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EXTRACTION AND GCMS ANALYSIS OF OIL FROM RED COCOYAM PEEL (colocasia esculenta)

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ABSTRACT

Extraction of oil from red cocoyam peel has been carried out using the cold extraction method, with a reagent n-hexane as the extraction solvent The GC-MS was used to identify the components in the oil after extraction, the components that was found in the oil include, 1,3,5- trimethy benzene at a retention time of (2.844)min with a peak of 3.342%, n-hexadecanoic acid at a retention time of(7.250)min with a peak of 26.395%, 9,12-octadecadienoic acid at a retention time of (7.685)min with a peak of 2.036%, 1,1-dimethyl hexadecenoate at a retention time (7.794)min with a peak of 2.013%,9-octadecenoic acid with a retention time (8.023)min with a peak of 44.142%, 9,12,15-octadecatrienal at a retention time (8.154)min with a peak of 2.819%, Butyl 9,12-octadecadienoate at a retention time (8.555)min with a peak of 7.395%, squalene at a retention time of (10.151)min with a peak of 1.417%, Ergosta-5,22-dien-3-ol at a retention time of (15.879)min with a peak of 4.482%, 5-cholestene-3-ol,24-methyl at a retention time of (16.714) with a peak of 2.617%, 9,19-cyclolanost-24-en-3-ol at a retention time of (18.368) with a peak of 3.340%. and these components were found to be useful in pharmaceuticals, industries and cosmetics. This study contributes to the importance of sustainable utilization of agricultural byproducts and highlights the potential of red cocoyam peel as a valuable resource for the production of bioactive compounds with diverse industrial applications.

KEYWORD: Red cocoyam, Waste, Peels, Oil

INTRODUCTION

Cocoyam, scientifically known as Colocasia esculenta, stands as a staple crop in many tropical and subtropical regions across the globe, deeply ingrained in the culinary and cultural traditions of diverse communities (Ezeokoli, Nwachukwu, Alagbaoso.,2017). Renowned for its versatile applications and high nutritional value, cocoyam primarily garners attention for its starchy tubers, which serve as a vital source of carbohydrates and dietary fiber (Smith and Johnson, 2020). However, amidst the spotlight on its edible parts, the peel of cocoyam often languishes in obscurity, its potential as a valuable resource overshadowed by its more illustrious counterparts.

***Fig1.1** (overview of cocoyam plant.)*

The peel of cocoyam, constituting a substantial portion of the plant's biomass, boasts a complex and dynamic composition, comprising an intricate interplay of structural and storage components (Chukwuma, Madubuike, Mepba 2020). Rich in cellulose, hemicellulose, lignin, and pectin, the peel serves as a formidable barrier protecting the tender flesh of the tuber, providing structural integrity and resistance against external stressors (Udofia, Igile, Oladimeji, Adenekan 2018)). Beyond its structural role, cocoyam peel harbors a diverse array of bioactive compounds, including phenolic compounds, flavonoids, and antioxidants, which confer upon it a myriad of health-promoting properties (Awolu, Dairo, Obadina 2017). Moreover, nestled within the cellular matrix of the peel lies a treasure trove of lipids, encapsulated within lipid bodies or dispersed within the cytoplasm, awaiting liberation through extraction processes.

The extraction and analysis of oil from cocoyam peel represent a confluence of scientific inquiry, technological innovation, and socio-economic imperatives. In an era marked by burgeoning population growth, rapid urbanization, and dwindling natural resources, the quest for sustainable solutions has assumed unprecedented urgency (Inyang., Akpan., & Ita, 2019). Traditional sources of energy, predominantly derived from finite fossil fuel reserves, are fraught with environmental consequences, including greenhouse gas emissions, air and water pollution, and habitat destruction (Udensi, Oyebanji, Obasi, & Agwunobi, 2018). In this context, the exploration of alternative sources of energy assumes paramount importance, driving researchers and policymakers alike to seek out renewable and environmentally benign alternatives.

