	–	–
4.208	Aniline	0.26	C_6H_7N	93	–	–	–	–
4.267	trans-3-Hexenoic Acid	0.65	$C_6H_{10}O_2$	114	–	–	–	–
4.325	2H-Pyran-2,6(3H)-dione	1.66	$C_5H_4O_3$	112	–	–	–	–
4.478	2-Hexenoic acid, (E)-	1.86	$C_6H_{10}O_2$	114	–	–	–	–
4.623	Dehydromevalonic lactone	0.26	$C_6H_8O_2$	112	–	–	–	–
5.718	1-Octadecyne	0.27	$C_{18}H_{34}$	250	–	–	–	–
6.105	Dodecane	0.58	$C_{12}H_{26}$	170	–	–	–	–
7.323	5-Methyltridecane	0.37	$C_{14}H_{30}$	198	–	–	–	–

Table 3. 3: Hexane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – HEXANE CONT'D					NEEM – HEXANE Retention Time (Mins)		PAWPAW–HEXANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
7.685	Tetradecane	1.70	$C_{14}H_{30}$	198	–	–	–	–
8.408	4-Methyltetradecane	0.20	$C_{15}H_{32}$	212	–	–	–	–
8.480	Butylated Hydroxytoluene	1.08	$C_{15}H_{24}O$	220	–	–	–	–
8.765	5-Methyltetradecane	1.56	$C_{15}H_{32}$	212	–	–	–	–
9.098	Hexadecane	1.38	$C_{16}H_{34}$	226	–	–	–	–
9.646	8-Hexylpentadecane	0.54	$C_{21}H_{44}$	296	–	–	–	–
9.955	3-Methylheptadecane	0.40	$C_{18}H_{38}$	254	–	–	–	–
10.157	2-Methylhexadec-1-ene	0.16	$C_{17}H_{34}$	238	–	–	–	–
10.367	Heptadecane	1.03	$C_{17}H_{36}$	240	12.024	–	–	–
10.448	2-methyltetracosane	0.33	$C_{25}H_{52}$	352	–	–	–	–
10.590	Phytol acetate	0.84	$C_{22}H_{42}O_2$	338	10.562	10.583	10.556	10.585

Table 3. 4: Hexane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – HEXANE CONT'D					NEEM – HEXANE Retention Time (Mins)		PAWPAW–HEXANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
10.818	Eicosane	1.04	$C_{20}H_{42}$	282	–	–	–	13.053
11.287	l-(+)-Ascorbic acid 2,6-dihexadecanoate	6.86	$C_{38}H_{68}O_8$	652	–	11.314	–	–
11.637	Methyl 2-bromo-5-methoxybenzoate	0.61	$C_9H_9BrO_3$	244	–	–	–	–
11.988	Trifluoroacetoxy hexadecane	0.49	$C_{18}H_{33}F_3O_2$	338	–	–	–	–
12.102	Pyrene	0.68	$C_{16}H_{10}$	202	–	–	–	12.097
12.282	9-Octadecenal, (Z)-	2.86	$C_{18}H_{34}O$	266	–	–	–	12.250
12.366	Octadecanoic acid	1.68	$C_{18}H_{36}O_2$	284	12.348	12.374	12.345	12.363
12.599	2-Octyl-1-dodecanol	0.83	$C_{20}H_{42}O$	298	–	–	–	–
12.782	Hexadecanoic acid, 2-hydroxyethyl ester	0.16	$C_{18}H_{36}O_3$	300	–	–	–	–
13.056	11-n-Decyltetracosane	0.42	$C_{34}H_{70}$	478	–	–	–	–
13.292	2,4-Dimethyldocosane	1.45	$C_{24}H_{50}$	338	–	–	–	–

Table 3. 5: Hexane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – HEXANE CONT'D					NEEM – HEXANE Retention Time (Mins)		PAWPAW –HEXANE Retention Time(Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
13.532	Tetratetracontane	0.85	$C_{44}H_{90}$	618	–	13.979	13.952	13.980
13.632	Phenol, 2,2'-methylenebis[6-(1,1-dimethylethyl)-4-methyl-	2.53	$C_{23}H_{32}O_2$	340	–	–	–	–
13.787	Hexatriacontane	1.56	$C_{36}H_{74}$	506	–	16.648	–	–
13.983	2-methylhexacosane	0.66	$C_{27}H_{56}$	380	–	–	–	16.030
14.119	2-methyloctacosane	0.23	$C_{29}H_{60}$	408	13.028	–	–	–
14.199	7-Hexyldocosane	0.90	$C_{28}H_{58}$	394	–	–	–	–
14.965	3,3,13,13-Tetraethylpentadecane	0.63	$C_{23}H_{48}$	324	–	–	–	–
15.757	1-Iodohexadecane	1.54	$C_{16}H_{33}I$	352	–	–	–	14.418
16.373	Sulfurous acid, octadecyl 2-propyl ester	0.98	$C_{21}H_{44}O_3S$	376	–	–	–	–
16.540	Cholesta-4,6-dien-3-ol, (3.beta.)	0.77	$C_{27}H_{44}O$	384	–	–	–	–
16.692	5-Methyloctadecane	2.96	$C_{19}H_{40}$	268	–	–	–	–

Table 3. 6: Hexane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – HEXANE CONT'D					NEEM – HEXANE Retention Time (Mins)		PAWPAW – HEXANE Retention Time(Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
17.353	1-Bromo-2-methyldecane	1.50	$C_{11}H_{23}Br$	234	–	–	–	–
17.480	Stigmasta-5,22-dien-3-ol, (3.beta.,22E)	1.01	$C_{29}H_{48}O$	412	17.460	–	17.467	17.483
17.657	6,6-Diethyloctadecane	0.54	$C_{22}H_{46}$	310	–	–	–	–
17.859	Stigmast-5-en-3-ol, (3.beta.,24S)-	1.15	$C_{29}H_{50}O$	414	17.861	17.853	17.861	17.852
18.105	Silane, dimethyl(docosyloxy)butoxy-	0.64	$C_{28}H_{60}O_2Si$	456	–	–	–	–
18.333	1-Bromotriacontane	1.70	$C_{30}H_{61}Br$	500	–	–	–	–
18.473	Testosterone Valerate	0.18	$C_{24}H_{36}O_3$	372	–	–	–	–
19.717	Acetic acid, (2,4-dichlorophenoxy)-, isooctyl ester	4.42	$C_{16}H_{22}Cl_2O_3$	332	–	–	–	–
22.207	Nonahexacontanoic acid	0.45	$C_{69}H_{138}O_2$	998	–	–	–	–
23.233	Octadecyl hexadecanoate	0.97	$C_{34}H_{68}O_2$	508	–	–	–	–

Tables 3.7 and 3.8 present the GC-MS results in ethanol for COA® herbal medicine and two of its constituent plants from both locations (Ghana and South Africa). Phytol acetate, 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, Pentadecanoic acid, Octadecanoic acid, 9-Octadecenamide, (Z) Octadecanamide, Cholesta-4,6-dien-3-ol, (3.beta.) and Stigmast-5-en-3-yl (9Z)-9-octadecenoate were some of the major findings.

Table 3. 7: Ethanol Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHANOL					NEEM – ETHANOL Retention Time (Mins)		PAWPAW – ETHANOL Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
2.530	Triethylamine	2.22	$C_6H_{15}N$	101	–	–	–	–
2.907	Formamide, N,N-dimethyl-	55.04	C_3H_7NO	73	–	–	–	–
3.098	Benzene, chloro-	2.75	C_6H_5Cl	112	–	–	–	3.126
3.752	Butanoic acid, 4-hydroxy-	1.24	$C_4H_8O_3$	104	–	–	–	–
4.088	Isocyanic acid, phenyl ester	0.41	C_7H_5NO	119	–	–	–	–
4.283	Aniline	0.78	C_6H_7N	93	–	–	–	–
10.590	Phytol acetate	1.17	$C_{22}H_{42}O_2$	338	10.602	10.582	10.562	10.581
10.728	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	0.45	$C_{20}H_{40}O$	296	10.744	–	10.703	10.835
11.297	Pentadecanoic acid	4.79	$C_{15}H_{30}O_2$	242	11.354	11.281	11.311	11.282
12.108	Pyrene	1.79	$C_{16}H_{10}$	202	–	–	–	–

Table 3. 8: Ethanol Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHANOL CONT'D					NEEM – ETHANOL Retention Time (Mins)		PAWPAW – ETHANOL Retention Time (Mins)	
Retention Time (Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
12.272	7-Tetradecenal, (Z)-	2.41	$C_{14}H_{26}O$	210	–	–	–	–
12.375	Octadecanoic acid	1.51	$C_{18}H_{36}O_2$	284	12.411	12.359	12.374	12.357
12.500	Hexadecanamide	2.91	$C_{16}H_{33}NO$	255	–	–	–	–
13.400	9-Octadecenamide, (Z)-	17.88	$C_{18}H_{35}NO$	281	–	–	15.185	–
13.505	Octadecanamide	2.50	$C_{18}H_{37}NO$	283	–	15.285	–	–
14.150	Diisooctyl phthalate	0.50	$C_{24}H_{38}O_4$	390	–	–	–	–
16.543	Cholesta-4,6-dien-3-ol, (3.beta.)-	0.40	$C_{27}H_{44}O$	384	–	16.529	–	16.529
16.642	Stigmast-5-en-3-yl (9Z)-9-octadecenoate	0.43	$C_{47}H_{82}O_2$	678	16.658	16.628	–	–
19.882	1,4-Methanoazulen-9-ol, decahydro-1,5,5,8a-tetramethyl-, [1R-(1.alpha.	0.42	$C_{15}H_{26}O$	222	–	–	–	–

Tables 3.9 to 3.14 present the GC-MS results in ethylacetate for COA® herbal medicine and two of its constituent plants from both locations (Ghana and South Africa). Pentadecanoic acid, n-Nonadecanol-1, Octadecanoic acid, Diisooctyl phthalate, 13-Docosenamide, (Z), Stigmasta-5,22-dien-3-ol, (3.beta.,22E), gamma.-Sitosterol were some of the major findings.

Table 3. 9: Ethylacetate Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHYLACETATE					NEEM – ETHYLACETATE Retention Time (Mins)		PAWPAW – ETHYLACETATE Retention Time (Mins)	
Retention Time (Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
2.555	Toluene	0.80	C_7H_8	92	–	–	–	–
2.588	Spiro[2,4]hepta-4,6-diene	1.38	C_7H_8	92	–	–	–	–
2.850	1,3-Octanediol	0.12	$C_8H_{18}O_2$	146	–	–	–	–
3.080	Furfural	0.23	$C_5H_4O_2$	96	–	–	–	–
3.141	Chlorobenzene	12.08	C_6H_5Cl	112	–	–	–	–
3.313	Hexyl chloroformate	0.16	$C_7H_{13}ClO_2$	164	–	–	–	–
4.083	2-Furancarboxaldehyde, 5-methyl-	0.17	$C_6H_6O_2$	110	–	–	–	–
4.485	2-Hexenoic acid, (E)-	0.48	$C_6H_{10}O_2$	114	–	–	–	–
8.808	1-Isopropyl-4,7-dimethyl-1,2-dihydronaphthalene, (S)-	0.23	$C_{15}H_{20}$	200	–	–	–	–
9.197	4,6-Heptadien-2-one, 3,6-dimethyl-3-(1-methylethyl)-, (E)-	0.25	$C_{12}H_{20}O$	180	–	–	–	–

Table 3. 10: Ethylacetate Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHYLACETATE CONT'D					NEEM – ETHYLACETATE Retention Time (Mins)		PAWPAW – ETHYLACETATE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
9.403	Di-epi-alpha.-cedrene-(I)	0.11	$C_{15}H_{24}$	204	–	–	–	–
9.513	1-Naphthalenol, 1,2,3,4,4a,7,8,8a-octahydro-16-dimethyl-4-(1-methylethyl)	0.26	$C_{15}H_{26}O$	222	–	–	–	–
9.610	2-Naphthalenemethanol, decahydro	0.17	$C_{15}H_{26}O$	222	–	–	–	–
9.693	Naphthalene, 1,6-dimethyl-4-(1-methylethyl)-	0.52	$C_{15}H_{18}$	198	–	–	–	–
9.727	Benzene, 1,2,4,5-tetraethyl-	0.82	$C_{14}H_{22}$	190	–	–	–	–
9.892	9-Undecenal, 2,10-dimethyl-	0.45	$C_{13}H_{24}O$	196	–	–	–	–
10.053	Neoclovene oxide	0.17	$C_{15}H_{24}O$	220	–	–	–	–
10.098	1-Cyclohexanone, 2-methyl-2-(3-methyl-2-oxobutyl)	0.81	$C_{12}H_{20}O_2$	196	–	–	–	–
10.238	4-(2-Acetyl-5,5-dimethylcyclopent-2-enylidene)butan-2-one	0.28	$C_{13}H_{18}O_2$	206	–	–	–	–

Table 3. 11: Ethylacetate Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHYLACETATE CONT'D					NEEM – ETHYLACETATE Retention Time (Mins)		PAWPAW – ETHYLACETATE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
10.323	Pentafluoropropionic acid, tridecyl ester	0.15	$C_{16}H_{27}F_5O_2$	346	–	–	–	–
10.390	2-Naphthalenemethanol, 2,3,4,4a,5,6,7,8-octahydro-.alpha	0.48	$C_{15}H_{26}O$	222	–	–	–	–
10.490	7-Oxocholesteryl isocaproate	0.58	$C_{33}H_{54}O_3$	498	–	–	–	–
10.578	(1S,2E,4S,5R,7E,11E)-Cembra-2,7,11-trien-4,5-diol	0.79	$C_{20}H_{34}O_2$	306	–	–	–	–
10.713	3,3,5,5-Tetramethyl-4,5-dihydro-3H-benzo[c]azepine, 2-oxide	0.20	$C_{14}H_{19}NO$	217	–	–	–	–
10.750	Phthalic acid, hexyl 4-trifluoromethoxybenzyl ester	0.23	$C_{22}H_{23}F_3O_5$	424	–	–	–	–
10.925	4,6,10,10-Tetramethyl-5-oxatricyclo[4.4.0.0(1,4)]dec-2-en-7-ol	0.25	$C_{13}H_{20}O_2$	208	–	–	–	–
11.043	3-Heptyn-2-one, 5-cyclopentyl-6-hydroxy-6-methyl-5-(1-methylethyl)	0.28	$C_{16}H_{26}O_2$	250	–	–	–	–

Table 3. 12: Ethylacetate Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHYLACETATE CONT'D					NEEM – ETHYLACETATE Retention Time (Mins)		PAWPAW – ETHYLACETATE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
11.092	Pentadecanoic acid, 14-methyl-, methyl ester	0.40	$C_{17}H_{34}O_2$	270	–	–	–	–
11.307	Pentadecanoic acid	2.62	$C_{15}H_{30}O_2$	242	11.380	–	11.313	–
11.429	Acetamide, 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)-	0.40	$C_{15}H_{22}ClNO_2$	283	–	–	–	–
11.537	3-Buten-2-one, 4-(2-hydroxy-2,6,6-trimethylcyclohexyl)-	0.40	$C_{13}H_{22}O_2$	210	–	–	–	–
11.993	n-Nonadecanol-1	0.12	$C_{19}H_{40}O$	284	12.006	–	–	–
12.033	Tricyclo[3.3.1.1(3,7)]decane, 1-(phenylmethyl)-	0.35	$C_{17}H_{22}$	226	–	–	–	–
12.172	Benzene, 1,1'-(1,3-butadiyne-1,4-diyl)bis	31.43	$C_{16}H_{10}$	202	–	–	–	–
12.267	cis-9-Hexadecenal	4.65	$C_{16}H_{30}O$	238	–	–	–	–

Table 3. 13: Ethylacetate Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHYLACETATE CONT'D					NEEM – ETHYLACETATE Retention Time (Mins)		PAWPAW – ETHYLACETATE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
12.368	Octadecanoic acid	0.59	$C_{18}H_{36}O_2$	284	12.445	12.415	12.369	12.410
12.403	1,4-Ethenoanthracene, 1,4-dihydro-	0.98	$C_{16}H_{12}$	204	–	–	–	–
12.483	Hexadecanamide	0.65	$C_{16}H_{33}NO$	255	–	–	–	–
12.562	Heneicosane	0.30	$C_{21}H_{44}$	296	–	–	–	–
13.303	3-Furan-2-yl-acrylic acid 4-[(2-chloro-benzoyl)-hydrazonomethyl]-phenyl ester	0.44	$C_{21}H_{15}ClN_2O_4$	394	–	–	–	–
13.390	9-Octadecenamide, (Z)-	4.54	$C_{18}H_{35}NO$	281	–	–	–	–
13.492	Octadecanamide	0.44	$C_{18}H_{37}NO$	283	–	–	–	–
13.632	Phenol, 2,2'-methylenebis[6-(1,1-dimethylethyl)-4-methyl-	0.15	$C_{23}H_{32}O_2$	340	–	–	–	–
14.147	Diisooctyl phthalate	0.92	$C_{24}H_{38}O_4$	390	14.168	–	–	–

Table 3. 14: Ethylacetate Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – ETHYLACETATE CONT'D					NEEM – ETHYLACETATE Retention Time (Mins)		PAWPAW – ETHYLACETATE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
15.203	13-Docosenamide, (Z)-	0.13	$C_{22}H_{43}NO$	337	15.238	15.220	15.184	15.221
17.483	Stigmasta-5,22-dien-3-ol, (3.beta.,22E)-	0.18	$C_{29}H_{48}O$	412	17.526	–	17.458	17.486
17.852	gamma.-Sitosterol	0.53	$C_{29}H_{50}O$	414	17.921	17.899	17.841	17.736

Tables 3.15 to 3.19 present the GC-MS results in dichloromethane for COA® herbal medicine and two of its constituent plants from both locations (Ghana and South Africa). 2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl and Heneicosane were some of the major findings.

Table 3. 15: Dichloromethane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – DICHLOROMETHANE					NEEM – DICHLOROMETHANE Retention Time (Mins)		PAWPAW – DICHLOROMETHANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
3.685	cis-2-Penten-1-ol	4.72	$C_5H_{10}O$	86	–	–	–	–
4.025	Butanoic acid	0.23	$C_4H_8O_2$	88	–	–	–	–
4.650	Butanoic acid, 3-methyl-	0.25	$C_5H_{10}O_2$	102	–	–	–	–
4.795	4-Hexen-1-ol, (Z)-	29.19	$C_6H_{12}O$	100	–	–	–	–
4.885	2-Hexen-1-ol, (E)-	4.57	$C_6H_{12}O$	100	–	–	–	–
4.930	Formic acid, hexyl ester	5.86	$C_7H_{14}O_2$	130	–	–	–	–
5.110	Pentanoic acid	0.51	$C_5H_{10}O_2$	102	–	–	–	–
5.175	3-Pentanol, 2-chloro-4-methyl	0.07	$C_6H_{13}ClO$	136	–	–	–	–
5.250	o-Xylene	0.07	C_8H_{10}	106	–	–	–	–
5.365	Ethanol, 2-butoxy-	0.54	$C_6H_{14}O_2$	118	–	–	–	–

Table 3. 16: Dichloromethane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – DICHLOROMETHANE CONT'D					NEEM – DICHLOROMETHANE Retention Time (Mins)		PAWPAW – DICHLOROMETHANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
5.470	Butanoic acid, 4-hydroxy-	0.35	$C_4H_8O_3$	104	–	–	–	–
5.560	Cyclopentane, 1,2,3,4,5-pentamethyl-	0.10	$C_{10}H_{20}$	140	–	–	–	–
5.645	2-Heptanol, acetate	0.18	$C_9H_{18}O_2$	158	–	–	–	–
5.955	1-Heptene, 4-methyl-	0.12	C_8H_{16}	112	–	–	–	–
6.600	2H-Pyran-2,6(3H)-dione	5.61	$C_5H_4O_3$	112	–	–	–	–
6.785	Hexanoic acid	7.77	$C_6H_{12}O_2$	116	–	–	–	–
6.945	3-Hexenoic acid, (E)-	3.16	$C_6H_{10}O_2$	114	–	–	–	–
7.035	Methoxymethylaminoacrylonitryl	1.78	$C_5H_8N_2O$	112	–	–	–	–
7.195	Benzyl alcohol	3.08	C_7H_8O	108	–	–	–	–
7.425	2(3H)-Furanone, 5-ethyldihydro-	8.08	$C_6H_{10}O_2$	114	–	–	–	–

Table 3. 17: Dichloromethane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – DICHLOROMETHANE CONT'D					NEEM – DICHLOROMETHANE Retention Time (Mins)		PAWPAW – DICHLOROMETHANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
7.680	2-Hexenoic acid, (E)-	15.29	$C_6H_{10}O_2$	114	–	–	–	–
7.825	Furyl hydroxymethyl ketone	0.40	$C_6H_6O_3$	126	–	–	–	–
7.915	alpha.-Methyl-.alpha.-[4-methyl-3-pentenyl]oxiranemethanol	0.53	$C_{10}H_{18}O_2$	170	–	–	–	–
7.980	1-Cyclohexyl-2-nitropropane-1,3-diol	1.30	$C_9H_{17}NO_4$	203	–	–	–	–
8.315	4H-Pyran-4-one, 3-hydroxy-2-methyl-	0.20	$C_6H_6O_3$	126	–	–	–	–
8.715	Cyclohexene,4-butyl-	0.37	$C_{10}H_{18}$	138	–	–	–	–
9.060	2H-Pyran-3-ol, 6-ethenyltetrahydro-2,2,6-trimethyl-	0.08	$C_{10}H_{18}O_2$	170	–	–	–	–
9.315	Methyl salicylate	2.65	$C_8H_8O_3$	152	–	–	–	–

Table 3. 18: Dichloromethane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – DICHLOROMETHANE CONT'D					NEEM – DICHLOROMETHANE Retention Time (Mins)		PAWPAW – DICHLOROMETHANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
9.655	Cyclopentan-1-al, 4-isopropylidene-2-methyl-	0.26	$C_{10}H_{16}O$	152	–	–	–	–
9.750	1-Methyl-3-butenyl 3-methyl-3-hydroxybutyl ether	0.08	$C_{10}H_{20}O_2$	172	–	–	–	–
9.790	2-Carene	0.11	$C_{10}H_{16}$	136	–	–	–	–
10.260	7-Octen-3-ol, 2,3,6-trimethyl-	0.07	$C_{11}H_{22}O$	170	–	–	–	–
10.530	Pentadecane	0.11	$C_{15}H_{32}$	212	–	–	–	–
10.760	p-Ethoxybenzyl alcohol	0.12	$C_9H_{12}O_2$	152	–	–	–	–
10.890	2,2'-Bioxepane	0.33	$C_{12}H_{22}O_2$	198	–	–	–	–
11.090	Furan, 2,5-diethyltetrahydro-	0.08	$C_8H_{16}O$	128	–	–	–	–
11.200	3,3,6-Trimethyl-1,5-heptadien-4-ol	0.08	$C_{10}H_{18}O$	154	–	–	–	–
11.675	Tetradecane	0.09	$C_{14}H_{30}$	198	–	–	–	–

Table 3. 19: Dichloromethane Fraction of COA® Comparison between Ghana and South Africa Plants

COA® HERBAL MEDICINE – DICHLOROMETHANE CONT'D					NEEM – DICHLOROMETHANE Retention Time (Mins)		PAWPAW – DICHLOROMETHANE Retention Time (Mins)	
Retention Time(Mins)	Name of Compound	Peak Area (%)	Molecular Formula	Molecular Weight	Ghana	South Africa	Ghana	South Africa
13.255	2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl-	0.07	$C_{11}H_{16}O_2$	180	–	–	–	8.765
13.715	Z-5-Nonadecene	0.13	$C_{19}H_{38}$	266	–	–	–	–
14.200	Epiglobulol	0.14	$C_{15}H_{26}O$	222	–	–	–	–
14.550	1-Naphthalenol, decahydro-1,4a-dimethyl-7-(1-methylethylidene)-, [1R-(1.alpha.,4a.beta.,8a.alpha.)]-	0.13	$C_{15}H_{26}O$	222	–	–	–	–
15.850	Oleyl alcohol, trifluoroacetate	0.08	$C_{20}H_{35}F_3O_2$	364	–	–	–	–
16.460	2-Methyl-5-(2,6,6-trimethyl-cyclohex-1-enyl)-pentane-2,3-diol	0.11	$C_{15}H_{28}O_2$	240	–	–	–	–
17.450	Heneicosane	0.11	$C_{21}H_{44}$	296	–	14.844	–	–
19.340	n-Tetracosanol-1	0.16	$C_{24}H_{50}O$	354	–	–	–	–
21.845	n-Nonadecanol-1	0.27	$C_{19}H_{40}O$	284	–	–	–	–

Tables 4.1 to 4.4 present the GC-MS results in hexane for neem plant from both locations (Ghana and South Africa). l-(+)-Ascorbic acid 2,6-dihexadecanoate, Caryophyllene oxide, Pentadecanal, Pentadecanoic acid, 1-Hexacosene, cis,cis,cis-7,10,13-Hexadecatrienal, Phytol, 9,12,15-Octadecatrienoic acid, (Z,Z,Z), Octadecanoic acid, Dichloroacetic acid, tridec-2-ynyl ester, Palmitic acid .beta.-monoglyceride, Squalene, Hexatriacontane, gamma.-Tocopherol, Vitamin E and gamma.-Sitosterol were some of the major findings.

Table 4. 1: Hexane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – HEXANE EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Toluene	C7H8	92	2.593	0.17	–	–
Butanoic acid, 2-methyl-, ethyl ester	C7H14O2	130	3.105	0.15	–	–
Ethylbenzene	C8H10	106	3.241	0.12	–	–
Benzene, 1,3-dimethyl	C8H10	106	3.310	0.49	–	–
Mesitylene	C9H12	120	4.365	0.17	–	–
2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4	C11H16O2	180	–	–	8.763	0.35
Dodecanoic acid	C12H24O2	200	8.796	0.17	8.809	0.15
Caryophyllene oxide	C15H24O	220	–	–	9.135	0.17
Tetradecanal	C14H28O	212	–	–	9.198	0.17
Pentadecanal	C15H30O	226	–	–	9.856	1.17
Tetradecanoic acid	C14H28O2	228	10.087	0.42	10.099	0.31
9,12,15-Octadecatrien-1-ol, (Z,Z,Z)	C18H32O	264	–	–	10.347	0.16
Phytol, acetate	C22H42O2	338	10.562	1.35	10.583	0.21
2-Hexadecene, 3,7,11,15-tetramethyl-, [R-[R*,R*]	C20H40	280	10.597	0.44	–	–
2-Pentadecanone, 6,10,14-trimethyl-	C18H36O	268	–	–	10.617	1.12
Pentadecanoic acid	C15H30O2	242	11.295	5.13	10.702	0.39
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	C20H40O	296	10.703	0.25	19.250	0.74
3-Eicosene, (E)-	C20H40	280	10.827	0.85	–	–
9,17-Octadecadienal, (Z)	C18H32O	264	–	–	10.912	0.15
1-Hexacosene	C26H52	364	–	–	11.075	0.71
l-(+)-Ascorbic acid 2,6-dihexadecanoate	C38H68O8	652	–	–	11.314	11.21
Hexadecanoic acid, ethyl ester	C18H36O2	284	–	–	11.467	0.25
cis,cis,cis-7,10,13-Hexadecatrienal	C16H26O	234	12.253	2.98	11.719	0.53
9-Octadecen-1-ol, (Z)	C18H36O	268	11.834	0.66	–	–

Table 4. 2: Hexane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – HEXANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
1-Heneicosanol	$C_{21}H_{44}O$	312	11.956	0.41	–	–
gamma.-Dodecalactone	$C_{12}H_{22}O_2$	198	–	–	11.964	0.21
Heptadecane	$C_{17}H_{36}$	240	12.024	0.50	–	–
Tetrahydropyranyl ether of citronellol	$C_{15}H_{28}O_2$	240	–	–	12.063	0.40
Phytol	$C_{20}H_{40}O$	296	12.089	1.33	12.118	4.18
9,12-Octadecadienoic acid (Z,Z)	$C_{18}H_{32}O_2$	280	12.218	1.48	–	–
9,12,15-Octadecatrienoic acid, (Z,Z,Z)	$C_{18}H_{30}O_2$	278	14.855	0.67	12.288	15.43
8,11,14-Eicosatrienoic acid, (Z,Z,Z)	$C_{20}H_{34}O_2$	306	12.305	0.18	–	–
Octadecanoic acid	$C_{18}H_{36}O_2$	284	12.348	0.74	12.374	1.64
Dichloroacetic acid, tridec-2-ynyl ester	$C_{15}H_{24}C_{l2}O_2$	306	12.375	0.17	–	–
Ethyl 9,12,15-octadecatrienoate	$C_{20}H_{34}O_2$	306	–	–	12.405	0.83
Octacosanoic acid, 2,4,6,8-tetramethyl-, methylester	$C_{33}H_{66}O_2$	494	–	–	12.517	0.24
4-Heptadecyne, 1-chloro-	$C_{17}H_{31}Cl$	270	–	–	12.624	0.19
Oxirane, hexadecyl	$C_{18}H_{36}O$	268	12.536	0.20	–	–
2-methyloctacosane	$C_{29}H_{60}$	408	13.028	0.36	–	–
4,8,12,16-Tetramethylheptadecan-4-olide	$C_{21}H_{40}O_2$	324	–	–	13.324	0.24
Eicosanoic acid	$C_{20}H_{40}O_2$	312	13.332	0.15	–	–
9-Octadecenamide, (Z)	$C_{18}H_{35}NO$	281	13.359	0.23	13.381	0.17
5,9,13-Pentadecatrien-2-one, 6,10,14-trimethyl	$C_{18}H_{30}O$	262	13.405	0.16	–	–
2-methyltetracosane	$C_{25}H_{52}$	352	13.955	0.23	–	–
Tetratetracontane	$C_{44}H_{90}$	618	–	–	13.979	0.22
Palmitic acid .beta.-monoglyceride	$C_{19}H_{38}O_4$	330	14.035	1.13	–	–
17-Pentatriacontene	$C_{35}H_{70}$	490	14.817	0.74	–	–
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	–	–	15.199	0.40
Squalene	$C_{30}H_{50}$	410	15.305	6.77	15.321	0.15

Table 4. 3: Hexane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – HEXANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
n-Tetracosanol-1	$C_{24}H_{50}O$	354	15.630	0.40	–	–
Hexatriacontane	$C_{36}H_{74}$	506	–	–	15.648	14.01
1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl-	$C_{30}H_{50}O$	426	15.715	0.38	–	–
Oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)	$C_{30}H_{50}O$	426	15.761	0.31	–	–
delta.-Tocopherol	$C_{27}H_{46}O_2$	402	15.852	2.05	–	–
Cholest-7-en-3-ol, 14-methyl-, (3.beta.)	$C_{28}H_{48}O$	400	16.005	0.62	–	–
beta.-Tocopherol	$C_{28}H_{48}O_2$	416	16.224	0.93	–	–
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.309	4.87	–	–
Heneicosane	$C_{21}H_{44}$	296	16.450	0.55	–	–
Z-12-Pentacosene	$C_{25}H_{50}$	350	16.488	0.48	–	–
2-Pentadecanone	$C_{15}H_{30}O$	226	–	–	16.575	0.78
Octacosanoic acid, methyl ester	$C_{29}H_{58}O_2$	438	–	–	16.622	0.21
Vitamin E	$C_{29}H_{50}O_2$	430	16.695	11.73	–	–
alpha.-Tocopherolquinone	$C_{29}H_{50}O_3$	446	–	–	16.704	1.6
Cholest-8(14)-en-3.alpha.-ol	$C_{27}H_{46}O$	386	16.750	0.26	–	–
9-Octadecenoic acid, 1,2,3-propanetriyl ester	$C_{57}H_{104}O_6$	884	–	–	16.779	0.51
Ergosterol	$C_{28}H_{44}O$	396	17.188	0.54	–	–
Oxirane, heptadecyl-	$C_{19}H_{38}O$	282	–	–	17.204	0.70
Cholest-5-en-3-ol, 24-propylidene-, (3.beta.)	$C_{30}H_{50}O$	426	17.286	1.14	–	–
Stigmasta-5,24(28)-dien-3-ol, (3.beta.)	$C_{29}H_{48}O$	412	–	–	17.303	1.05
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.333	4.54	17.343	0.58
16-Hentriacontanone	$C_{31}H_{62}O$	450	17.405	0.32	–	–
Stigmasterol	$C_{29}H_{48}O$	412	17.460	2.27	–	–

Table 4. 4: Hexane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – HEXANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
2-methylhexacosane	$C_{27}H_{56}$	380	–	–	17.485	6.87
1-Heptacosanol	$C_{27}H_{56}O$	396	17.536	0.48	–	–
9,19-Cyclolanost-23-ene-3,25-diol, 3-acetate	$C_{32}H_{52}O_3$	484	17.616	0.78	–	–
E,E,Z-1,3,12-Nonadecatriene-5,14-diol	$C_{19}H_{34}O_2$	294	–	–	17.779	0.30
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.861	9.73	17.853	4.71
9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate	$C_{32}H_{52}O_2$	468	18.018	0.43	–	–
13,15-Octacosadiyne	$C_{28}H_{50}$	386	18.085	0.67	–	–
Cholest-4-en-3-one	$C_{27}H_{44}O$	384	18.130	0.57	–	–
33-Norgorgosta-5,24(28)-dien-3-ol, (3.beta.)	$C_{29}H_{46}O$	410	18.337	1.29	–	–
9,19-Cyclolanost-24-en-3-ol, (3.beta.)	$C_{30}H_{50}O$	426	18.416	2.13	–	–
2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	$C_{23}H_{32}O$	324	18.481	2.27	–	–
Ursodeoxycholic acid	$C_{24}H_{40}O_4$	392	18.625	0.21	–	–
9,19-Cyclo-9.beta.-lanostane-3.beta.,25-diol	$C_{30}H_{52}O_2$	444	18.668	1.15	–	–
9,19-Cyclolanostan-3-ol, 24-methylene	$C_{31}H_{52}O$	440	18.829	0.53	–	–
Docosyl trifluoroacetate	$C_{24}H_{45}F_3O_2$	422	18.920	1.22	–	–
9,19-Cyclolanost-23-ene-3,25-diol	$C_{30}H_{50}O_2$	442	18.967	0.82	–	–
Oxacyclohexadecan-2-one	$C_{15}H_{28}O_2$	240	19.487	0.39	–	–
10,12,14-Nonacosatriynoic acid	$C_{29}H_{46}O_2$	426	–	–	19.510	0.35
Stigmastane-3,6-dione, (5.alpha.)	$C_{29}H_{48}O_2$	428	20.060	0.67	–	–

Tables 4.5 to 4.8 present the GC-MS results in ethanol for neem plant from both locations (Ghana and South Africa). gamma-Elemene, 3-Eicosene, (E), Phytol acetate, 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, Pentadecanoic acid, Phytol, 9,12,15-Octadecatrienoic acid, (Z,Z,Z), Octadecanoic acid, 13-Docosenamide, (Z), Stigmasterol, Stigmasta-5,22-dien-3-ol, acetate, (3.beta.), gamma.-Sitosterol and 10,12,14-Nonacosatriynoic acid were some of the major findings.

Table 4. 5: Ethanol Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM –ETHANOL EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
3-Mercapto-3-methylbutanol	$C_5H_{12}OS$	120	–	–	2.815	0.45
Formamide, N-methoxy	$C_2H_5NO_2$	75	2.894	0.33	2.884	2.00
Propanoic acid, 2-hydroxy-2-methyl	$C_4H_8O_3$	104	3.558	0.41	–	–
Glycerin	$C_3H_8O_3$	92	4.896	0.78	–	–
Phenol, 2-amino-4-methoxy	$C_7H_9NO_2$	139	–	–	6.399	0.42
2-Decenal, (Z)	$C_{10}H_{18}O$	154	–	–	6.646	0.55
gamma-Elemene	$C_{15}H_{24}$	204	7.997	1.33	–	–
Dodecane, 4-methyl	$C_{13}H_{28}$	184	–	–	8.124	0.56
Dodecanoic acid	$C_{12}H_{24}O_2$	200	8.832	0.27	8.807	0.56
1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)	$C_{15}H_{24}$	204	8.987	1.25	–	–
3-Eicosene, (E)	$C_{20}H_{40}$	280	10.867	1.40	9.046	2.65
Tetradecanal	$C_{14}H_{28}O$	212	–	–	9.858	0.60
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	10.127	0.46	10.099	0.68
Z-5-Nonadecene	$C_{19}H_{38}$	266	–	–	10.322	3.27
Acetic acid, 2-(2,2,6-trimethyl-7-oxa-bicyclo[4.1.0]hept-1-yl)-propenyl ester	$C_{14}H_{22}O_3$	238	10.333	0.38	–	–
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.602	2.94	10.582	0.76
2-Pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268	–	–	10.616	2.03
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	10.744	0.81	–	–
1-Hexacosene	$C_{26}H_{52}$	364	–	–	11.075	9.01
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.354	9.27	11.281	7.50

Table 4. 6: Ethanol Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
1-Nonadecene	$C_{19}H_{38}$	266	–	–	11.478	2.56
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	11.486	0.32	–	–
Bromoacetic acid, decyl ester	$C_{12}H_{23}BrO_2$	278	–	–	11.532	0.40
Arabino-Hex-1-enitol, 1,5-anhydro-2-deoxy	$C_6H_{10}O_4$	146	11.588	0.78	–	–
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	11.879	1.08	–	–
Sulfurous acid, hexyl nonyl ester	$C_{15}H_{32}O_3S$	292	–	–	11.963	3.22
1-Heneicosanol	$C_{21}H_{44}O$	312	11.998	0.42		–
Tetrahydropyranyl ether of citronellol	$C_{15}H_{28}O_2$	240	–	–	12.063	4.12
Cyclopentanone, 2-(5-oxohexyl)	$C_{11}H_{18}O_2$	182	–	–	12.092	0.59
Phytol	$C_{20}H_{40}O$	296	12.143	8.03	–	–
2-Octylcyclopropene-1-heptanol	$C_{18}H_{34}O$	266	–	–	12.248	0.88
9,12,15-Octadecatrienoic acid, (Z,Z,Z)	$C_{18}H_{30}O_2$	278	12.337	13.95	–	–
Octadecanoic acid	$C_{18}H_{36}O_2$	284	12.411	2.40	12.359	1.23
trans-2-Hexadecenoic acid	$C_{16}H_{30}O_2$	254	–	–	12.431	0.86
2-Dodecen-1-yl(-)succinic anhydride	$C_{16}H_{26}O_3$	266	–	–	12.512	2.16
n-Tetracosanol-1	$C_{24}H_{50}O$	354	–	–	12.532	1.93
Trans-3-Hexen-1-ol, tert-butyldimethylsilyl ether	$C_{12}H_{26}OSi$	214	–	–	12.618	0.67
1-Heptacosanol	$C_{27}H_{56}O$	396	17.585	0.34	13.502	1.22
Cycloheptadecanol	$C_{17}H_{34}O$	254	14.003	0.21	–	–
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	14.081	1.02	–	–
Methyl (Z)-5,11,14,17-eicosatetraenoate	$C_{21}H_{34}O_2$	318	14.899	2.03	–	–
Octadecanoic acid, 2,3-dihydroxypropyl ester	$C_{21}H_{42}O_4$	358	14.965	0.33	–	–
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	–	–	15.202	34.53

Table 4. 7: Ethanol Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Octadecanamide	$C_{18}H_{37}NO$	283	–	–	15.285	0.51
Tetratetracontane	$C_{44}H_{90}$	618	15.653	0.21	15.634	0.69
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.345	0.22	–	–
2-methylhexacosane	$C_{27}H_{56}$	380	–	–	16.458	0.67
Octadecane, 1-chloro	$C_{18}H_{37}Cl$	288	16.478	0.71	–	–
Cholesta-4,6-dien-3-ol, (3.beta.)	$C_{27}H_{44}O$	384	–	–	16.529	1.23
Stigmast-5-en-3-ol, oleate	$C_{47}H_{82}O_2$	678	16.658	0.29	16.628	0.50
Vitamin E	$C_{29}H_{50}O_2$	430	16.713	1.35	–	–
1-Phenanthrenecarboxylic acid, 1,2,3,4,4a,9,10,10a-octahydro-1,4a-dimethyl	$C_{17}H_{22}O_2$	258	16.820	0.25	–	–
17-(1,5-Dimethyl-hex-2-enyl)-10,13-dimethyl-2,3,4,9,10,11,12,13,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	$C_{27}H_{42}O$	382	16.898	0.21	–	–
6-Methyl-8-(2,6,6-trimethyl-1-cyclohexenyl)-3,5,7-octatrien-2-one	$C_{18}H_{26}O$	258	17.078	1.75	–	–
Ergosterol	$C_{28}H_{44}O$	396	17.231	0.63	–	–
Pregnenolone	$C_{21}H_{32}O_2$	316	17.309	0.93	–	–
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.372	1.61	–	–
22,23-Dibromostigmasterol acetate	$C_{31}H_{50}Br_2O_2$	612	18.352	0.84	17.469	0.92
Stigmasterol	$C_{29}H_{48}O$	412	17.515	3.36	–	–
Ergosta-7,22-dien-3-ol, (3.beta.,22E)	$C_{28}H_{46}O$	398	17.684	0.28	–	–
Andrographolide	$C_{20}H_{30}O_5$	350	17.785	0.49	–	–
Stigmasta-5,22-dien-3-ol, acetate, (3.beta.)	$C_{31}H_{50}O_2$	454	–	–	17.838	3.53