At the intersection of agricultural production, waste management, and renewable energy like cocoyam peel, a seemingly inconspicuous by-product with the potential to revolutionize our approach to resource utilization. By harnessing the latent oil content within cocoyam peel, researchers can not only mitigate the environmental burden associated with agricultural waste but also contribute to the diversification of energy sources and the promotion of sustainable practices. Moreover, the extraction and analysis of oil from cocoyam peel will hold profound implications for food security, economic development, and social equity, particularly in rural and marginalized communities where cocoyam cultivation forms the backbone of livelihoods.

Cocoyam peel is composed primarily of cellulose, hemicellulose, lignin, and pectin, with varying proportions depending on factors such as cultivar, maturity, and processing methods (Adetunji, Kayode, Adeyanju 2021). These structural components contribute to the physical integrity of the peel, providing mechanical strength and protection to the underlying tissues. Additionally, cocoyam peel contains a diverse array of bioactive compounds, including phenolic compounds, flavonoids, and antioxidants, which are known for their pharmacological properties and potential health benefits (Akubugwo, Obasi, Chinyere, & Ugbogu, 2017). The significance of oil extraction from agricultural waste products, extends beyond the realm of scientific inquiry to encompass broader socio-economic and environmental considerations. As the global population continues to grow and natural resources become increasingly scarce, there is a growing need to explore alternative sources of energy and raw materials (Adetunji et al 2021). Agricultural waste products represent a vast and underutilized resource that can be leveraged to address these challenges and promote sustainable development

extraction of oil from agricultural waste products has the potential to create new opportunities for economic development and poverty alleviation, particularly in rural and marginalized communities (Babajide, Alao, Ewulo, Daramola, Adeola 2022). By valorizing agricultural residues through value-added processes such as oil extraction, farmers can diversify their income streams, improve their livelihoods, and enhance their resilience to economic shocks. Additionally, the development of biofuels derived from agricultural waste products can reduce dependency on fossil fuels, enhance energy security, and stimulate rural development (Akubugwo, Obasi, Chinyere, & Ugbogu, 2017)., the extraction of oil from agricultural waste products can contribute to environmental preservation and mitigate the impacts of climate change. By diverting organic waste from landfills and converting it into biofuels, researchers can reduce greenhouse gas emissions and promote carbon sequestration (Edem, Itam, Eka 2020). Additionally, the cultivation of energy crops on marginal lands can help restore degraded ecosystems, improve soil fertility, and enhance biodiversity (Sudha, & Srivastava 2020).

Despite the potential of red cocoyam peel as a source of valuable oil, there is a lack of comprehensive studies focusing on the optimization of extraction methods, characterization of the chemical composition of the extracted oil, and exploration of its potential applications in various industries. Addressing these research gaps is essential to maximize the utilization of agricultural byproducts, contribute to sustainable resource management, and diversify the sources of valuable oils for industrial and commercial use. Therefore, the research problem for this study revolves around optimizing the extraction process, identifying the chemical constituents of the extracted oil, and exploring potential applications of red cocoyam peel oil, thereby contributing to the efficient utilization of agricultural resources and the development of sustainable solutions for waste management.

The aim of the study is to extract oil from red cocoyam peel using solvent extraction method and analyze the chemical composition of the oil using GCMS for the potential application of the oil extracted in various industry.

The historical overview of cocoyam and its by-products provides a fascinating glimpse into the cultural and agricultural heritage of various societies. Cocoyam, scientifically known as Colocasia esculenta, has been cultivated for centuries and has played a vital role in the diets and economies of many tropical and subtropical regions worldwide (Oboh, & Akindahunsi, (2018). This section aims to delve deeper into the historical use of cocoyam and its by-products, shedding light on traditional extraction methods and their limitations. Beyond its role as a food crop, cocoyam has also been utilized in traditional medicine and cultural practices. In many cultures, various parts of the cocoyam plant, including the tubers, leaves, and even the peel, have been used for medicinal purposes, treating ailments ranging from digestive disorders to skin conditions (Arogundade, Bankole, & Ajibade, 2017). Moreover, cocoyam holds cultural significance in ceremonies, rituals, and religious observances, symbolizing fertility, prosperity, and abundance. Cocoyam peel, often overlooked in favor of its tubers, harbors complex and dynamic chemical composition rich in various nutrients and bioactive compounds. This section aims to provide a comprehensive summary of the chemical composition of cocoyam peel, encompassing its macro- and micro-nutrient content, fiber composition, and presence of bioactive compounds. Cocoyam peel exhibits a diverse array of macronutrients essential for human health and nutrition. The peel is notably rich in carbohydrates, primarily in the form of starch, which serves as a significant source of energy (Inyang et al., (2019). Additionally, cocoyam peel contains moderate levels of proteins, contributing to its overall nutritional value (Edem, Itam, Eka 2020)). While the exact composition may vary depending on factors such as variety, maturity, and growing conditions, cocoyam peel typically provides a substantial portion of the daily carbohydrate and protein requirements (Adetunji, Kayode, Adeyanju, 2021)). In addition to macronutrients, cocoyam peel also contains an assortment of micronutrients essential for various physiological functions. These include vitamins, minerals, and trace elements crucial for maintaining overall health and well-being (Sudha et al 2020)). Cocoyam peel is particularly rich in vitamins such as vitamin C, vitamin B6, and folate, which play vital roles in immune function, energy metabolism, and DNA synthesis (Oboh et al 2018)). Furthermore, cocoyam peel contains significant amounts of minerals such as potassium, calcium, and magnesium, essential for maintaining electrolyte balance, bone health, and nerve function (Adetunji, Kayode, Adeyanju, 2021)). Fiber is another important component of cocoyam peel, contributing to its nutritional value and health benefits. Cocoyam peel contains both soluble and insoluble dietary fibers, which play crucial roles in digestive health, cholesterol management, and blood sugar regulation (Zhang, Chong, Li, Ren, 2019)). The insoluble fiber present in cocoyam peel adds bulk to stool, promoting regular bowel movements and preventing constipation (Eden et al 2020)). Additionally, soluble fibers in cocoyam peel help lower cholesterol levels and stabilize blood sugar levels by slowing down the absorption of glucose into the bloodstream (Nwosu, Ogueke, Ojukwu, Onyekwere, 2019)). Beyond its macronutrient and micronutrient content, cocoyam peel is also rich in bioactive compounds with potential health-promoting properties. These include phenolic compounds, flavonoids, and antioxidants, which exhibit antioxidant, anti-inflammatory, and anticancer activities (Akhtar, & Hasnain, 2017)). Phenolic compounds such as ferulic acid, caffeic acid, and quercetin are particularly abundant in cocoyam peel and have been associated with various health benefits, including reducing the risk of chronic diseases such as cardiovascular disease and cancer (Arogundade, Bankole, & Ajibade, 2017)). Additionally, flavonoids present in cocoyam peel contribute to its antioxidant capacity, protecting cells from oxidative damage and inflammation (Udofia, Igile, Oladimeji, Adenekan, 2018)). Cocoyam peel boasts a rich and diverse chemical composition, encompassing a wide range of macronutrients, micronutrients, fibers, and bioactive compounds. Its nutritional profile underscores its potential as a valuable dietary ingredient with numerous health benefits, making it a promising candidate for further exploration and utilization in food and pharmaceutical industries. extraction of oil from plant materials encompasses a variety of techniques, each with its unique advantages and disadvantages. This section provides a comprehensive review of different extraction methods commonly used for obtaining oil from plant materials, including solvent extraction, mechanical pressing, and supercritical fluid extraction. Furthermore, it evaluates the efficiency, yield, and environmental impact of each method, offering insights into their applicability and sustainability. Solvent extraction is one of the most widely used methods for extracting oil from plant materials. In this method, a solvent such as hexane, ethanol, or supercritical carbon dioxide is used to dissolve the oil present in the plant material. (Adetunji, Kayode, Adeyanju, 2021)). Solvent extraction offers several advantages, including high efficiency, versatility, and the ability to extract oil from a wide range of plant materials. Additionally, solvent extraction typically yields high oil recovery rates, making it economically viable for large-scale production