Table 4. 8: Ethanol Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.899	5.05	–	–
Cholest-5-en-3-ol, 24-propylidene-, (3.beta.)	$C_{30}H_{50}O$	426	17.982	0.85	–	–
3-Oxatricyclo[20.8.0.0(7,16)]triaconta-1(22),7(16),9,13,23,29-hexaene	$C_{29}H_{42}O$	406	18.110	12.88	–	–
Acetic acid, 10,13-dimethyl-17-(1-methyl-4-oxobutyl)-12-oxohexadecahydro-cyclopenta[a]phenanthren-3-yl ester	$C_{26}H_{40}O_4$	416	18.177	0.53	–	–
dl-.alpha.-Tocopherol	$C_{29}H_{50}O_2$	430	18.539	0.84	–	–
17-(1,5-Dimethyl-3-phenylthiohex-4-enyl)-4,4,10,13,14-pentamethyl-2,3,4,5,6,7,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopent	$C_{36}H_{54}OS$	534	18.707	0.26	–	–
Estafiatin	$C_{36}H_{54}OS$	246	18.861	0.39	–	–
9,19-Cyclolanost-24-en-3-ol, acetate, (3.beta.)	$C_{32}H_{52}O_2$	468	19.395	0.18	–	–
10,12,14-Nonacosatriynoic acid	$C_{29}H_{46}O_2$	426	19.639	5.92	–	–
2,2,4-Trimethyl-3-(3,8,12,16-tetramethyl-heptadeca-3,7,11,15-tetraenyl)-cyclohexanol	$C_{30}H_{52}O$	428	19.877	0.68	–	–
1H-Cyclopropa[3,4]benz[1,2-e]azulene-5,7b,9,9a-tetrol, 1a,1b,4,4a,5,7a,8,9-octahydro-3-(hydroxymethyl)-1,1,6,8-tetramethyl-, 9,9a-diacetate	$C_{24}H_{34}O_7$	434	20.308	0.55	–	–
20-Ethynyl-5-pregnen-3,20-diol	$C_{23}H_{34}O_2$	342	20.851	0.88	–	–
Cholesta-8,24-dien-3-ol, (3.beta.,5.alpha.)	$C_{27}H_{44}O$	384	21.420	0.63	–	–
Cyclopropanecarboxylic acid, 1-methyl-, 2,6-bis(1,1-dimethylethyl)-4-methylphenyl ester	$C_{20}H_{30}O_2$	302	22.367	0.21	–	–

Tables 4.9 to 4.12 present the GC-MS results in ethylacetate for neem plant from both locations (Ghana and South Africa). Octadecanoic acid, Pentadecanoic acid, 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, Phytol, 9,12,15-Octadecatrienoic acid, (Z,Z,Z), Squalene, Tetratetracontane, Tricyclo[4.3.0.0(7,9)]nonane, 2,2,5,5,8,8-hexamethy, Stigmast-5-en-3-ol, oleate, Vitamin E. 2-methylhexacosane, Stigmasterol, gamma.-Sitosterol, dl-.alpha.-Tocopherol and 10,12,14-Nonacosatriynoic acid were some of the major findings.

Table 4. 9: Ethylacetate Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHYLACETATE EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Benzene, 1,3-dimethyl	C_8H_{10}	106	3.319	0.34	–	–
Benzene, 1-ethyl-3-methyl	C_9H_{12}	120	4.375	0.24	–	–
Benzene, 1,2,4-trimethyl	C_9H_{12}	120	–	–	4.373	0.16
1,2,3-Propanetriol, 1-acetate	$C_5H_{10}O_4$	134	5.273	0.24	5.237	0.19
1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)	$C_{15}H_{24}$	204	7.996	2.18	–	–
2,6,10-Dodecatriene, 12-acetoxy-6-hydroxymethyl-2,10-dimethyl	$C_{17}H_{28}O_3$	280	8.785	0.20	–	–
Dodecanoic acid	$C_{12}H_{24}O_2$	200	–	–	8.814	0.27
Octadecanoic acid	$C_{18}H_{36}O_2$	284	10.088	4.53	12.415	3.99
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	–	–	10.107	0.34
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.472	0.88	10.583	1.19
2-Hexadecene, 3,7,11,15-tetramethyl	$C_{20}H_{40}$	280	10.515	0.29	–	–
2-Pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268	10.636	0.54	10.615	0.33
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.380	12.36	10.710	10.42
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	10.760	0.52	19.303	1.93
3-Eicosene	$C_{20}H_{40}$	280	–	–	10.851	0.86
n-Heptadecanol-1	$C_{17}H_{36}O$	256	10.873	0.62	–	–
1-Hexacosene	$C_{26}H_{52}$	364	–	–	11.077	0.20
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	–	–	11.468	0.22
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	11.886	0.83	11.863	0.77
1-Heneicosanol	$C_{21}H_{44}O$	312	–	–	11.982	0.41
n-Nonadecanol-1	$C_{19}H_{40}O$	284	12.006	0.34	–	–

Table 4. 10: Ethylacetate Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Phytol	$C_{20}H_{40}O$	296	12.147	4.52	12.123	5.25
9,12,15-Octadecatrienoic acid, (Z,Z,Z)	$C_{18}H_{30}O_2$	278	12.379	19.97	12.353	25.86
3-Methyl-1-dodecyn-3-ol	$C_{13}H_{24}O$	196	12.548	1.49	–	–
Cyclopropanecarboxylic acid, undec-2-enyl ester	$C_{15}H_{26}O_2$	238	12.694	1.99	–	–
7-Hydroxyfarnesen	$C_{15}H_{24}O$	220	13.111	0.32	–	–
Methyl (Z)-5,11,14,17-eicosatetraenoate	$C_{21}H_{34}O_2$	318	13.252	0.48	19.215	0.45
1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl	$C_{30}H_{50}O$	426	13.398	0.48	–	–
Squalene	$C_{30}H_{50}$	410	13.442	0.36	15.335	0.37
Cyclohexaneacetic acid, .alpha.-methyl-.alpha	$C_{13}H_{24}O_2$	212	13.897	0.28	–	–
Hexanoic acid, heptadecyl ester	$C_{23}H_{46}O_2$	354	13.975	0.46	–	–
2-methyloctacosane	$C_{29}H_{60}$	408	–	–	13.989	1.21
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	14.091	0.76	14.074	0.22
Diisooctyl phthalate	$C_{24}H_{38}O_4$	390	14.168	0.21	–	–
Cyclopropane, 1,1-dichloro-2,2,3,3-tetramethyl	$C_7H_{12}Cl_2$	166	14.700	0.26	–	–
Doconexent	$C_{22}H_{32}O_2$	328	–	–	14.749	0.21
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	15.238	1.90	15.220	1.28
Tetratetracontane	$C_{44}H_{90}$	618	15.664	3.11	15.662	7.26
Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy	$C_{30}H_{52}O_2$	444	15.809	0.33	21.287	1.97
Heptacosane, 1-chloro	$C_{27}H_{55}Cl$	414	16.059	0.39	–	–
Tricyclo[4.3.0.0(7,9)]nonane, 2,2,5,5,8,8-hexamethy	$C_{15}H_{26}$	206	–	–	0.20	16.115

Table 4. 11: Ethylacetate Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Pentadecanal	$C_{15}H_{30}O$	226	–	–	16.249	0.17
Cholest-5-en-3-ol (3.beta.)-, tetradecanoate	$C_{41}H_{72}O_2$	596	16.270	0.58	–	–
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.357	0.78	16.343	0.18
Cholesta-4,6-dien-3-ol, (3.beta.)	$C_{27}H_{44}O$	384	16.567	0.42	–	–
Stigmast-5-en-3-ol, oleate	$C_{47}H_{82}O_2$	678	16.673	1.97	–	–
Vitamin E	$C_{29}H_{50}O_2$	430	16.724	1.18	16.715	1.45
9-Octadecenoic acid, 1,2,3-propanetriyl ester	$C_{57}H_{104}O_6$	884	–	–	16.809	0.48
Bufa-20,22-dienolide, 14,15-epoxy-3,5-dihydroxy	$C_{24}H_{32}O_5$	400	17.089	0.45	–	–
Hexadecanal	$C_{16}H_{32}O$	240	17.248	1.23	17.237	0.60
6-Methyl-8-(2,6,6-trimethyl-1-cyclohexenyl)-3,5,7-octatrien-2-one	$C_{18}H_{26}O$	258	17.322	0.59	–	–
Stigmasta-5,24(28)-dien-3-ol, (3.beta.)	$C_{29}H_{48}O$	412	–	–	17.334	1.91
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.383	1.04	–	–
Cholesta-8,24-dien-3-ol, (3.beta.,5.alpha.)	$C_{27}H_{44}O$	384	17.448	0.23	–	–
2-methylhexacosane	$C_{27}H_{56}$	380	18.875	0.35	17.515	3.81
1-Heptacosanol	$C_{27}H_{56}O$	396	–	–	17.590	0.35
Stigmasterol	$C_{29}H_{48}O$	412	17.526	3.38	–	–
2-Nonadecanone	$C_{19}H_{38}O$	282	–	–	17.682	0.36
2,13-Octadecadien-1-ol	$C_{18}H_{34}O$	266	–	–	17.808	0.57
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.921	5.36	17.899	4.70
Cholest-5-en-3-ol, 24-propylidene-, (3.beta.)	$C_{30}H_{50}O$	426	18.002	0.61	17.982	0.34
3-Oxatricyclo[20.8.0.0(7,16)]triaconta-1(22),7(16),9,13,23,29-hexaene	$C_{29}H_{42}O$	406	18.104	4.91	18.055	0.36
22,23-Dibromostigmasterol acetate	$C_{31}H_{50}Br_2O_2$	612	–	–	18.346	0.27

Table 4. 12: Ethylacetate Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
dl-.alpha.-Tocopherol	$C_{29}H_{50}O_2$	430	–	–	18.550	2.57
Cholest-4-en-3-one	$C_{27}H_{44}O$	384	18.808	0.23	–	–
Docosyl heptafluorobutyrate	$C_{26}H_{45}F7O_2$	522	–	–	18.997	0.18
10,12,14-Nonacosatriynoic acid	$C_{29}H_{46}O_2$	426	19.645	2.66	19.597	1.63
2,2,4-Trimethyl-3-(3,8,12,16-tetramethyl-heptadeca-3,7,11,15-tetraenyl)-cyclohexanol	$C_{30}H_{52}O$	428	19.899	0.54	–	–
Androst-5-en-3-one, 17,19-bis(acetyloxy)-4,4-dimethyl	$C_{25}H_{36}O_5$	416	–	–	20.615	0.19
Tetracontane-1,40-diol	$C_{40}H_{82}O_2$	594			21.121	0.57
i-Propyl 9,12,15-octadecatrienoate	$C_{21}H_{36}O_2$	320	21.275	0.24		
17-(1,5-Dimethyl-hex-2-enyl)-10,13-dimethyl-2,3,4,9,10,11,12,13,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	$C_{27}H_{42}O$	382	21.379	1.07	–	–
Cholestan-5-ol-6-one	$C_{27}H_{46}O_2$	402	21.455	0.45	–	–
2-Butenoic acid, 2-methyl-, 1a,2,4,4a,5,9-hexahydro-4,4a,6-trimethyl-3H-oxireno[8,8a]naphtho[2,3-b]furan-5-yl ester	$C_{20}H_{26}O_4$	330	22.659	1.25	22.586	0.31

Tables 4.13 to 4.17 present the GC-MS results in dichloromethane for neem plant from both locations (Ghana and South Africa). Phytol acetate, 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, Pentadecanoic acid, Phytol, Cyclopropaneoctanoic acid, 2-[[2-[(2-ethylcyclopropyl)methyl]cyclopropyl]methyl]-, methyl ester, Octadecanoic acid, 13-Docosenamide, (Z), 9-Octadecenamide, (Z), Squalene, Tetratetracontane, gamma.-Tocopherol, 1-Heptacosanol, Vitamin E, Ergost-5-en-3-ol, (3.beta.), Stigmasterol and gamma.-Sitosterol were some of the major findings.

Table 4. 13: Dichloromethane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – DICHLOROMETHANE EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Prop-2-ynyl (E)-2-methylbut-2-enoate	$C_8H_{10}O_2$	138	–	–	9.268	0.24
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	10.125	0.34	10.104	0.26
2-Hexadecene, 3,7,11,15-tetramethyl	$C_{20}H_{40}$	280	10.560	0.28	–	–
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.604	8.72	10.583	2.30
2-Pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268	–	–	10.618	0.63
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	10.742	3.26	10.726	0.86
n-Heptadecanol-1	$C_{17}H_{36}O$	256	–	–	10.851	2.08
cis,cis,cis-7,10,13-Hexadecatrienal	$C_{16}H_{26}O$	234	12.283	1.57	10.950	0.47
1-Hexacosene	$C_{26}H_{52}$	364	–	–	11.077	0.31
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.321	3.22	11.301	7.64
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	11.484	0.44	–	–
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	11.875	0.94	11.859	1.45
1-Heneicosanol	$C_{21}H_{44}O$	312	11.996	0.51	11.979	1.12
Phytol	$C_{20}H_{40}O$	296	12.130	0.83	12.115	6.28
11,14-Eicosadienoic acid, methyl ester	$C_{21}H_{38}O_2$	322	12.248	0.57	–	–
Cyclopropaneoctanoic acid, 2-[[2-[(2-ethylcyclopropyl)methyl]cyclopropyl]methyl]-, methyl ester	$C_{22}H_{38}O_2$	334	–	–	12.279	13.66
Octadecanoic acid	$C_{18}H_{36}O_2$	284	–	–	12.372	3.02
9,12-Octadecadienoic acid, ethyl ester	$C_{20}H_{36}O_2$	308	12.386	0.84	–	–
Linolenic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{21}H_{36}O_4$	352	12.418	0.37	–	–
(2,2,6-Trimethyl-bicyclo[4.1.0]hept-1-yl)-methanol	$C_{11}H_{20}O$	168	–	–	12.518	0.22

Table 4. 14: Dichloromethane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
cis-9-Hexadecenoic acid, trimethylsilyl ester	$C_{19}H_{38}O_2Si$	326	12.694	0.63	–	–
4,8,12,16-Tetramethylheptadecan-4-olide	$C_{21}H_{40}O_2$	324	–	–	13.329	0.26
1-Naphthalenepropanol,.alpha.-ethyldecahydro-5-(hydroxymethyl)-.alpha.,5,8a-trimethyl-2-methylene	$C_{20}H_{36}O_2$	308	13.523	0.28	–	–
1H-Indene, 1-hexadecyl-2,3-dihydro	$C_{25}H_{42}$	342	–	–	13.947	0.52
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	14.078	1.12	–	–
cis, 6-Octadecenoic acid, trimethylsilyl ester	$C_{21}H_{42}O_2Si$	354	–	–	14.718	0.22
cis-5,8,11-Eicosatrienoic acid, trimethylsilyl ester	$C_{23}H_{42}O_2Si$	378	–	–	14.741	0.25
Heneicosane	$C_{21}H_{44}$	296			14.844	0.53
9-Octadecenal, (Z)	$C_{18}H_{34}O$	266	14.858	1.04	–	–
9,12,15-Octadecatrienoic acid, methyl ester	$C_{19}H_{32}O_2$	292	14.898	0.48	–	–
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	–	–	15.213	8.79
9-Octadecenamide, (Z)	$C_{18}H_{35}NO$	281	15.224	2.53	–	–
Squalene	$C_{30}H_{50}$	410	15.339	1.70	–	–
Tetratetracontane	$C_{44}H_{90}$	618	16.487	0.96	15.646	7.10
5.beta.-Cholan-16,22-epoxy-3.alpha.-ol 24-iodo-3-O-acetyl	$C_{26}H_{41}IO_3$	528	–	–	15.703	0.25
Oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)-, (all-E)	$C_{30}H_{50}O$	426	15.812	0.16	–	–

Table 4. 15: Dichloromethane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl)	$C_{27}H_{46}O_2$	402	15.894	0.66	–	–
Octatriacontyl pentafluoropropionate	$C_{41}H_{77}F_5O_2$	696	16.045	0.41	–	–
Hexadecanal	$C_{16}H_{32}O$	240	–	–	16.238	1.62
beta.-Tocopherol	$C_{28}H_{48}O_2$	416	16.271	0.26	–	–
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.348	1.75	16.335	0.55
1-Heptacosanol	$C_{27}H_{56}O$	396	16.487	15.84	16.518	1.26
Cholesta-4,6-dien-3-ol, (3.beta.)	$C_{27}H_{44}O$	384	–	–	16.547	0.44
2-Nonadecanone	$C_{19}H_{38}O$	282	–	–	16.592	0.40
Stigmast-5-en-3-ol, oleate	$C_{47}H_{82}O_2$	678	–	–	16.649	0.38
alpha.-Tocopheryl acetate	$C_{31}H_{52}O_3$	472	–	–	16.701	0.48
Vitamin E	$C_{29}H_{50}O_2$	430	16.718	4.92	–	–
7-Methyl-Z-tetradecen-1-ol acetate	$C_{17}H_{32}O$	268	–	–	16.799	0.41
2,10-Dodecadien-1-ol, 3,7,11-trimethyl	$C_{15}H_{28}O$	224	–	–	17.018	0.24
cis-1-Chloro-9-octadecene	$C_{18}H_{35}Cl$	286	17.237	0.76	–	–
Stigmasta-5,24(28)-dien-3-ol, (3.beta.)	$C_{29}H_{48}O$	412			17.317	0.81
Fucosterol	$C_{29}H_{48}O$	412	17.332	0.53	–	–
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.376	3.25	17.358	0.50
Heptacosane, 1-chloro	$C_{27}H_{55}Cl$	414	–	–	17.498	4.71
Stigmasterol	$C_{29}H_{48}O$	412	17.513	2.02	–	–
17-Pentatriacontene	$C_{35}H_{70}$	490	–	–	17.578	0.98
Tetracosyl pentafluoropropionate	$C_{27}H_{49}F_5O_2$	500	17.588	2.10	–	–

Table 4. 16: Dichloromethane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Cucurbitacin b, 25-desacetoxy	$C_{30}H_{44}O_6$	500	–	–	17.668	0.60
Ergosta-7,22-dien-3-ol, (3.beta.,22E)	$C_{28}H_{46}O$	398	17.676	0.43	–	–
3,7,11,15-Tetramethylhexadeca-1,3,6,10,14-pentaene	$C_{20}H_{32}$	272	–	–	17.727	0.35
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.904	8.45	17.873	4.62
Methyl 3-hydroxybisnorallocholanate	$C_{23}H_{38}O_3$	362	–	–	17.966	0.51
Cholest-5-en-3-ol, 24-propylidene-, (3.beta.)	$C_{30}H_{50}O$	426	17.985	1.54	–	–
9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate, (3.beta.,4.alpha.,5.alpha.)	$C_{32}H_{52}O_2$	468	18.072	3.19	–	–
1-Octadecanesulphonyl chloride	$C_{18}H_{37}ClO_2S$	352	–	–	18.127	0.32
Cholest-4-en-3-one	$C_{27}H_{44}O$	384	18.183	1.07	–	–
Triacontyl trifluoroacetate	$C_{32}H_{61}F_3O_2$	534	18.232	1.06	–	–
33-Norgorgosta-5,24(28)-dien-3-ol, (3.beta.)	$C_{29}H_{46}O$	410	18.391	0.80	–	–
4-(6,6-Dimethyl-2-methylenecyclohex-3-enylidene)pentan-2-ol	$C_{14}H_{22}O$	206	–	–	18.445	0.47
9,19-Cyclolanost-24-en-3-ol, (3.beta.)	$C_{30}H_{50}O$	426	18.467	0.90	–	–
Oxirane, heptadecyl	$C_{19}H_{38}O$	282	–	–	18.502	3.41
2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl	$C_{23}H_{32}O$	324	18.540	0.76	–	–
9,19-Cyclo-9.beta.-lanostane-3.beta.,25-diol	$C_{30}H_{52}O_2$	444	18.725	0.33		
4-epi-cubedol	$C_{15}H_{26}O$	222	–	–	18.757	0.29
2-Pentadecanone	$C_{15}H_{30}O$	226	19.125	0.43	–	–
3-Oxatricyclo[20.8.0.0(7,16)]triaconta-1(22),7(16),9,13,23,29-hexaene	$C_{29}H_{42}O$	406	19.229	0.80	–	–

Table 4. 17: Dichloromethane Fraction of Neem Plant Comparison between Ghana and South Africa

NEEM – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
2,13-Octadecadien-1-ol	$C_{18}H_{34}O$	266	19.302	0.58	–	–
9,19-Cyclolanost-23-ene-3,25-diol, 3-acetate	$C_{32}H_{52}O_3$	484	19.309	0.84	–	–
Stigmastane-3,6-dione, (5.alpha.)	$C_{29}H_{48}O_2$	428	19.375	0.48	–	–
3,5,9-Trimethyl-deca-2,4,8-trien-1-ol	$C_{13}H_{22}O$	194	–	–	19.568	0.72
l-Alanine, N-(heptafluorobutyryl)-, undec-10-enyl ester	$C_{18}H_{26}F_7NO_3$	437	–	–	–	–
Isoxazolo(2,3-a)pyridine, 2,7-dicarbaldehyde dioxime-2,4,7-trimethyl-perhydro	$C_{12}H_{21}N_3O_3$	255	19.721	0.47	–	–
2,2,4-Trimethyl-3-(3,8,12,16-tetramethyl-heptadeca-3,7,11,15-tetraenyl)-cyclohexanol	$C_{30}H_{52}O$	428	–	–	19.857	0.37
Z-2-Octadecen-1-ol	$C_{18}H_{36}O$	268	–	–	20.250	0.28
Androst-5-en-3-one, 17,19-bis(acetyloxy)-4,4-dimethyl	$C_{25}H_{36}O_5$	416	–	–	20.595	0.67
3.alpha.,5.alpha.-Cyclo-ergosta-7,9(11),22t-triene-6.beta.-ol	$C_{28}H_{42}O$	394	–	–	21.312	1.79
Cholesta-8,24-dien-3-ol, (3.beta.,5.alpha.)	$C_{27}H_{44}O$	384	–	–	21.395	0.98
1,2-Ethanediol, 1,2-dimyrtenyl	$C_{20}H_{30}O_2$	302	–	–	21.662	0.46
Decalin-8a-ol-7-one, 4a,8-dimethyl-2-[2-(t-butyldimethylsilyloxy)-1-methyleneethyl]	$C_{21}H_{38}O_3Si$	366	–	–	21.910	0.72
6-(1,5-Dimethyl-hex-4-enyl)-1,6-dihydroxy-1,8a-dimethyl-3-oxo-1,2,3,3a,5a,6,7,8,8a,9,10,10a-dodecahydrodicyclopenta[a,e]cyclooctene	$C_{25}H_{38}O_4$	402	–	–	22.872	0.36

Tables 5.1 to 5.3 present the GC-MS results in hexane for pawpaw plant from both locations (Ghana and South Africa). Phytol acetate, Pentadecanoic acid, Phytol, 13-Docosenamide, (Z), Squalene, gamma.-Tocopherol, Vitamin E, Ergost-5-en-3-ol, (3.beta.), Stigmasterol, gamma.-Sitosterol, Fucosterol and 9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate were some of the major findings.