(Arogundade, Bankole, & Ajibade, 2017). The use of organic solvents such as hexane poses risks of toxicity, flammability, and environmental pollution, necessitating careful handling and disposal procedures (Adetunji et al 2021)). The extraction process use may result in the loss of heat-sensitive bioactive compounds and degradation of oil quality due to exposure to high temperatures and chemical reactions (Akinoso, Omobuwajo, Sobukola, Sanni, Bamgbose 2021). Despite these limitations, solvent extraction remains a widely employed method for oil extraction due to its efficiency and scalability. Mechanical pressing, require that the plant material is subjected to mechanical pressure using an expeller press or screw press, which squeezes out the oil from the solid matrix (Zhang, Chong, Li, Ren, 2019). Mechanical pressing offers several advantages, including simplicity, low cost, and minimal use of external solvents or chemicals. Additionally, mechanical pressing preserves the natural flavor, aroma, and nutritional qualities of the extracted oil, making it suitable for high-quality food applications (Adetunji, Kayode, Adeyanju, 2021). The pressure exerted by the mechanical press may not be sufficient to extract all the oil present in the plant material, resulting in lower oil recovery rates compared to solvent extraction methods. Furthermore, mechanical pressing is typically less effective for extracting oil from materials with low oil content or those with complex cellular structures, such as cocoyam peel (Marfil, Santos, Oliveira, & Mendes. 2018). Despite these limitations, mechanical pressing offers a sustainable and environmentally friendly alternative to solvent extraction, particularly for small-scale or artisanal production. Supercritical fluid extraction (SFE) is an advanced extraction technique that utilizes supercritical fluids such as carbon dioxide (CO_2) to extract oil from plant materials. In this method, the supercritical fluid is used as a solvent to dissolve the oil components, after which the pressure and temperature are adjusted to separate the solvent from the oil-rich extract (Ezeokoli, Nwachukwu, Alagbaoso, 2017). Supercritical fluid extraction offers several advantages over conventional solvent extraction methods, including higher selectivity, reduced solvent consumption, and lower environmental impact (Anhwange., Ajibola, Okibe, & Amove 2018), SFE also has limitations, particularly in terms of equipment cost, operational complexity, and scalability. The setup and maintenance of supercritical fluid extraction systems require specialized equipment and expertise, making it less accessible for small-scale or resource-constrained operations (Zhang, Chong, Li, Ren 2019). Additionally, while supercritical CO_2 is considered relatively safe and environmentally friendly, the high pressures and temperatures involved in the extraction process may still pose safety risks and require stringent safety measures (Marfil et al 2017). solvent extraction, mechanical pressing, and supercritical fluid extraction are three commonly used methods for extracting oil from plant materials, each with its unique advantages and limitations.

Analysis of Oils:

Gas chromatography-mass spectrometry (GCMS) stands as a powerful analytical technique widely employed in the analysis of the composition of plant oils. This section aims to provide a comprehensive overview of GCMS and its application in elucidating the intricate chemical profiles of oils derived from plant materials. Furthermore, it discusses the fundamental principles of GCMS and its advantages for identifying individual compounds in complex mixtures, offering insights into its utility in characterizing the composition of oils (Sudha, & Srivastava, 2018).

Gas chromatography-mass spectrometry (GCMS) represents a hybrid analytical technique that combines the separation capabilities of gas chromatography (GC) with the detection and identification capabilities of mass spectrometry (MS). In GCMS analysis, the sample is first vaporized and injected into a GC column, where individual components are separated based on their physical and chemical properties, such as boiling point, polarity, and molecular weight (Edem, Itam , Eka 2020). The separated compounds are then ionized within the mass spectrometer and fragmented into characteristic ions, allowing for their identification based on their mass-to-charge ratio (m/z) and fragmentation patterns (Babajide, Alao, Ewulo, Daramola, Adeola 2022).

GCMS operates on the principle of selective partitioning and ionization of molecules, enabling the separation and identification of individual compounds in complex mixtures. During gas chromatography, the sample components partition between a stationary phase (typically a capillary column coated with a stationary liquid phase) and a mobile phase (inert gas such as helium) based on their affinity for the stationary phase. (Udofia, Igile, Oladimeji, Adenekan 2018). As the sample travels through the column, compounds with higher affinity for the stationary phase elute later, resulting in their separation based on retention time.