Table 5. 1: Hexane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – HEXANE EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl-, (R)	$C_{11}H_{16}O_2$	180	–	–	8.768	0.25
Tetradecyl trifluoroacetate	$C_{16}H_{29}F_3O_2$	310	–	–	10.326	0.25
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.556	0.21	10.585	0.30
2-Pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268	–	–	10.620	0.88
Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	11.061	0.13	–	–
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.290	3.91	11.285	4.54
1-Hexadecanethiol	$C_{16}H_{34}S$	258	–	–	11.475	0.47
trans-Geranylgeraniol	$C_{20}H_{34}O$	290	–	–	11.503	0.32
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	11.862	0.35	–	–
Heptadecane, 2,6,10,15-tetramethyl	$C_{21}H_{44}$	296	12.019	0.99	–	–
Heneicosane	$C_{21}H_{44}$	296	12.531	0.42	12.049	0.53
Pyrene	$C_{16}H_{10}$	202	–	–	12.097	0.63
Phytol	$C_{20}H_{40}O$	296	12.099	0.94	12.136	0.47
9,12-Octadecadienoic acid	$C_{18}H_{32}O_2$	280	–	–	12.223	0.69
cis,cis,cis-7,10,13-Hexadecatrienal	$C_{16}H_{26}O$	234	12.256	4.27	–	–
9-Octadecenal, (Z)	$C_{18}H_{34}O$	266	–	–	12.250	1.93
Octadecanoic acid	$C_{18}H_{36}O_2$	284	12.345	0.78	12.363	0.64
Eicosane	$C_{20}H_{42}$	282	–	–	13.053	0.47
4,8,12,16-Tetramethylheptadecan-4-olide	$C_{21}H_{40}O_2$	324	13.295	0.14	13.325	0.51
9-Octadecenamide, (Z)	$C_{18}H_{35}NO$	281	–	–	13.384	0.26
n-Tetracosanol-1	$C_{24}H_{50}O$	354	–	–	13.502	0.35
Tetratetracontane	$C_{44}H_90$	618	13.952	0.62	13.980	3.15
Hexadecane, 1-iodo	$C_{16}H_{33}I$	352	–	–	14.418	0.29

Table 5. 2: Hexane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – HEXANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	15.179	0.58	15.204	16.33
Squalene	$C_{30}H_{50}$	410	15.302	7.57	15.322	4.22
2,13-Octadecadien-1-ol	$C_{18}H_{34}O$	266	–	–	15.416	0.28
1-Heneicosanol	$C_{21}H_{44}O$	312	–	–	15.678	0.37
1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl	$C_{30}H_{50}O$	426	15.714	0.20	15.740	0.39
Oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)	$C_{30}H_{50}O$	426	15.761	0.17	15.791	0.28
2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl)	$C_{27}H_{46}O_2$	402	15.852	1.57	15.877	0.58
2-methylhexacosane	$C_{27}H_{56}$	380			16.030	1.21
beta.-Tocopherol	$C_{28}H_{48}O_2$	416	16.222	0.60	–	–
Hexadecanal	$C_{16}H_{32}O$	240	–	–	16.228	5.82
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.304	3.84	16.324	1.46
2-Dodecen-1-yl(-)succinic anhydride	$C_{16}H_{26}O_3$	266	16.508	0.25	–	–
Stigmasta-5,22-dien-3-ol, acetate, (3.beta.)	$C_{31}H_{50}O_2$	454	–	–	16.535	0.61
Vitamin E	$C_{29}H_{50}O_2$	430	16.691	12.86	16.686	1.42
Pentadecanal	$C_{15}H_{30}O$	226	17.194	0.47	–	–
Oxirane, heptadecyl	$C_{19}H_{38}O$	282	–	–	17.204	0.61
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.334	5.84	17.344	3.61
Stigmasterol	$C_{29}H_{48}O$	412	17.467	2.44	17.483	2.43
9,19-Cyclolanost-23-ene-3,25-diol, 3-acetate	$C_{32}H_{52}O_3$	484	17.602	1.93	17.631	0.46

Table 5. 3: Hexane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – HEXANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
1H-Indene, octahydro-2,3a,4-trimethyl-2-(1-methylethyl)	$C_{15}H_{28}$	208	17.682	0.43	–	–
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.861	9.47	17.852	12.10
Fucosterol	$C_{29}H_{48}O$	412	17.942	3.44	17.953	1.52
9,19-Cyclolanostan-3-ol, 24-methylene	$C_{31}H_{52}O$	440	18.075	2.02	18.851	2.07
Cholest-4-en-3-one	$C_{27}H_{44}O$	384	18.127	1.30	18.135	0.50
9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate	$C_{32}H_{52}O_2$	468	18.262	7.53	18.265	5.61
33-Norgorgosta-5,24(28)-dien-3-ol, (3.beta.)	$C_{29}H_{46}O$	410	18.349	1.35		
Stigmasta-7,16-dien-3-ol, (3.beta.,5.alpha.)	$C_{29}H_{48}O$	412	–	–	18.351	0.64
9,19-Cyclolanost-24-en-3-ol, (3.beta.)-	$C_{30}H_{50}O$	426	–	–	18.425	1.31
3-(1,1-Dimethylbutyl)-6a,7,10,10a-tetrahydro-6,6,9-trimethyl-6H-dibenzo[b,d]pyran	$C_{22}H_{32}O$	312	–	–	18.546	0.80
1-Heptatriacotanol	$C_{37}H_{76}O$	536	18.477	7.95	19.249	3.34
D:A-Friedoolean-6-ene	$C_{30}H_{50}$	410	18.659	2.29	–	–
Stigmast-4-en-3-one	$C_{29}H_{48}O$	412	18.731	1.24	18.750	2.02
9,19-Cyclolanost-23-ene-3,25-diol, 3-acetate	$C_{32}H_{52}O_3$	484	19.243	2.14	–	–
9,19-Cyclolanost-24-en-3-ol, acetate	$C_{32}H_{52}O_2$	468	19.771	0.22	–	–
9,19-Cyclo-27-norlanostan-25-one, 3-(acetyloxy)-24-methyl	$C_{32}H_{52}O_3$	484	–	–	19.793	0.27
Cholest-4-ene-3,6-dione	$C_{27}H_{42}O_2$	398	–	–	20.005	0.67
Stigmastane-3,6-dione	$C_{29}H_{48}O_2$	428	–	–	20.068	2.27

Tables 5.4 to 5.8 present the GC-MS results in ethanol for pawpaw plant from both locations (Ghana and South Africa). gamma.-Elemene, 3-Eicosene, (E), Pentadecanoic acid, Hexadecanoic acid, ethyl ester, Phytol, Octadecanoic acid, 4,8,12,16-Tetramethylheptadecan-4-olide, 9-Octadecenamide, (Z), Squalene, Tetratetracontane, Vitamin E, Pregnenolone, Ergost-5-en-3-ol, (3.beta.), gamma.-Sitosterol and l-Alanine, N-(heptafluorobutyryl)-, undec-10-enyl ester were some of the major findings.

Table 5. 4: Ethanol Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHANOL EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Hexanal	$C_6H_{12}O$	100	–	–	2.866	0.51
Benzene, chloro	C_6H_5Cl	112	–	–	3.126	1.67
Phenol, 2-amino-4-methoxy	$C_7H_9NO_2$	139	–	–	6.386	0.61
2-Decenal, (Z)-	$C_{10}H_{18}O$	154	–	–	6.642	0.37
1-Tetradecene	$C_{14}H_{28}$	196	–	–	7.624	0.72
Cyclohexane, 1-ethenyl-1-methyl-2,4-bis(1-methylethenyl)	$C_{15}H_{24}$	204	7.671	0.23	–	–
gamma.-Elemene	$C_{15}H_{24}$	204	7.969	3.43	–	–
Nonane, 3-methyl-5-propyl	$C_{13}H_{28}$	184	–	–	8.122	0.53
1,6-Cyclodecadiene, 1-methyl-5-methylene-8-(1-methylethyl)	$C_{15}H_{24}$	204	8.386	0.29	–	–
Phosphoric acid, diethyl octyl ester	$C_{12}H_{27}O_4P$	266			8.655	0.42
1,6,10-Dodecatrien-3-ol, 3,7,11-trimethyl	$C_{15}H_{26}O$	222	8.749	0.24	–	–
Dodecanoic acid	$C_{12}H_{24}O_2$	200	8.794	0.14	–	–
3-Eicosene, (E)	$C_{20}H_{40}$	280	–	–	9.045	1.86
2-Piperidinone, N-[4-bromo-n-butyl]	$C_9H_{16}BrNO$	233	–	–	9.580	0.63
1-(7-Hydroxy-1,6,6-trimethyl-10-oxatricyclo[5.2.1.0(2,4)]dec-9-yl)ethanone	$C_{14}H_{22}O_3$	238	–	–	9.723	0.70
3-Buten-2-ol, 2-methyl-4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]hept-2-yl)	$C_{14}H_{24}O_2$	224	–	–	9.811	0.48
gamma.-Gurjunenepoxide-(1)	$C_{15}H_{24}O$	220	9.813	0.16	–	–
Acetic acid, 5,6-epoxynorbornan-2-yl ester	$C_9H_{12}O_3$	168	–	–	9.906	0.64
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	–	–	10.095	0.78

Table 5. 5: Ethanol Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
9-Isopropyl-1-methyl-2-methylene-5-oxatricyclo[5.4.0.0(3,8)]undecane	$C_{15}H_{24}O$	220	10.315	0.26	–	–
Z-5-Nonadecene	$C_{19}H_{38}$	266	–	–	10.320	3.57
1-(6-Methyl-2-pyrazinyl)-3-methyl-1-butanol	$C_{10}H_{16}N_2O$	180	–	–	10.368	0.54
2-Hexadecene, 3,7,11,15-tetramethyl	$C_{20}H_{40}$	280	10.522	0.16	–	–
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.562	1.51	10.581	0.93
2-Pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268	10.597	0.88	10.615	4.61
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	10.703	0.72	10.835	0.48
2-Butyloxycarbonyloxy-1,1,10-trimethyl-6,9-epidioxydecalin	$C_{18}H_{30}O_5$	326	–	–	11.036	0.48
1-Hexacosene	$C_{26}H_{52}$	364	–	–	11.073	2.49
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.311	8.86	11.282	9.51
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	–	–	11.467	5.86
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	11.835	0.44	–	–
1-Heneicosanol	$C_{21}H_{44}O$	312	11.955	0.17	–	–
10-Methylundecan-4-olide	$C_{12}H_{22}O2$	198	–	–	11.962	1.30
Tetrahydropyranyl ether of citronellol	$C_{15}H_{28}O_2$	240	–	–	12.061	1.26
Benzene, 1,1'-(1,3-butadiyne-1,4-diyl)bis	$C_{16}H_{10}$	202	–	–	12.092	0.66
Phytol	$C_{20}H_{40}O$	296	12.096	5.29	12.118	0.71
E-6-Octadecen-1-ol acetate	$C_{20}H_{38}O_2$	310	–	–	12.213	0.37
8,10-Hexadecadien-1-ol	$C_{16}H_{30}O$	238	–	–	12.245	0.56

Table 5. 6: Ethanol Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Cyclopentanone, 2-(5-oxohexyl)	$C_{11}H_{18}O_2$	182	–	–	12.275	1.28
9,12,15-Octadecatrienoic acid	$C_{18}H_{30}O_2$	278	12.301	18.88	–	–
Octadecanoic acid	$C_{18}H_{36}O_2$	284	12.374	2.99	12.357	1.35
trans-2-Hexadecenoic acid	$C_{16}H_{30}O_2$	254	–	–	12.430	0.66
10,13,13-Trimethyl-11-tetradecen-1-ol acetate	$C_{19}H_{36}O_2$	296	–	–	12.511	4.60
2-methylhexacosane	$C_{27}H_{56}$	380	17.463	5.26	13.047	0.43
4,8,12,16-Tetramethylheptadecan-4-olide	$C_{21}H_{40}O_2$	324	–	–	13.321	1.21
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	–	–	13.376	0.62
n-Tetracosanol-1	$C_{24}H_{50}O$	354	–	–	13.502	1.14
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	14.038	0.50	–	–
9-Hexacosene	$C_{26}H_{52}$	364	–	–	14.393	1.14
2-methyltetracosane	$C_{25}H_{52}$	352	14.819	1.39	–	–
Heptafluorobutyric acid, n-octadecyl ester	$C_{22}H_{37}F_7O_2$	466	–	–	14.842	0.49
9-Octadecenamide, (Z)	$C_{18}H_{35}NO$	281	15.185	1.77	–	–
Squalene	$C_{30}H_{50}$	410	15.301	0.23	–	–
Tetratetracontane	$C_{44}H_{90}$	618	15.626	7.23	–	–
2-Methyl-Z-4-tetradecene	$C_{15}H_{30}$	210	–	–	16.025	0.62
Pentadecanal	$C_{15}H_{30}O$	226	16.210	0.26	–	–
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.304	0.55	–	–
Eicosane	$C_{20}H_{42}$	282	–	–	16.456	0.39
Cholesta-4,6-dien-3-ol, (3.beta.)	$C_{27}H_{44}O$	384	–	–	16.529	1.30
2-Nonadecanol	$C_{19}H_{40}O$	284	16.568	0.55	–	–

Table 5. 7: Ethanol Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Vitamin E	$C_{29}H_{50}O_2$	430	16.669	1.64	–	–
17-(1,5-Dimethyl-hex-2-enyl)-10,13-dimethyl-2,3,4,9,10,11,12,13,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	$C_{27}H_{42}O$	382	16.773	0.44	–	–
2,4,4-Trimethyl-3-(3-oxobutyl)cyclohex-2-enone	$C_{13}H_{20}O_2$	208	16.855	0.24	–	–
Pregnenolone	$C_{21}H_{32}O_2$	316	17.026	1.00	–	–
Hexadecanal	$C_{16}H_{32}O$	240	17.187	3.20	–	–
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.322	1.36	17.332	1.05
Stigmasterol	$C_{29}H_{48}O$	412	–	–	17.465	0.79
1-Heptacosanol	$C_{27}H_{56}O$	396	17.528	0.30	–	–
Cembra-2,7,11-trien-4,5-diol	$C_{20}H_{34}O_2$	306	–	–	17.595	0.63
Oxirane, [(hexadecyloxy)methyl]	$C_{19}H_{38}O_2$	298	17.626	0.50	–	–
26,27-Dinorergosta-5,23-dien-3-ol, (3.beta.)	$C_{26}H_{42}O$	370	17.708	0.22	–	–
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.845	5.47	17.839	5.76
Cholest-5-en-3-ol, 24-propylidene-, (3.beta.)	$C_{30}H_{50}O$	426	17.926	0.50	–	–
3-Oxatricyclo[20.8.0.0(7,16)]triaconta-1(22),7(16),9,13,23,29-hexaene	$C_{29}H_{42}O$	406	18.011	3.41	–	–
2-methyloctacosane	$C_{29}H_{60}$	408	18.077	0.40	–	–
Cholest-4-en-3-one	$C_{27}H_{44}O$	384	–	–	18.131	0.49
2-Methyl-Z-7,8-epoxyhexadecane	$C_{17}H_{34}O$	254	18.168	0.26	–	–
9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate	$C_{32}H_{52}O_2$	468	–	–	18.255	0.58
4,22-Stigmastadiene-3-one	$C_{29}H_{46}O$	410	18.284	0.45	–	–

Table 5. 8: Ethanol Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHANOL EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Stigmasta-3,5-dien-7-one	$C_{29}H_{46}O$	410	–	–	18.465	0.64
Stigmast-4-en-3-one	$C_{29}H_{48}O$	412	–	–	18.736	0.90
9,19-Cyclolanostan-3-ol, 24-methylene-, (3.beta.)	$C_{31}H_{52}O$	440	–	–	18.835	0.46
Acetic acid, chloro-, octadecyl ester	$C_{20}H_{39}ClO_2$	346	–	–	18.981	0.83
30-Norlupan-28-oic acid, 3-hydroxy-21-methoxy-20-oxo-, methyl ester, (3.beta.)	$C_{31}H_{50}O_5$	502	–	–	19.138	0.47
9,19-Cyclolanost-23-ene-3,25-diol, 3-acetate,	$C_{32}H_{52}O_3$	484	–	–	19.236	0.99
Stigmastane-3,6-dione, (5.alpha.)	$C_{29}H_{48}O_2$	428	–	–	19.292	1.29
l-Alanine, N-(heptafluorobutyryl)-, undec-10-enyl ester	$C_{18}H_{26}F_7NO_3$	437	–	–	19.495	2.70
Humulane-1,6-dien-3-ol	$C_{15}H_{26}O$	222	19.511	0.47	–	–
2,2,4-Trimethyl-3-(3,8,12,16-tetramethyl-heptadeca-3,7,11,15-tetraenyl)-cyclohexanol	$C_{30}H_{52}O$	428	19.796	0.52	–	–
Z-2-Octadecen-1-ol	$C_{18}H_{36}O$	268	20.181	0.25	–	–
3-Acetoxy-bisnor-5-cholenic acid	$C_{24}H_{36}O_4$	388	20.759	0.25	–	–
Tetracontane-1,40-diol	$C_{40}H_{82}O_2$	594	21.011	0.36	–	–
Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy	$C_{30}H_{52}O_2$	444	21.170	0.64	–	–
Ergost-25-ene-3,5,6,12-tetrol	$C_{28}H_{48}O_4$	448	21.311	0.46	–	–
2-Butenoic acid, 2-methyl-, 1a,2,4,4a,5,9-hexahydro-4,4a,6-trimethyl-3H-oxireno[8,8a]naphtho[2,3-b]furan-5-yl ester	$C_{20}H_{26}O_4$	330	22.473	0.34	–	–

Tables 5.9 to 5.14 present the GC-MS results in ethylacetate for pawpaw plant from both locations (Ghana and South Africa). Phytol, acetate, Pentadecanoic acid, l-(+)-Ascorbic acid 2,6-dihexadecanoate, Hexadecanoic acid, ethyl ester, Phytol, 9,12,15-Octadecatrienoic acid, (Z,Z,Z), 9,12-Octadecadienoic acid (Z,Z), Octadecanoic acid, 4H-1-Benzopyran-4-one, 2,3-dihydro-5,7-dihydroxy-2-phenyl, Squalene, Vitamin E, Stigmasterol and gamma.-Sitosterol were some of the major findings.

Table 5. 9: Ethylacetate Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHYLACETATE EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Formamide, N-methoxy	$C_2H_5NO_2$	75	2.885	0.24	–	–
2-Pentanone, 4-hydroxy-4-methyl-	$C_6H_{12}O_2$	116	–	–	3.081	0.31
Propanoic acid, 2-hydroxy-2-methyl	$C_4H_8O_3$	104	3.539	0.44	–	–
2-Octene, 2-methyl-6-methylene	$C_{10}H_{18}$	138	–	–	4.843	0.11
Glycerin	$C_3H_8O_3$	92	4.937	0.26	–	–
1,2,3-Propanetriol, 1-acetate	$C_5H_{10}O_4$	134	–	–	5.501	1.78
Benzeneacetic acid, .alpha.-methyl	$C_9H_{10}O_2$	150	–	–	6.990	0.21
cis-Vaccenic acid	$C_{18}H_{34}O_2$	282	–	–	7.327	0.42
gamma.-Elemene	$C_{15}H_{24}$	204	7.966	1.26	–	–
6,6-Dimethyl-10-methylene-1-oxa-spiro[4.5]decane	$C_{12}H_{20}O$	180	–	–	8.377	0.32
4-(2,2,6-Trimethyl-7-oxabicyclo[4.1.0]hept-4-en-1-yl)pent-3-en-2-one	$C_{14}H_{20}O_2$	220	–	–	8.643	0.16
Naphtho[1,2-d]oxazol-2(1H)-one, 1-ethyl-3a,4,5,9b-tetrahydro-3a,5,5,9b-tetramethyl	$C_{17}H_{23}NO_2$	273	–	–	8.726	0.24
Dodecanoic acid	$C_{12}H_{24}O_2$	200	8.797	0.32	–	–
1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)	$C_{15}H_{24}$	204	8.952	1.10	–	–
Methyl-(2-hydoxy-3-ethoxy-benzyl)ether	$C_{10}H_{14}O_3$	182	–	–	9.460	0.20
Podocarp-7-en-3-one, 13.beta.-methyl-13-vinyl	$C_{20}H_{30}O$	286	–	–	9.863	0.23
4-((1E)-3-Hydroxy-1-propenyl)-2-methoxyphenol	$C_{10}H_{12}O_3$	180	–	–	10.056	0.66
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	10.088	0.59	–	–
5-Isopropyl-6-methyl-hepta-3,5-dien-2-ol	$C_{11}H_{20}O$	168	10.292	0.32	–	–

Table 5. 10: Ethylacetate Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Acetic acid, 2-(2,2,6-trimethyl-7-oxa-bicyclo[4.1.0]hept-1-yl)-propenyl ester	$C_{14}H_{22}O_3$	238	–	–	10.323	0.12
Naphthalene, decahydro-1,1,4a-trimethyl-6-methylene-5-(3-methyl-2,4-pentadienyl)	$C_{20}H_{32}$	272	–	–	10.493	0.68
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.562	2.19	10.574	0.59
2-Hexadecene, 3,7,11,15-tetramethyl	$C_{20}H_{40}$	280	10.594	0.73	–	–
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	10.703	0.75	10.823	0.43
1-Phenanthrenecarboxaldehyde, 1,2,3,4,4a,9,10,10a-octahydro-1,4a-dimethyl-7-(1-methylethyl)	$C_{20}H_{28}O$	284	–	–	10.711	1.92
3-Eicosene, (E)	$C_{20}H_{40}$	280	10.825	1.42	–	–
Dodecanoic acid, tetradecyl ester	$C_{26}H_{52}O_2$	396	–	–	11.213	0.68
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.313	10.09	–	–
l-(+)-Ascorbic acid 2,6-dihexadecanoate	$C_{38}H_{68}O_8$	652	–	–	11.370	4.26
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	11.444	0.30	–	–
(Z)6,(Z)9-Pentadecadien-1-ol	$C_{15}H_{28}O$	224	–	–	11.573	0.57
Arabino-Hex-1-enitol, 1,5-anhydro-2-deoxy	$C_6H_{10}O_4$	146	11.553	0.67	–	–
Fumaric acid, decyl 4-heptyl ester	$C_{21}H_{38}O_4$	354	–	–	11.684	1.11
Cyclohexane, 1-ethenyl-1-methyl-2-(1-methylethenyl)-4-(1-methylethylidene)	$C_{15}H_{24}$	204	–	–	11.800	2.00
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	11.835	1.01	–	–
1-Heneicosanol	$C_{21}H_{44}O$	312	11.954	0.38	–	–
Phytol	$C_{20}H_{40}O$	296	12.098	7.13	12.111	0.66
9,12,15-Octadecatrienoic acid, (Z,Z,Z)	$C_{18}H_{30}O_2$	278	12.290	15.68	–	–
9,12-Octadecadienoic acid (Z,Z)	$C_{18}H_{32}O_2$	280	–	–	12.294	3.89

Table 5. 11: Ethylacetate Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Octadecanoic acid	$C_{18}H_{36}O_2$	284	12.369	2.39	12.410	1.79
Eicosanoic acid, ethyl ester	$C_{22}H_{44}O_2$	340	12.502	0.26	–	–
beta.-Pimaric acid	$C_{20}H_{30}O_2$	302	–	–	12.587	5.84
Dehydroabietic acid	$C_{20}H_{28}O_2$	300	–	–	13.014	8.04
4H-1-Benzopyran-4-one, 2,3-dihydro-5,7-dihydroxy-2-phenyl	$C_{15}H_{12}O_4$	256	–	–	13.287	4.40
Eicosanoic acid	$C20H_{40}O_2$	312	13.336	0.36	13.363	1.42
15-Hydroxydehydroabietic acid, methyl ester	$C_{21}H_{30}O_3$	330	–	–	13.485	1.63
1-(Adamanthyl-1)-2-(1-chloro-2,2,3-trimethylcyclopropyl-1)acethylene	$C_{18}H_{25}Cl$	276	–	–	13.623	1.98
Dispirocyclohexane-1',2-(2,3,3a,4,5,6-hexahydrindene-4,4"cyclohexan-2"-one-1-carboxylic acid, 1',1',4',3a,5-pentamethyl100	$C_{26}H_{40}O_3$	400	–	–	13.926	1.73
Cycloheptadecanol	$C_{17}H_{34}O$	254	13.961	0.23	–	–
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	14.039	1.12	14.063	1.32
5,5,12-Trimethyl-10-oxatricyclo[6.3.2.0(1,6)]tridec-6-en-8-ylmethylacetate	$C_{18}H_{28}O_3$	292	–	–	14.193	0.92
Naringenin	$C_{15}H_{12}O_5$	272	–	–	14.406	1.57
9-Octadecenoic acid, 1,2,3-propanetriyl ester	$C_{57}H1_{04}O_6$	884	–	–	14.503	1.64
6-Methyl-8-(2,6,6-trimethyl-1-cyclohexenyl)-3,5,7-octatrien-2-one	$C_{18}H_{26}O$	258	17.029	2.32	14.640	2.31

Table 5. 12: Ethylacetate Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
17-Pentatriacontene	$C_{35}H_{70}$	490	–	–	14.837	3.06
Methyl (Z)-5,11,14,17-eicosatetraenoate	$C_{21}H_{34}O_2$	318	14.859	2.38	–	–
Octadecanoic acid, 2,3-dihydroxypropyl ester	$C_{21}H_{42}O_4$	358	14.928	0.37	–	–
Tetracosanoic acid	$C_{24}H_{48}O_2$	368	–	–	15.133	0.84
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	–	–	15.221	0.86
Squalene	$C_{30}H_{50}$	410	–	–	15.315	2.07
Eicosane	$C_{20}H_{42}$	282	–	–	15.463	0.49
Cholesta-2,8-dien-6-ol, 14-methyl-, acetate,	$C_{30}H_{48}O_2$	440	–	–	15.533	0.40
Tetratetracontane	$C_{44}H_{90}$	618	–	–	15.627	1.34
Oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)	$C_{30}H_{50}O$	426	–	–	15.783	0.57
2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl)	$C_{27}H_{46}O_2$	402	–	–	15.873	0.88
1-Heptatriacotanol	$C_{37}H_{76}O$	536	16.007	0.34	–	–
Octadecane, 1-chloro	$C_{18}H_{37}Cl$	288			16.018	1.25
beta.-Tocopherol	$C_{28}H_{48}O_2$	416	16.222	0.29	–	–
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.300	0.65	16.321	0.99
Kauran-18-al, 17-(acetyloxy)-, (4.beta.)	$C_{22}H_{34}O_3$	346	16.422	0.34	–	–
Cholesta-4,6-dien-3-ol, (3.beta.)	$C_{27}H_{44}O$	384	16.508	0.65	16.524	1.07
Vitamin E	$C_{29}H_{50}O_2$	430	16.666	1.76	16.685	1.07
(-)-Nortrachelogenin	$C_{20}H_{22}O_7$	374	–	–	16.843	1.68
alpha.-Tocopheryl acetate	$C_{31}H_{52}O_3$	472	16.855	0.31	–	–

Table 5. 13: Ethylacetate Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Ergosterol	$C_{28}H_{44}O$	396	17.182	0.77	17.204	0.43
Pregnenolone	$C_{21}H_{32}O_2$	316	17.257	1.06	–	–
Ergost-5-en-3-ol, (3.beta.)-	$C_{28}H_{48}O$	400	17.318	1.44	17.350	1.43
Stigmasterol	$C_{29}H_{48}O$	412	17.458	3.39	17.486	0.70
Tetracosyl trifluoroacetate	$C_{26}H_{49}F_3O_2$	450	–	–	17.573	0.33
5,6-Dihydroergosterol	$C_{28}H_{46}O$	398	17.628	0.36	17.652	0.41
Pregna-5,17(20)-dien-3-ol	$C_{21}H_{32}O$	300	17.723	0.50	–	–
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.841	5.23	17.736	3.82
Cholest-5-en-3-ol, 24-propylidene-, (3.beta.)	$C_{30}H_{50}O$	426	17.922	0.75	–	–
3-Oxatricyclo[20.8.0.0(7,16)]triaconta-1(22),7(16),9,13,23,29-hexaene	$C_{29}H_{42}O$	406	18.048	11.80	–	–
5-(7a-Isopropenyl-4,5-dimethyl-octahydroinden-4-yl)-3-methyl-penta-2,4-dien-1-ol	$C_{20}H_{32}O$	288	18.122	0.49	–	–
Stigmast-4-en-3-one	$C_{29}H_{48}O$	412	–	–	18.171	0.68
Carda-5,20(22)-dienolide, 3-[(6-deoxy-.alpha.-L-mannopyranosyl)oxy]-14-hydroxy-, (3.beta.)	$C_{29}H_{42}O_8$	518	18.182	0.39	–	–
6.beta.-Hydroxymethandienone	$C_{20}H_{28}O_3$	316	18.289	0.63	–	–
9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate	$C_{32}H_{52}O_2$	468	–	–	18.304	1.77
dl-.alpha.-Tocopherol	$C_{29}H_{50}O_2$	430	18.469	1.00	–	–
Stigmasta-3,5-dien-7-one	$C_{29}H_{46}O$	410	–	–	18.528	2.17
9,19-Cyclolanost-23-ene-3,25-diol	$C_{30}H_{50}O_2$	442	18.642	0.24	–	–

Table 5. 14: Ethylacetate Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – ETHYLACETATE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
9,19-Cyclolanostan-3-ol, 24-methylene	$C_{31}H_{52}O$	440	–	–	18.707	0.61
Ethanone, 1-(1,2,3,4,7,7a-hexahydro-1,4,4,5-tetramethyl-1,3a-ethano-3aH-inden-6-yl)	$C_{17}H_{26}O$	246	18.794	0.66	–	–
Tetracosyl pentafluoropropionate	$C_{27}H_{49}F_5O_2$	500	–	–	18.963	0.91
9,19-Cyclolanost-23-ene-3,25-diol	$C_{30}H_{50}O_2$	442	–	–	19.443	0.17
13-Octadecenal, (Z)	$C_{18}H_{34}O$	266	–	–	19.531	0.31
10,12,14-Nonacosatriynoic acid	$C_{29}H_{46}O_2$	426	19.553	4.74	–	–
Triacontyl acetate	$C_{32}H_{64}O_2$	480	–	–	19.531	0.30
2,2,4-Trimethyl-3-(3,8,12,16-tetramethyl-heptadeca-3,7,11,15-tetraenyl)-cyclohexanol	$C_{30}H_{52}O$	428	19.802	0.78	–	–
Stigmastane-3,6-dione	$C_{29}H_{48}O_2$	428	–	–	20.131	0.63
9,19-Cyclolanost-23-ene-3,25-diol, 3-acetate	$C_{32}H_{52}O_3$	484	–	–	20.222	0.51
9,19-Cyclolanost-23-ene-3,25-diol	$C_{30}H_{50}O_2$	442	–	–	20.413	0.08
3-Acetoxy-bisnor-5-cholenic acid	$C_{24}H_{36}O_4$	388	20.762	0.73	–	–
17-(1,5-Dimethyl-hex-2-enyl)-10,13-dimethyl-2,3,4,9,10,11,12,13,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	$C_{27}H_{42}O$	382	21.250	0.52	–	–
2-Butenoic acid, 2-methyl-, 1a,2,4,4a,5,9-hexahydro-4,4a,6-trimethyl-3H-oxireno[8,8a]naphtho[2,3-b]furan-5-yl ester	$C_{20}H_{26}O_4$	330	22.507	1.82	–	–
Ergosta-8(14),15,22-trien-3-ol	$C_{28}H_{44}O$	396	–	–	25.122	0.10

Tables 5.15 to 5.18 present the GC-MS results in dichloromethane for pawpaw plant from both locations (Ghana and South Africa). 1,2,3-Propanetriol, 1-acetate, Phytol, acetate, 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, 3-Eicosene, (E), Pentadecanoic acid, Hexadecanoic acid, ethyl ester, 9-Octadecenal, (Z), 9,12-Octadecadienoic acid, ethyl ester, 13-Docosenamide, (Z), Squalene, 1-Heptacosanol, Vitamin E, Stigmasterol and gamma.-Sitosterol were some of the major findings.

Table 5. 15: Dichloromethane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – DICHLOROMETHANE EXTRACT						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Toluene	C_7H_8	92	2.581	1.23	–	–
1,2,3-Propanetriol, 1-acetate	$C_5H_{10}O_4$	134	–	–	6.440	4.21
1,5,9-Undecatriene, 2,6,10-trimethyl	$C_{14}H_{24}$	192	–	–	8.599	0.23
2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl	$C_{11}H_{16}O_2$	180	–	–	8.765	0.16
Undecanoic acid	$C_{11}H_{22}O_2$	186	–	–	8.806	0.15
Tetradecanoic acid	$C_{14}H_{28}O_2$	228	10.125	0.34	10.088	0.22
Acetic acid, 2-(2,2,6-trimethyl-7-oxa-bicyclo[4.1.0]hept-1-yl)-propenyl ester	$C_{14}H_{22}O_3$	238	–	–	10.294	0.57
2,3-Bis(1-methylallyl)pyrrolidine	$C_{12}H_{21}N$	179	–	–	10.368	0.16
Estran-3-one, 17-(acetyloxy)-2-methyl	$C_{21}H_{32}O_3$	332	–	–	10.480	0.29
2-Hexadecene, 3,7,11,15-tetramethyl	$C_{20}H_{40}$	280	10.560	1.83	10.526	1.02
Phytol, acetate	$C_{22}H_{42}O_2$	338	10.604	8.72	10.566	4.59
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	10.742	3.26	10.708	0.88
3-Eicosene, (E)-	$C_{20}H_{40}$	280	–	–	10.830	2.77
2,6-Octadiene-1,8-diol, 2,6-dimethyl	$C_{10}H_{18}O_2$	170	–	–	11.058	0.28
Pentadecanoic acid	$C_{15}H_{30}O_2$	242	11.321	3.22	11.276	5.01
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	11.484	0.44	11.447	1.13
2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl	$C_{15}H_{26}O$	222	–	–	11.482	0.36
9-Octadecen-1-ol, (Z)	$C_{18}H_{36}O$	268	0.94	0.94	11.838	2.29
Tetradecyl trifluoroacetate	$C_{16}H_{29}F_3O_2$	310	–	–	11.958	1.19
Phytol	$C_{20}H_{40}O$	296	12.130	0.83	12.092	0.83

Table 5. 16: Dichloromethane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
1,E-11,Z-13-Octadecatriene	$C_{18}H_{32}$	248	–	–	12.208	1.41
9-Octadecenal, (Z)-	$C_{18}H_{34}O$	326	14.858	1.04	12.238	4.05
11,14-Eicosadienoic acid, methyl ester	$C_{21}H_{38}O_2$	322	12.248	0.57	–	–
cis,cis,cis-7,10,13-Hexadecatrienal	$C_{16}H_{26}O$	234	12.283	1.57	–	–
9,12-Octadecadienoic acid, ethyl ester	$C_{20}H_{36}O_2$	308	12.386	0.84	12.347	2.01
7-Tetradecenal, (Z)	$C_{14}H_{26}O$	210	–	–	12.379	1.26
Linolenic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{21}H_{36}O_4$	352	12.418	0.37	–	–
Heptadecanoic acid, ethyl ester	$C_{19}H_{38}O_2$	298	–	–	12.501	0.56
cis-9-Hexadecenoic acid, trimethylsilyl ester	$C_{19}H_{38}O_2Si$	326	12.694	0.63	–	–
2,6,10-Dodecatrien-1-ol, 12-acetoxy-2,6,10-trimethyl	$C_{17}H_{28}O_3$	280	–	–	12.819	0.21
2-methyltetracosane	$C_{25}H_{52}$	352	–	–	12.819	0.13
4,8,12,16-Tetramethylheptadecan-4-olide	$C_{21}H_{40}O_2$	324	–	–	13.303	0.49
13-Docosenamide, (Z)	$C_{22}H_{43}NO$	337	–	–	13.365	7.74
5,9,13-Pentadecatrien-2-one, 6,10,14-trimethyl	$C_{18}H_{30}O$	262	–	–	13.408	0.17
Heptadecanal	$C_{17}H_{34}O$	254	–	–	13.656	0.57
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	14.078	1.12	14.040	0.53
Heptadecane	$C_{17}H_{36}$	240	–	–	14.395	0.18
Heneicosyl acetate	$C_{23}H_{46}O_2$	354	–	–	14.432	0.32

Table 5. 17: Dichloromethane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
2,6,10-Dodecatrien-1-al, 12-(acetoxy)-2,6,10-trimethyl	$C_{17}H_{26}O_3$	278	–	–	14.764	0.16
1-Decanol, 2-octyl	$C_{18}H_{38}O$	270	–	–	14.817	1.18
9,12,15-Octadecatrienoic acid, methyl ester	$C_{19}H_{32}O_2$	292	14.898	0.48	–	–
9-Octadecenamide, (Z)	$C_{18}H_{35}NO$	281	15.224	2.53	–	–
Octadecanamide	$C_{18}H_{37}NO$	283	–	–	15.268	0.50
Squalene	$C_{30}H_{50}$	410	15.339	1.70	15.299	0.80
Hexadecanal	$C_{16}H_{32}O$	240	–	–	15.392	0.37
Tetratetracontane	$C_{44}H_{90}$	618	16.487	0.96	15.617	1.83
1-Heptacosanol	$C_{27}H_{56}O$	396	15.671	15.84	16.479	1.52
trans-Geranylgeraniol	$C_{20}H_{34}O$	290	–	–	15.717	0.15
1,6,10,14,18,22-Tetracosahexaen-3-ol, 2,6,10,15,19,23-hexamethyl	$C_{30}H_{50}O$	426	15.758	0.16	–	–
Oxirane, 2,2-dimethyl-3-(3,7,12,16,20-pentamethyl-3,7,11,15,19-heneicosapentaenyl)	$C_{30}H_{50}O$	426	15.812	0.16	–	–
2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl)	$C_{27}H_{46}O_2$	402	–	–	15.852	0.21
Tricosyl acetate	$C_{25}H_{50}O_2$	382	–	–	16.042	0.24
Octatriacontyl pentafluoropropionate	$C_{41}H_{77}F_5O_2$	696	16.045	0.41	–	–
beta.-Tocopherol	$C_{28}H_{48}O_2$	416	16.271	0.26	–	–
gamma.-Tocopherol	$C_{28}H_{48}O_2$	416	16.348	1.75	16.301	0.76
2-Nonadecanone	$C_{19}H_{38}O$	282	–	–	16.548	0.24
Stigmast-5-en-3-ol, oleate	$C_{47}H_{82}O_2$	678	–	–	16.612	0.33

Table 5. 18: Dichloromethane Fraction of Pawpaw Plant Comparison between Ghana and South Africa

PAWPAW – DICHLOROMETHANE EXTRACT CONT'D						
Name of Compound	Molecular Formula	Molecular Weight	Ghana Plant		South Africa Plant	
			Retention Time	Peak Area (%)	Retention Time	Peak Area (%)
Vitamin E	$C_{29}H_{50}O_2$	430	16.718	4.92	16.663	0.46
cis-1-Chloro-9-octadecene	$C_{18}H_{35}Cl$	286	17.237	0.76	–	–
Cholest-5-en-3-ol, 24-propylidene-, (3.beta)	$C_{30}H_{50}O$	426	17.985	1.54	17.268	0.23
Ergost-5-en-3-ol, (3.beta.)	$C_{28}H_{48}O$	400	17.376	3.25	17.313	2.11
Fucosterol	$C_{29}H_{48}O$	412	17.332	0.53	–	–
Stigmasterol	$C_{29}H_{48}O$	412	17.513	2.02	17.452	1.86
Docosyl trifluoroacetate	$C_{24}H_{45}F_3O_2$	422	–	–	17.525	1.31
Tetracosyl pentafluoropropionate	$C_{27}H_{49}F_5O_2$	500	17.588	2.10	–	–
gamma.-Sitosterol	$C_{29}H_{50}O$	414	17.904	8.45	17.830	10.40
Triacontyl trifluoroacetate	$C_{32}H_{61}F_3O_2$	534	18.232	1.06	–	–
9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate	$C_{32}H_{52}O_2$	468	18.232	3.19	18.247	1.54
Cholest-4-en-3-one	$C_{27}H_{44}O$	384	18.805	1.07	18.726	0.99
Tetracosyl trifluoroacetate	$C_{26}H_{49}F_3O_2$	450	–	–	18.920	6.84
l-Alanine, N-(heptafluorobutyryl)-, undec-10-enyl ester	$C_{18}H_{26}F_7NO_3$	437	19.585	6.11	–	–
Triacontyl acetate	$C_{32}H_{64}O_2$	480	–	–	19.759	2.31
Stigmastane-3,6-dione, (5.alpha.)	$C_{29}H_{48}O_2$	428	–	–	20.055	1.10

3.4. DISCUSSION

In the days of old, the significance of herbal shrubs has been unearthed. Prior to then, there happen not to be chemically derived medicines, hence the use of herbal physic for the curative purposes of all ailment was widely employed. Based on this knowledge, is perceived that shrubs are generously endowed with medicinal attributes that are useful to mankind [17]. Orthodox therapeutic substances used for basic medical care necessity, are widely employed by the underdeveloped nations of around 80% of the universe populace and has in recent times, caught the attention of researchers with major rationale been that, chemically derived therapeutic agents which is now widely used by patients are said to possess a lot of adverse effect and leads to some weighty problems [17]. This may have been the reason why a research was carried out in Ghana for herbal remedy to various health diseases and hence gave birth to COA® herbal medicine. A good understanding of the phytochemical ingredient of plants is prudent, not exclusively for the uncovering of biologically active agents, but rather on the basis that, such data could probably be of importance in unveiling new origins of economic materials such as tannins, flavonoids, saponins [18]. Phytochemicals are non-nourishment giving plant chemicals that possess safeguarding or disorder prophylaxis attributes [19]. Diverse phytochemicals have been discovered to own a far-ranging span of task. These phytochemicals are established to possess ventures over unicellular and multicellular organisms [20]. Applications of these phytochemicals includes but not restricted to antibacterial, anti-tuberculosis, anticancer, antihistamine [20].

The out-come of the phytochemical screening of the COA® herbal medicine and two of its constituent plants *Azadirachta indica* (Neem) and *Carica papaya* Linn. (Pawpaw), revealed the presence of some phytochemicals such as; Alkaloids, Anthraquinones, Flavonoids, Saponins, Terpenoids, Steroids, and Cardiac glucoside as shown in Table 3.1. However, varying concentrations of these phytochemicals were noticed among the plants. The colors observed during the screening was thicker and deeper for *Azadirachta indica* (Neem) plant of Ghana when juxtaposed with that of the South African plant and those of COA® herbal medicine and *Carica papaya* Linn. (Pawpaw) plant from Cape Coast Ghana and Port Shepstone South Africa. In previous studies, *Azadirachta indica* (Neem) and *Carica papaya* Linn. (Pawpaw) plant leaf extracts using different solvents such as, ethanol, methanol, hexane, chloroform have been proven to constitute these phytochemicals (alkaloids, flavonoids, saponins, terpenoids and steroids, tannins and cardiac glycosides) which were observed to be present in this study [21-36]. Hence this justifies why COA® herbal medicine having two of its constituent plants to be *Azadirachta indica* (Neem) and *Carica papaya* Linn. (Pawpaw) tested positive for these phytochemicals.

The result of the GC–MS (Table 3.2-3.19) showed that of a truth some of the phytochemical components of the COA® herbal medicine was present in two of the plants it purported to have used in the production of the herbal medicine. These phytochemical constituents that appear to be common to the COA® and the two plants, have similar retention times such as Phyto acetate (Table 3.3),

Octadecanoic acid (Table 3.4), Pentadecanoic acid (Table 3.7), Stigmast-5-en-3-ol (Table 3.6), Stigmast-5,22-dien-3-ol (Table 3.1.6), 13-Docosenamide (Table 3.14), and others shown in the tables above (Table 3.2 – 3.19).

Phyto chemicals have been known to be of medicinal importance to mankind and some of these are evidently present in this COA® herbal medicine such as Octadecanoic acid (Table 3.4) which is employed in the derivation of fatty acids. Another study previously reported this phytochemical compound for its antioxidant, antiandrogenic, anti-inflammatory, antibacterial and antifungal upshot [32]. This study also found the presence of l-(+)-Ascorbic acid-2,6-dihexadecanoate (Table 3.4), known for its intrinsic effect as an Antibacterial, Sperm quality enhancer, anti-inflammatory and Antioxidant [37]. 3,7,11,15-Tetramethyl-2-Hexadecen-1-ol also known for its anticancer, antimicrobial, antiandrogenic, and anti-inflammatory use [37]. Also, 13-Docosenamide (Table 3.14), known for its antimicrobial activity [17], Stigmast-5,22-dien-3-ol (Table 3.6), known to have some intrinsic effect such as anti-hypoglycemic, anticancer, antioxidant and anti-inflammatory effect [20]. All these phytochemicals and many more are seen to be present in the COA® herbal medicine from the GC – MS analysis result and this may therefore justify the claims of COA® herbal medicine for its use as antidiabetic, anticancer, antiviral and antihypertensive activities among others.

Again, from the result of the GC–MS analysis (Table 4.1 – 4.17), indeed there are similarities in the constituents of *Azadirachta indica* (Neem) plants from both locations and allot of disparities. Most of the compounds which were common to both plants, have retention times that are closely related with exception to cis,cis,cis-7,10,13-Hexadecatrienal (Table 4.1), 9,12,15-Octadecatrienoic acid, (Z,Z,Z) (Table 4.2), 1-Heptacosanol (Table 4.6), 22,23-Dibromostigmasterol acetate (Table 4.7), Octadecanoic acid (Table 4.9), Pentadecanoic acid (Table 4.9), 3,7,11,15-Tetramethyl-2-hexadecen-1-ol (Table 4.9), Squalene (Table 4.10), Tricyclo[20.8.0.0(7,16)]triacontane-1(22),7(16)-diepoxy (Table 4.10), cis,cis,cis-7,10,13-Hexadecatrienal (Table 4.13) and Tetratetracontane (Table 4.14). Also, there were noticeable discrepancies in the percentage peak areas of some of the phytochemicals present which were common to both plants. Some of these phytochemicals includes; gamma-Sitosterol (Table 4.11 & 4.16), Ergost-5-en-3-ol, (3.beta.) (Table 4.15), Phytol, acetate (Table 4.5, 4.13), Pentadecanoic acid (Table 4.5, 4.9 & 4.13), Phytol (Table 4.6 & 4.13), Octadecanoic acid (Table 4.6 & 4.9), 9,12,15-Octadecatrienoic acid, (Z,Z,Z) (Table 4.10) etcetera. Disparities in the phytochemical and chemical constituents of both plants are numerous as seen in Table 4.1 – 4.17 and this clearly distinguishes them from each other though they are of the same subfamily but grown in two different locations.

Finally, from the result of the GC–MS analysis (Table 5.1 – 5.18), the *Carica papaya* Linn. (Pawpaw) plants from both locations can be seen to have some similarities in their phytochemical and chemical constituents and allot of disparities. Most of the compounds which are common to both plants, have retention times that are not far from each other. Some of these phytochemicals includes; Phytol (Table

5.1, 5.5 and 5.10) which is known to be a key acyclic diterpene alcohol compound that is a precursor for vitamins E and K_1, and has been reported to possess antimicrobial, anticancer, anti-inflammatory and antidiuretic properties [38], Hexadecanoic acid, ethyl ester which is known to be a palmitic acid, having pharmacological properties of being used as an antioxidant and as a hypocholesterolemia [39], 3,7,11,15-Tetramethyl-2-hexadecen-1-ol (Table 5.15) which have been proven to have a cancer-preventive, antimicrobial and anti-inflammatory activities [33], Octadecanoic acid (Table 5.1, 5.6, 5.11) which is known for its antibacterial and antifungal activities [40] and many others shown in above (Table 5.1 – 5.18).

In the same way, both plants have some phytochemical and chemical properties that differ from each other which could be because of their differences in geographical location from which they were obtained. Some of this includes; 9,12,15-Octadecatrienoic acid, (Z,Z,Z) (Table 5.6, 5.10) which is a Linolenic acid and have been proven to possess anti-inflammatory, insectifuge, hypocholesterolemic, cancer preventive, nematicide, hepatoprotective, antihistaminic, antieczemic, antiacne, 5- alpha reductase inhibitor, antiandrogenic, antiarthritic and anticoronary properties [33], and this was found in the plant gotten from Cape Coast of Ghana. It was one of the most abundant phytochemicals found in the plant with a percentage area of 18.88 and 15.68 (Table 5.6, 5.10), Dehydroabietic acid (Table 5.11) which is a naturally occurring diterpenoid has been proven to possess various pharmacological functions such as; antimicrobial, antiulcer, and cardiovascular activity. It was also suggested to act as an anti-aging reagent because of its ability to prevent lipofuscin accumulation and collagen secretion in human dermal fibroblasts [41] and this was found to be present only in the plant obtained from Port Shepstone, South Africa with a good percentage peak area of 8.04 (Table 5.11) when compared to some other phytochemicals present.

It has been reported that the engrossment of secondary metabolites normally differs from plant to plant affiliated to indistinguishable subfamily [42], this is squarely to countless determinants like territorial diversity, since the out-turn of territorial diversity is immensely scale-contingent on. Also, the immense complexity and diversity of soil, (such as; soil assembly, appearance and deepness, damp continuous possession attributes, air penetration in the soil) fabricate a massive disparity in the type and number of chemical integrals even in the same country [9] how much more, two disparate countries with disparities in climatic conditions. This was greatly observed in the out-come of the GC-MS analysis done on both plants.

CONCLUSION

COA® herbal medicine, based on the results obtained, can be said to be rich in therapeutically potent phytochemical compounds with some of them contained in two of its constituent plants *Azadirata indica* (Neem) and *Carica papaya* Linn. (Pawpaw), therefore showing some similarities with two of its

acclaimed constituent plants. In addition, the retention times of COA® herbal medicine and leaf extracts of the above two plants were also seen to have little variations (Table 3.2-3.19) which could be due to the presence of other compounds in the herbal medicine and hence preferential discharge on the GC-MS stationary phase through the help of the mobile phase used. Differences and similarities in the various phytochemicals present in two of its constituent plants *Azadirata indica* (Neem) (Table 4.1 – 4.17) and *Carica papaya* Linn. (Pawpaw) (Table 5.1 – 5.18) from Ghana and South Africa was also observed. Also, COA® herbal medicine is seen to contain phytochemicals such as terpenoids, steroids that have been known to have anti-cancer, antioxidant activities for the treatment of diseases acclaimed by its producer.

Conflict of Interest

The authors declare no conflict of interest.

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CHAPTER FOUR: SYNTHESIS AND DISCUSSION; SIGNIFICANCE OF FINDINGS

4.1. FINDINGS FROM THE COMPARISON OF COA® HERBAL MEDICINE AND TWO OF ITS CONSTITUENT PLANTS

The embryonic upshot of this study was to investigate the phytochemical make-up of COA® herbal medicine fashioned to be used against various disease conditions peculiar to mankind alongside two of its constituent plants obtained from Cape Coast Ghana, Durban and Port Shepstone South Africa. The outcome of the study revealed the presence of some already known phytochemicals which includes; Alkaloids, Anthraquinones, Flavonoids, Saponins, Terpenoids, Steroids, and Cardiac glycosides with established medicinal and pharmacological activities. These phytochemicals such as tannins, alkaloids, triterpenoids, saponins, and others obtained in this herbal medicine have been known for their various potent activities against bacteria, fungi, cancer, leukemic cell lines, and so many other ailments[1]. Some of these phytochemicals are seen to be common with the two of its constituent plants. These phytochemical constituents that appear to be common to the COA® herbal medicine and the two plants have similar retention times such as Phyto acetate (Table 3.3), Octadecanoic acid (Table 3.4), Pentadecanoic acid (Table 3.7), Stigmast-5-en-3-ol (Table 3.6), Stigmast-5,22-dien-3-ol (Table 3.1.6), 13-Docosenamide (Table 3.14), and others shown in the tables above (Table 3.2 – 3.19).

Many communicable diseases are established to have been managed with herbal medicines throughout the history of mankind[2]. The root of *Inula racemosa* has been employed as folk physic in East Asia and Europe to cure bacterial infirmities[3] and even today, flora substances plays an unrelenting crucial function in basic haleness care as curative solution in innumerable developing nations[4]. To advocate the appropriate utilization and to establish their prospects as originators for modern drugs, it is paramount to investigate the medicinal plants and their derivatives (herbal medicines). Consequently, academias are heightening up their curiosity to herbal medicine to originate superior placebos against numerous ailments[5]. The results of the phytochemical screening and the GC – MS fingerprinting show that the COA® herbal medicine was made from these plants and hence there was no sign of counterfeiting.

4.2. FINDINGS FROM THE COMPARISON OF NEEM PLANTS OBTAINED FROM DIFFERENT LOCATIONS (GHANA AND SOUTH AFRICA)

The literature review on neem in this study, revealed the pharmacological properties of various parts of the plant while the result of the GC-MS of revealed the presence of some

phytochemicals that has been experimentally shown to have these effects that were reported in the literature review of this work. There were a lot of similarities in these phytochemicals since these plants although obtained from different locations, are all the same species[6]. Most of the compounds which were common to both plants from both locations, had retention times that were closely related with exception to cis,cis,cis-7,10,13-Hexadecatrienal (Table 4.2), 9,12,15-Octadecatrienoic acid, (Z,Z,Z) (Table 4.3), 1-Heptacosanol (Table 4.7), 22,23-Dibromostigmasterol acetate (Table 4.8), Octadecanoic acid (Table 4.10), Pentadecanoic acid (Table 4.10), 3,7,11,15-Tetramethyl-2-hexadecen-1-ol (Table 4.10), Squalene (Table 4.11), Tricyclo[20.8.0.0(7,16)]triacontane-1(22),7(16)-diepoxy (Table 4.11), cis,cis,cis-7,10,13-Hexadecatrienal (Table 4.14) and Tetratetracontane (Table 4.15). Also, there were noticeable discrepancies in the percentage peak areas of some of the phytochemicals present which were common to both plants. Some of these phytochemicals includes; gamma.-Sitosterol (Table 4.12 & 4.17), Ergost-5-en-3-ol, (3.beta.) (Table 4.16), Phytol, acetate (Table 4.6, 4.14), Pentadecanoic acid (Table 4.6, 3.10 & 4.14), Phytol (Table 4.7 & 4.14), Octadecanoic acid (Table 4.7 & 4.10), 9,12,15-Octadecatrienoic acid, (Z,Z,Z) (Table 4.11). Disparities in the phytochemical and chemical constituents of both plants are numerous as seen in Table 4.1 – 4.18 and this clearly distinguishes them from each other though they are of the same subfamily but grown in two different locations. Hence this further confirms the possibility for location effect such as climate change or differences, soil structure and texture differences[7].

4.3. FINDINGS FROM THE COMPARISON OF PAWPAW PLANTS OBTAINED FROM DIFFERENT LOCATIONS (GHANA AND SOUTH AFRICA)

From the literature review on pawpaw in this study, the pharmacological importance of this plant was reviewed, and it was shown to possess pharmacologically active phytochemicals which are said to be active on various diseases. The out-come of the preliminary phytochemical screening of this plant showed that it contained alkaloids, anthraquinones, flavonoids, terpenoid and steroids, saponins, tannins and cardiac glucoside. Going further to the GC-MS, it was observed from the result that the two plants from Ghana and South Africa had some phytochemical similarities and some disparities. Some of these phytochemicals which were common to both plants includes but not limited to; Phytol, Hexadecanoic acid, ethyl ester, 3,7,11,15-Tetramethyl-2-hexadecen-1-ol, Octadecanoic acid while 9,12,15-Octadecatrienoic acid, (Z,Z,Z), which were present in the plant from Cape Coast of Ghana only and not in that of Port Shepstone South Africa was noted to be of high abundance with a percentage area of 18.88 and 15.68 (Table 5.7, 5.11). Also, Dehydroabietic acid (Table 5.12) which was present in the plant from Port Shepstone South Africa and absent in that of Cape Coast Ghana was found to be of high abundance when compared to other compound present in the South Africa plant with a percentage peak

area of 8.04. Hence this further confirms the possibility for location effect such as climate change or differences, soil structure and texture differences[7].

GENERAL CONCLUSION

In summary, COA® herbal mixture as evaluated in this study can be said to have a trace of its origin from two of its constituent plants used for this study which was the part of the claims of the producer because it was found to contain some phytochemicals in common with these two plants *Azadirachta indica* (neem) and *Carica papaya* Linn. (pawpaw). It can also be concluded from this study that COA® herbal medicine may be used to cure some of the ailment being claimed by the manufacturer because the analysis showed that it contains some phytochemicals that have being proven over time from various studies to have a curative effect on these diseases that COA® claims to cure.

Finally, from this study, plant extracts from the various locations were seen to exhibit similarities in their phytochemical constituents, closely related retention times and different phytochemicals which could be related to biodiversity of the soil contents and climate present in the different locations of cultivation. Hence if COA® is to be reproduced in South Africa, although it would contain allot of similar compounds like that of Ghana, it would also have its own peculiarities that would distinguish it from that of Ghana because of some different phytochemicals contained in the plants located in South Africa that may not be present in those found in Ghana as shown in this study.

RECOMMENDATIONS

From this study, the following are the possible recommendations

1. Further studies should be carried out comparing the COA® herbal medicine with the remaining four of its acclaimed plants (*Vermonia amygdalina, Persea americana* (Avocado), *Spondias mombin, and Ocimum viride*) used for its production to authenticate or validate the claims of the manufacturer about the six medicinal plants used in producing the herbal medicine.
2. Further studies like *in vivo, in vitro* should also be carried out using this herbal medicine (COA®) to confirm its ability to cure all the acclaimed diseases.
3. Finally, studies should be done on the two plants from South Africa used for this study and probably the six plants at large to determine the various percentage contents of the different phytochemicals present in them and to help ascertain the probable use of these plants to produce COA® herbal medicine here in South Africa so as to reduce cost of purchase of this herbal medicine and hence make it readily available for use in large quantities here in South Africa.

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APPENDIX

Appendix 1: Ethics Exemption

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI
RESEARCH OFFICE
BIOMEDICAL RESEARCH ETHICS ADMINISTRATION
Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 260-4609
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

12 October 2018

Mr B Akwasi (218069763)
Mr J Nwabuife (218084368)
School of Health Sciences
College of Health Sciences
Concordford14@gmail.com

Dear Mr B Akwasi

Protocol: A comparative chemistry of coal herbal medicine and herbal extracts of vermonia amygdaline (bitter leaf), Persea Americana (Avocado) Azardirachta indica (Neem) and Carica papaya (Pawpaw).
Degree: MSc
BREC REF: EXM612/18

I refer to your application to BREC received on 05 October 2018 and wish to advise you that exemption of ethics review has been granted for this study.

This exemption will be **noted** at the next Biomedical Research Ethics Committee meeting to be held on **13 November 2018.**

[redacted]

Prof V Rambiritch
Chair: Biomedical Research Ethics Committee

Supervisor: Nlooto@ukzn.ac.za
Co Supervisor: Dr R Kaarpomath
Postgrad admin: Nenep1@ukzn.ac.za

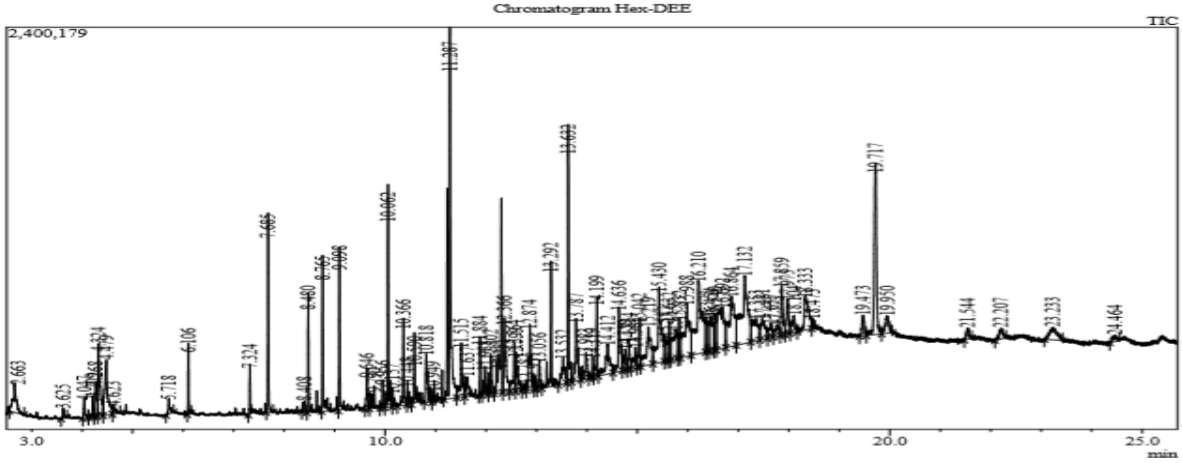
Appendix 2: GC – MS Finger print of the hexane fraction of COA® herbal mixture.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 12:14:05 AM
Sample Type	: Unknown
Sample Name	: Hex-DEE
Sample ID	: AJ
Vial #	: 78
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt

Chromatogram Hex-DEE



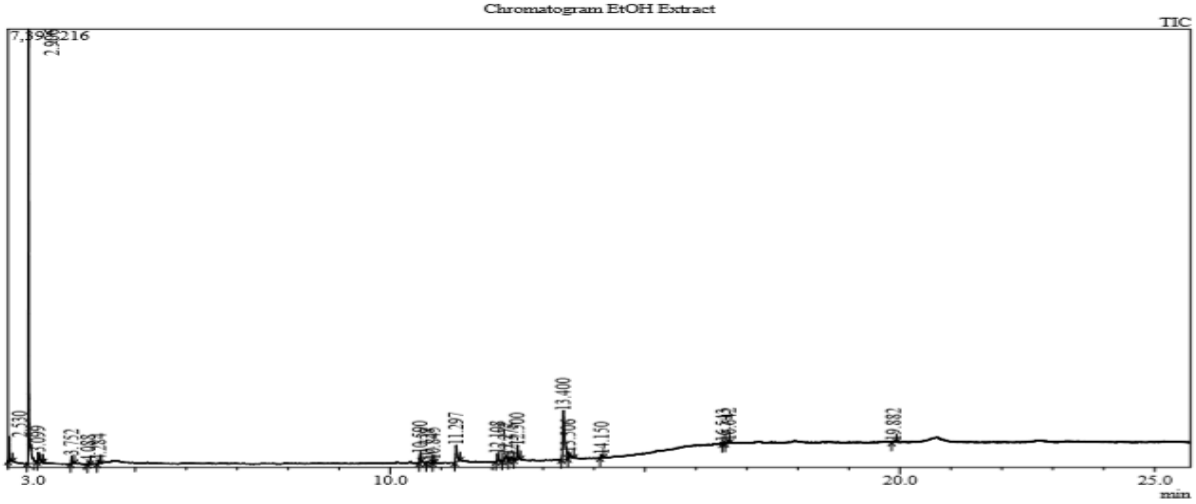
Appendix 3: GC – MS Fingerprint of the ethanol fraction of COA® herbal mixture.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 12:50:08 AM
Sample Type	: Unknown
Sample Name	: EtOH Extract
Sample ID	: AJ
Vial #	: 79
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt

Chromatogram EtOH Extract

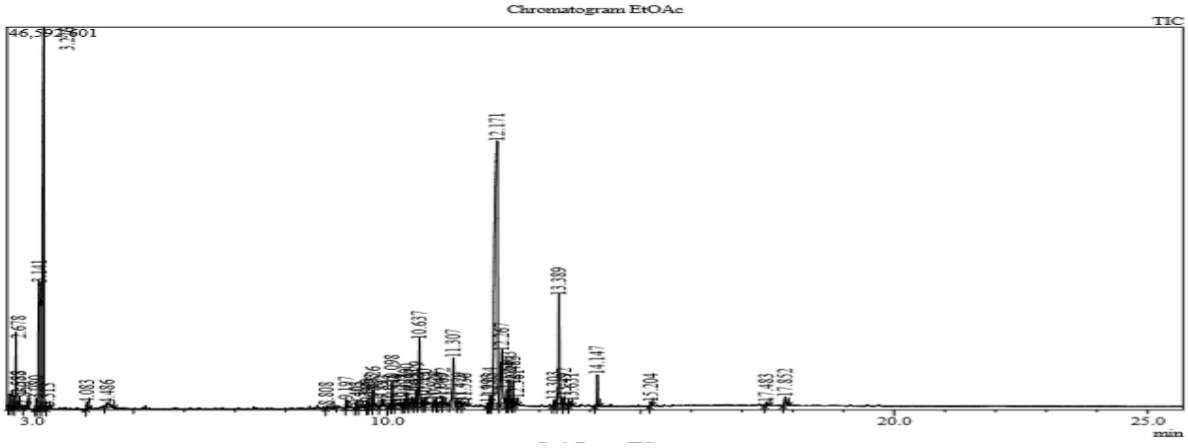


Appendix 4: GC – MS Fingerprint of the ethylacetate fraction of COA® herbal mixture.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 1:26:30 AM
Sample Type	: Unknown
Sample Name	: EtOAc
Sample ID	: AJ
Vial #	: 80
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt

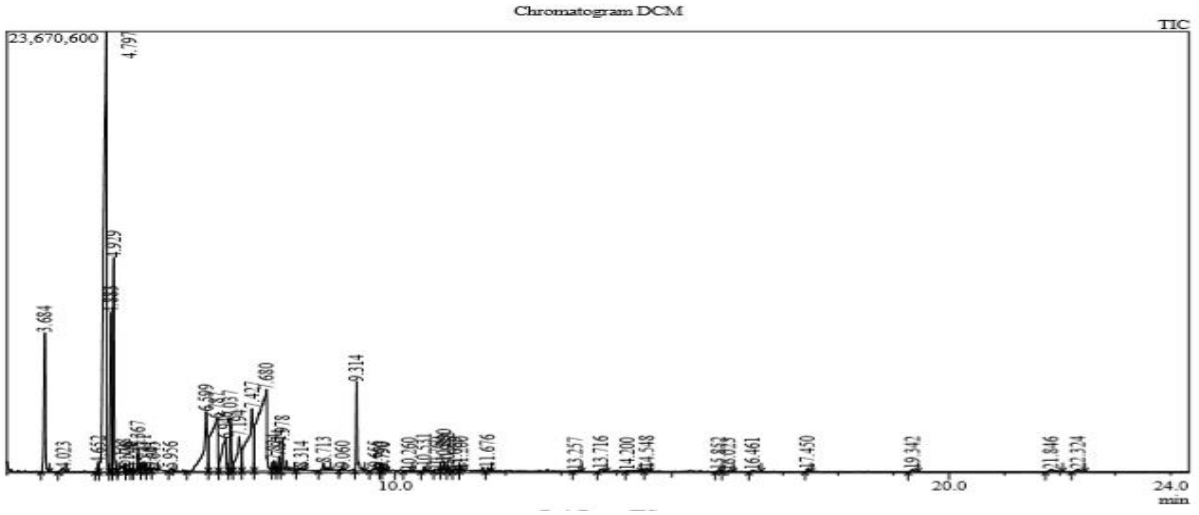


Appendix 5: GC – MS Fingerprint of the dichloromethane fraction of COA® herbal mixture.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/01 2:26:03 PM
Sample Type	: Unknown
Sample Name	: DCM
Sample ID	: AJ
Vial #	: 76
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\general - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt



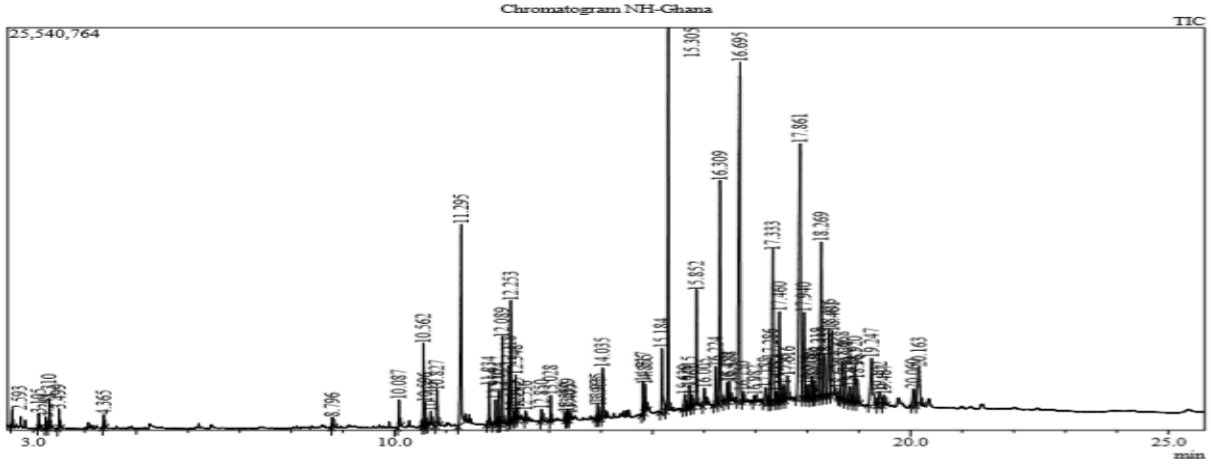
Appendix 6: GC – MS Fingerprint of the hexane fraction of Neem plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/26 11:26:04 PM
Sample Type	: Unknown
Sample Name	: NH-Ghana
Sample ID	: Joshua
Vial #	: 46
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

Chromatogram NH-Ghana



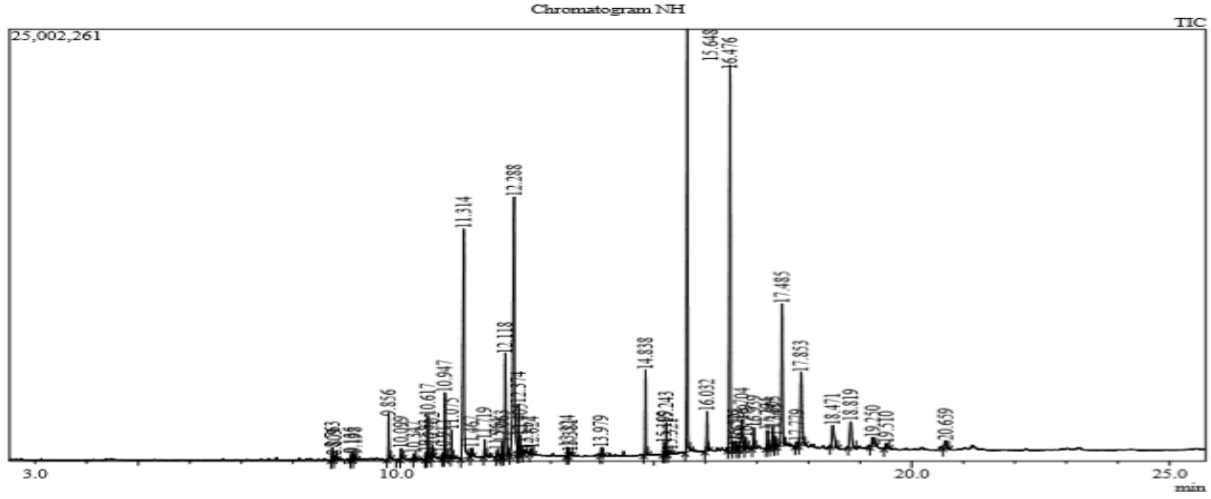
Appendix 7: GC – MS Fingerprint of the hexane fraction of Neem plant from Durban South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 3:15:13 AM
Sample Type	: Unknown
Sample Name	: NH
Sample ID	: AJ
Vial #	: 83
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt

Chromatogram NH

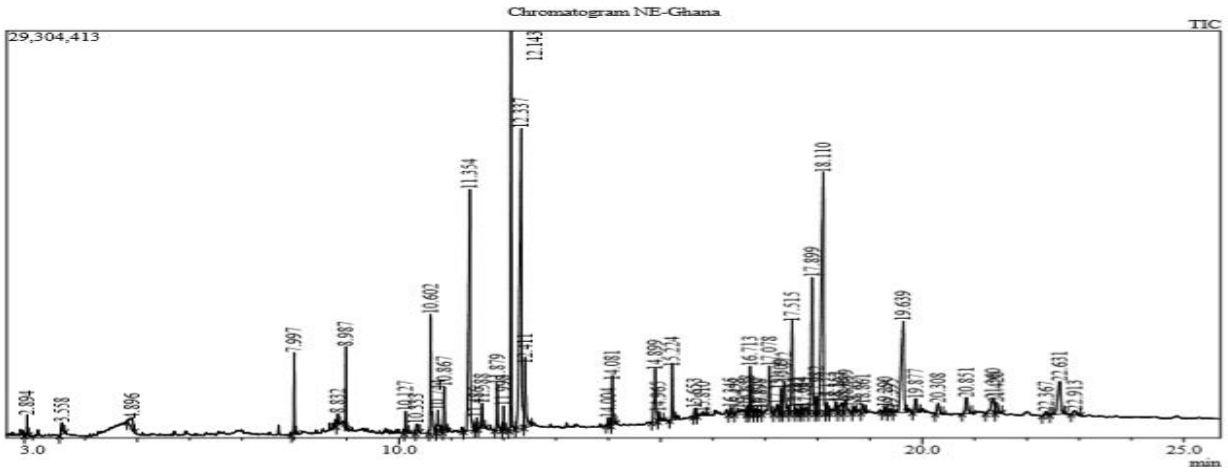


Appendix 8: GC – MS Fingerprint of the ethanol fraction of Neem plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/28 4:49:49 PM
Sample Type	: Unknown
Sample Name	: NE-Ghana
Sample ID	: Joshua
Vial #	: 76
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

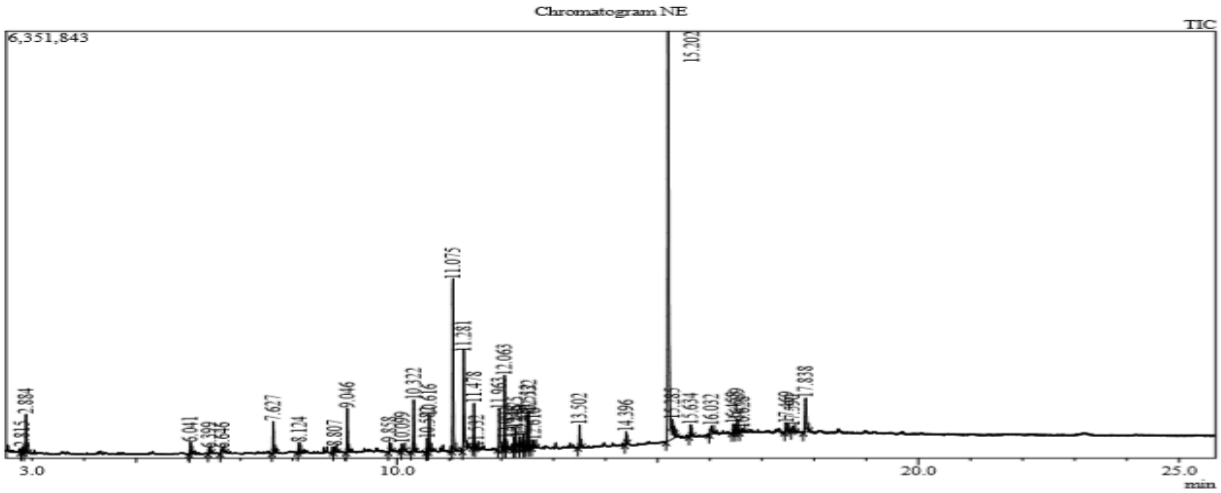


Appendix 9: GC – MS Fingerprint of the ethanol fraction of Neem plant from Durban South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 5:03:50 AM
Sample Type	: Unknown
Sample Name	: NE
Sample ID	: AJ
Vial #	: 86
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt

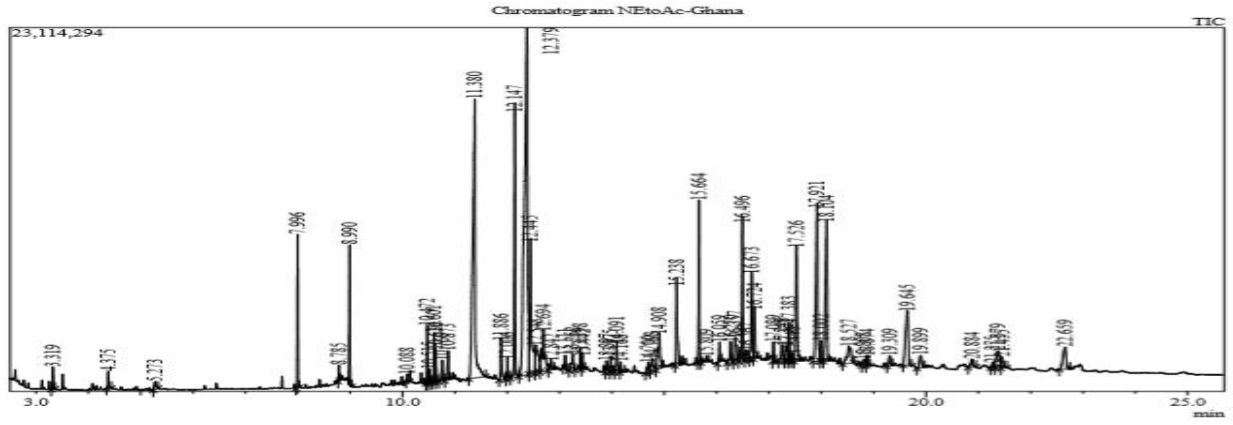


Appendix 10: GC – MS Fingerprint of the ethylacetate fraction of Neem plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/10/01 9:13:23 AM
Sample Type	: Unknown
Sample Name	: NEtoAc-Ghana
Sample ID	: Joshua
Vial #	: 77
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

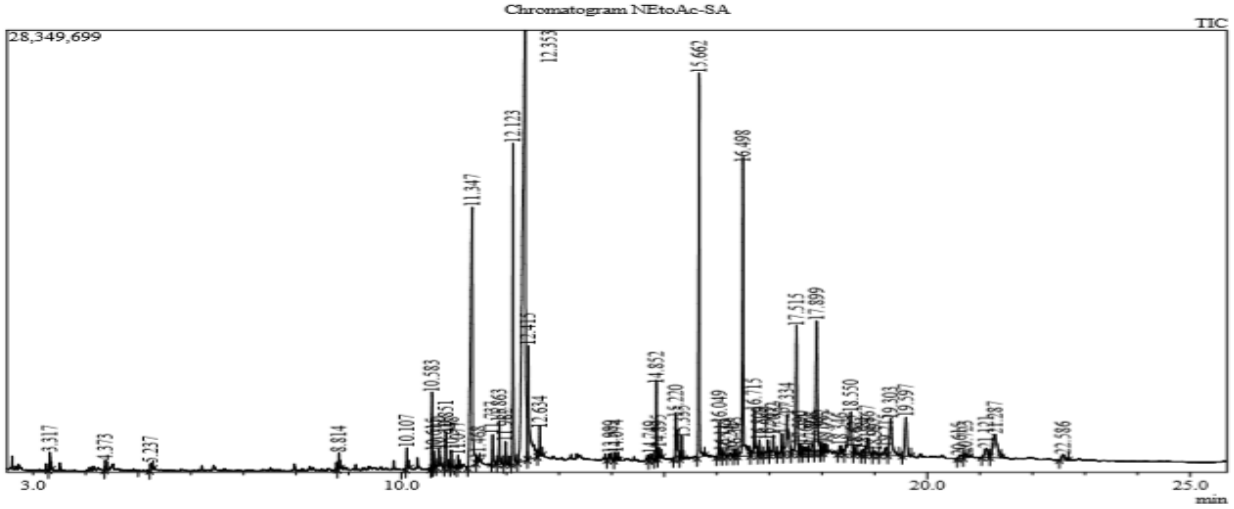


Appendix 11: GC – MS Fingerprint of the ethylacetate fraction of Neem plant from Durban South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/26 2:24:30 PM
Sample Type	: Unknown
Sample Name	: NEtoAc-SA
Sample ID	: Joshua
Vial #	: 30
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

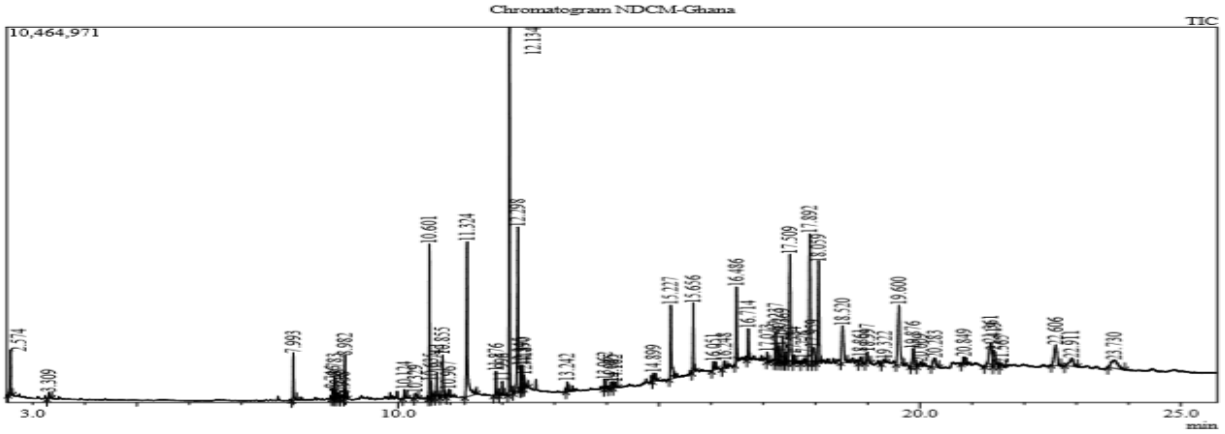


Appendix 12: GC – MS Fingerprint of the dichlorometane fraction of Neem plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/10/01 9:58:00 AM
Sample Type	: Unknown
Sample Name	: NDCM-Ghana
Sample ID	: Joshua
Vial #	: 78
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

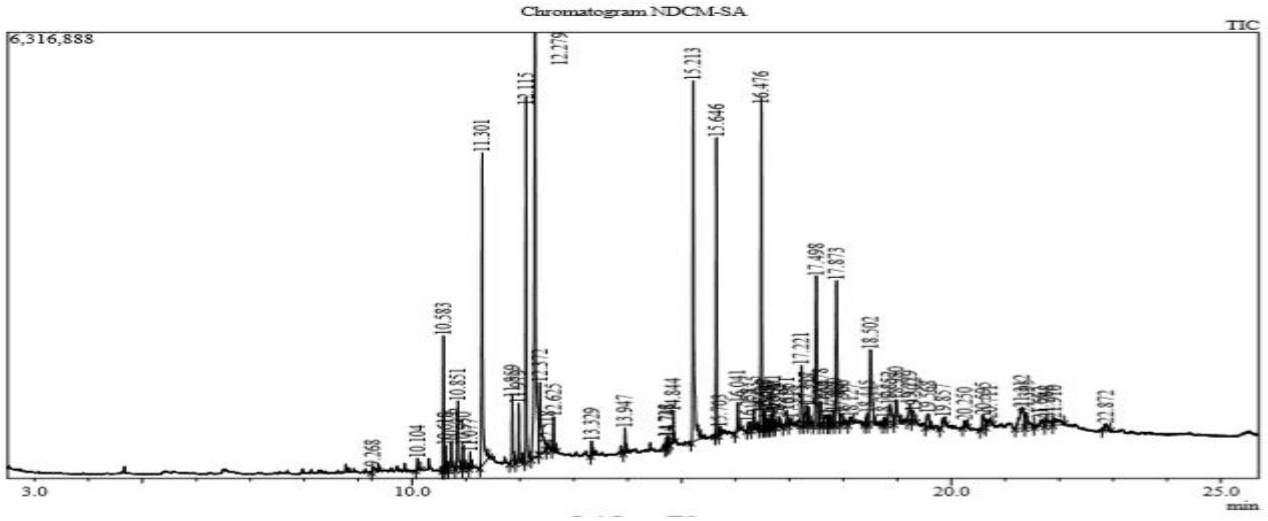


Appendix 13: GC – MS Fingerprint of the dichlorometane fraction of Neem plant from Durban South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/26 1:11:25 PM
Sample Type	: Unknown
Sample Name	: NDCM-SA
Sample ID	: Joshua
Vial #	: 28
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

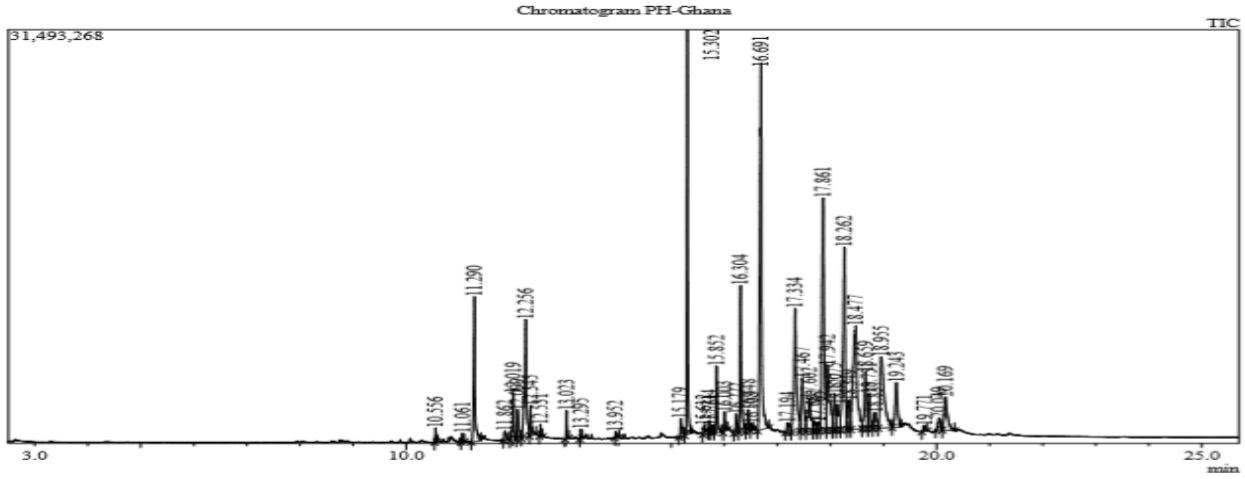


Appendix 14: GC – MS Fingerprint of the hexane fraction of Pawpaw plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/10/08 2:12:34 PM
Sample Type	: Unknown
Sample Name	: PH-Ghana
Sample ID	: Joshua
Vial #	: 5
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Archived Data\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 10 02.qgt



Appendix 15: GC – MS Fingerprint of the hexane fraction of Pawpaw plant from Port Shepstone South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 2:39:03 AM
Sample Type	: Unknown
Sample Name	: PH
Sample ID	: AJ
Vial #	: 82
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
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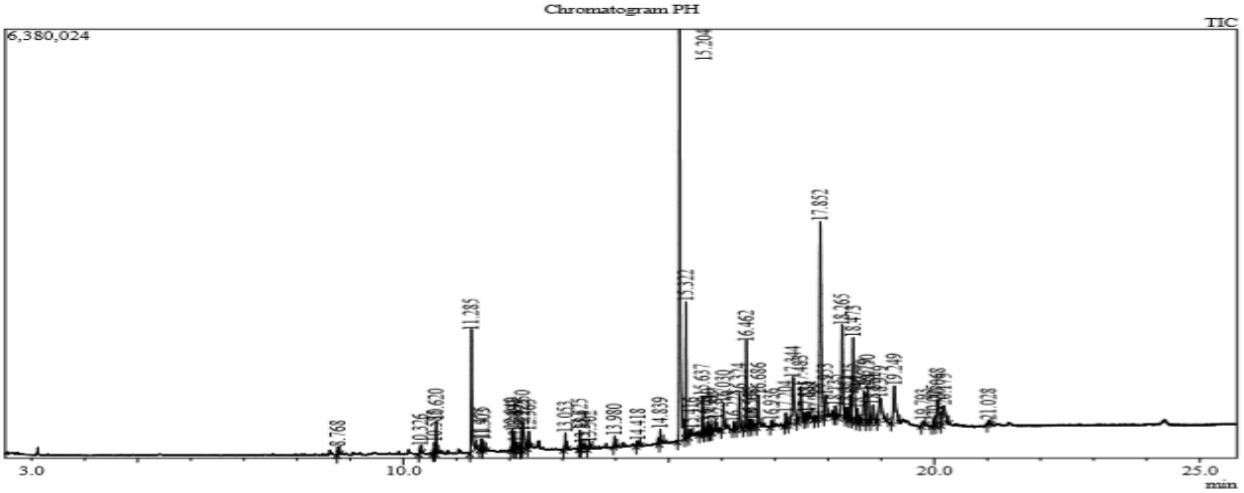
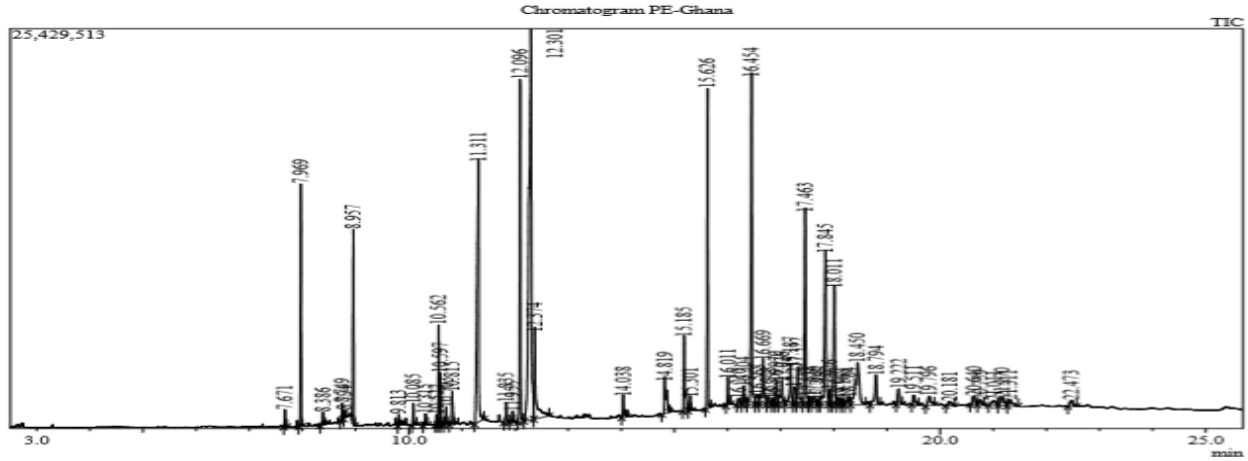


Appendix 16: GC – MS Fingerprint of the ethanol fraction of Pawpaw plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/26 10:50:16 PM
Sample Type	: Unknown
Sample Name	: PE-Ghana
Sample ID	: Joshua
Vial #	: 45
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

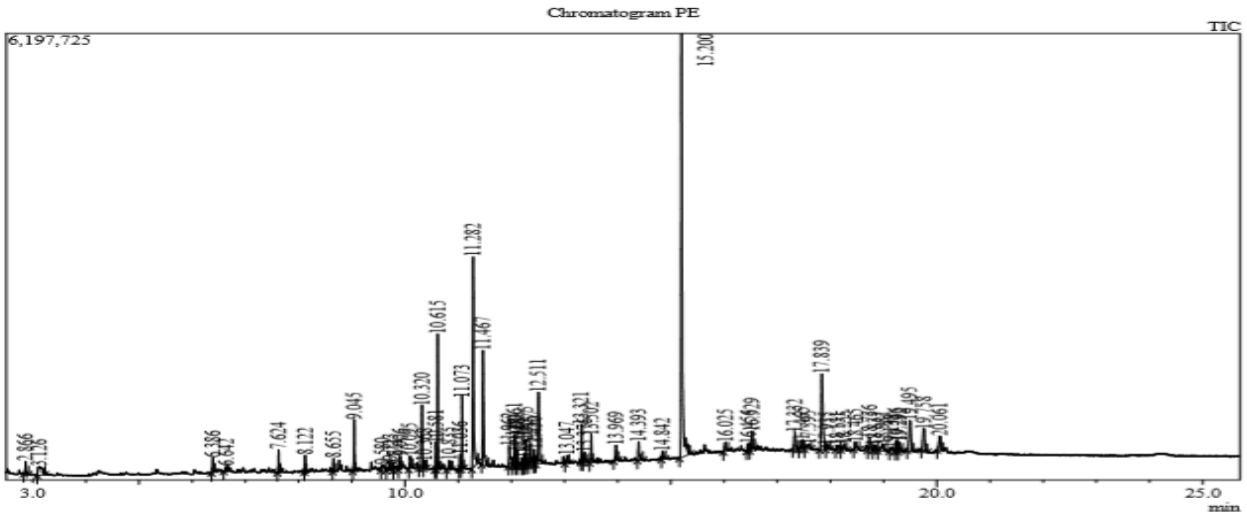


Appendix 17: GC – MS Fingerprint of the ethanol fraction of Pawpaw plant from Port Shepstone South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/08/02 5:40:04 AM
Sample Type	: Unknown
Sample Name	: PE
Sample ID	: AJ
Vial #	: 87
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 07 03.qgt

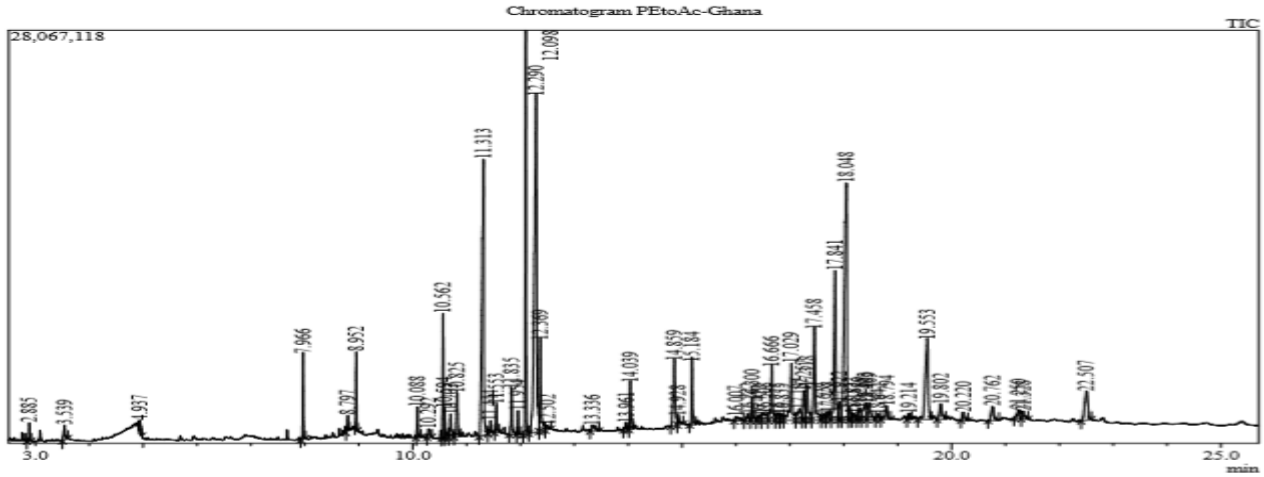


Appendix 18: GC – MS Fingerprint of the ethylacetate fraction of Pawpaw plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/27 12:01:58 AM
Sample Type	: Unknown
Sample Name	: PEtoAc-Ghana
Sample ID	: Joshua
Vial #	: 47
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

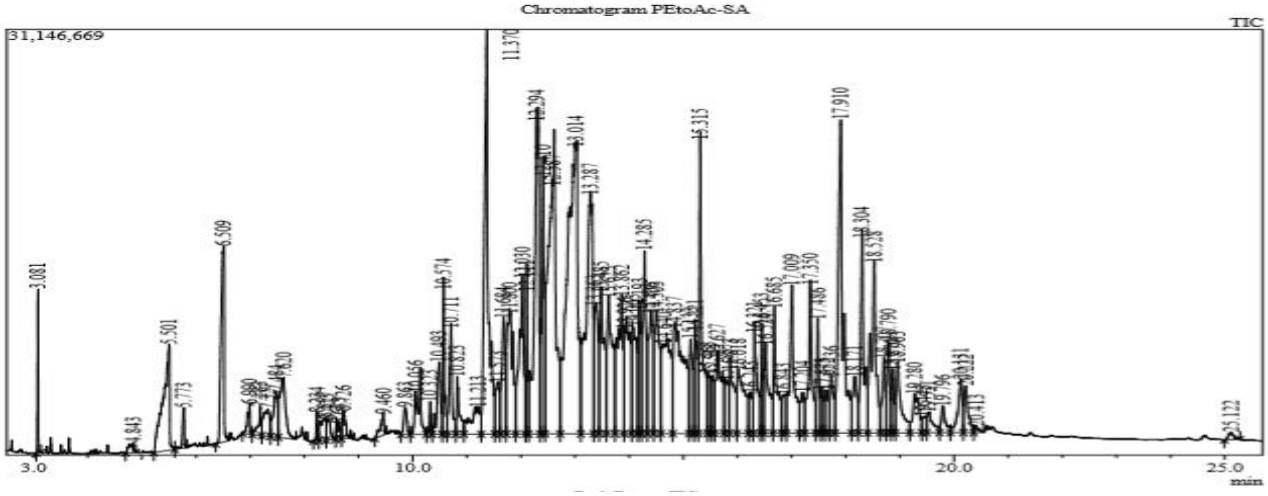


Appendix 19: GC – MS Fingerprint of the ethylacetate fraction of Pawpaw plant from Port Shepstone South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/26 10:20:16 AM
Sample Type	: Unknown
Sample Name	: PEtoAc-SA
Sample ID	: Joshua
Vial #	: 27
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt

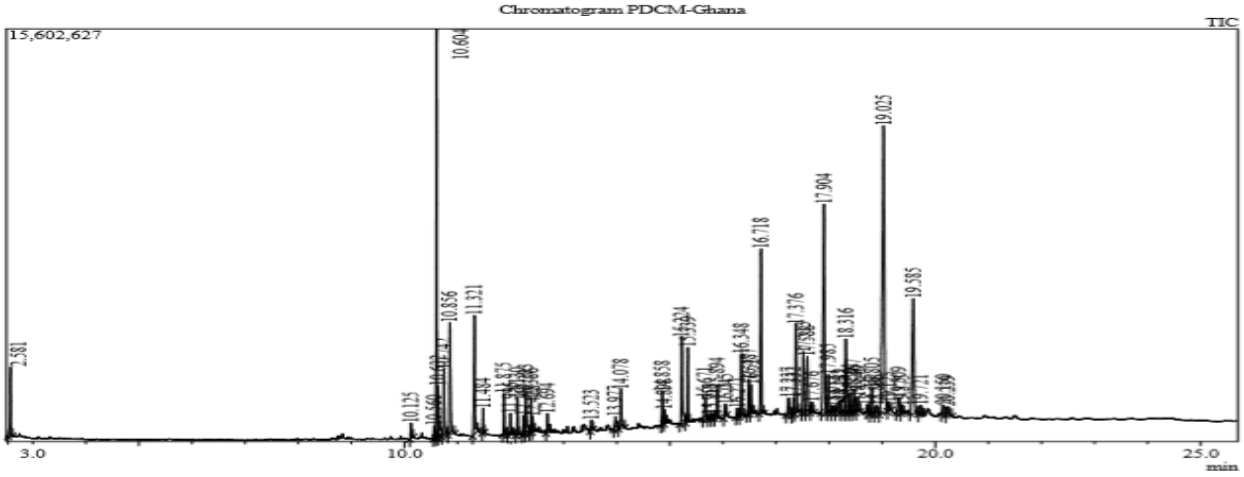


Appendix 20: GC – MS Fingerprint of the dichloromethane fraction of Pawpaw plant from Cape Coast Ghana.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/10/01 10:33:44 AM
Sample Type	: Unknown
Sample Name	: PDCM-Ghana
Sample ID	: Joshua
Vial #	: 79
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt



Appendix 21: GC – MS Fingerprint of the dichloromethane fraction of Pawpaw plant from Port Shepstone South Africa.

Qualitative Analysis Report

Sample Information

Analyzed	: 2018/09/26 3:37:14 PM
Sample Type	: Unknown
Sample Name	: PDCM-SA
Sample ID	: Joshua
Vial #	: 32
Injection Volume	: 1.00
Method File	: C:\Shimadzu GCMS\Raw Data 2017-8\UKZN - M Nlooto\M Nlooto - split.qgm
Tuning File	: C:\GCMSsolution\System\Tune1\Normal Conc - 2018 09 25.qgt