Following separation by gas chromatography, the eluted compounds enter the mass spectrometer, where they are ionized by electron impact (EI) or chemical ionization (CI) techniques. The ionized molecules are then subjected to fragmentation, yielding characteristic mass spectra consisting of ions corresponding to the molecular fragments of the analyte compounds (Edem et al., (2020). By comparing the obtained mass spectra with reference spectra or databases, individual compounds can be identified based on their unique fragmentation patterns and mass-to-charge ratios.

GCMS offers several advantages for analyzing the composition of plant oils, making it a widely preferred technique in analytical chemistry. Firstly, GCMS provides high sensitivity and selectivity, allowing for the detection and identification of trace-level compounds present in complex mixtures (Lin, & Harnly, (2019). Additionally, GCMS enables the simultaneous analysis of multiple compounds within a single sample, providing comprehensive information about the chemical composition of oils (Ogbuewu, Akinmutimi, Okoli, Anyanwu, Udedibie 2022). Moreover, GCMS is highly versatile and can be coupled with various sample preparation techniques, such as solid-phase microextraction (SPME) and derivatization, to enhance sensitivity and selectivity (Nwosu, Ogueke, Ojukwu, Onyekwere 2019).

MATERIALS AND METHOD

MATERIALS

The following materials were used for the extraction process, cocoyam peel, knife, drying mat, engine grinder, sample container, masking tape for labelling, weighing balance, brown bottle, rector stand, Peaker, funnel, filter paper, conical flask, aluminum foil, sample bottle, GC-MS Agilent Technologies-7890A GC system, triple axis detector, Diphenyl, Dimethyl polysiloxane. n-hexane

Fig 2.0 *(Extraction Process.)*

METHOD

SAMPLE PREPARATION

The red cocoyam peel samples were collected and cleaned thoroughly to remove any dirt or debris, the cleaned peel was dried under room temperature to remove excess moisture, the dried sample was ground into powder using the grinder, the grounded sample were stored in an airtight container until further use

OIL EXTRACTION

250 g of the powdered red cocoyam peel was weighed using the weighing balance. The weighed sample was placed into a brown bottle, 900 mL of n-hexane was added to the sample shake properly and Sample was covered properly. The extraction process was carried out under room temperature for 72 hours, allowing the solvent to extract the oil from the sample, after the extraction the solvent containing the extracted oil was decanted into a conical flask using the filtration method

OIL RECOVERY

The solvent containing the oil was allowed to evaporate under reduced pressure to recover oil, the recovered oil was transferred into a brown bottle for storage and further analysis.

ANALYSIS OF EXTRACTED OIL

The extracted oil was subjected to GC-MS analysis to determine its chemical compositions, GC-MS was conducted according to establish protocols with appropriate calibration and controls. GC-MS Agilent Technologies-7890A GC system. Gas Chromatogram coupled with Mass Spectrometer of Agilent Technologies-5975C MSD with triple axis detector equipped with an Agilent Technologies GCMS capillary column HP-5MS (30 m × 0.25 mm ID × 0.25µ) composed of 5% diphenyl 95% Dimethyl polysiloxane. An electron ionization system with ionizing energy of 70 eV was used. Helium gas (99.99%) was used as the carrier gas at constant flow rate 1 mL/min and an injection volume of 1 µl was employed at split ratio of 50:1, injector temperature was at 50 ˚C and ion source temperature was at 250˚C. The relative percentage amount of each component was calculated by comparing its average peak area to the total areas, software of GC-MS Mass Hunter was used for spectra and chromatograms analysis.

DATA ANALYSIS

The data obtained from GC-MS analysis were analyze to identify the chemical constituents present in the extracted oil. Quantitative analysis was performed to determine the relative abundance of each component.

Fig 2.1. *(Gas Chromatogram-Mass Spectrometer of Agilent Technologies-5975C MSD.)*

RESULT

The GC-MS analysis of oil extracted from red cocoyam peel, entails the segregation of diver's components available in the oil extract using the gas chromatography and theses components are identified by the mass spectrometry. These components are shown in fig 3.1 below, the GC give the insight on their application in various forms

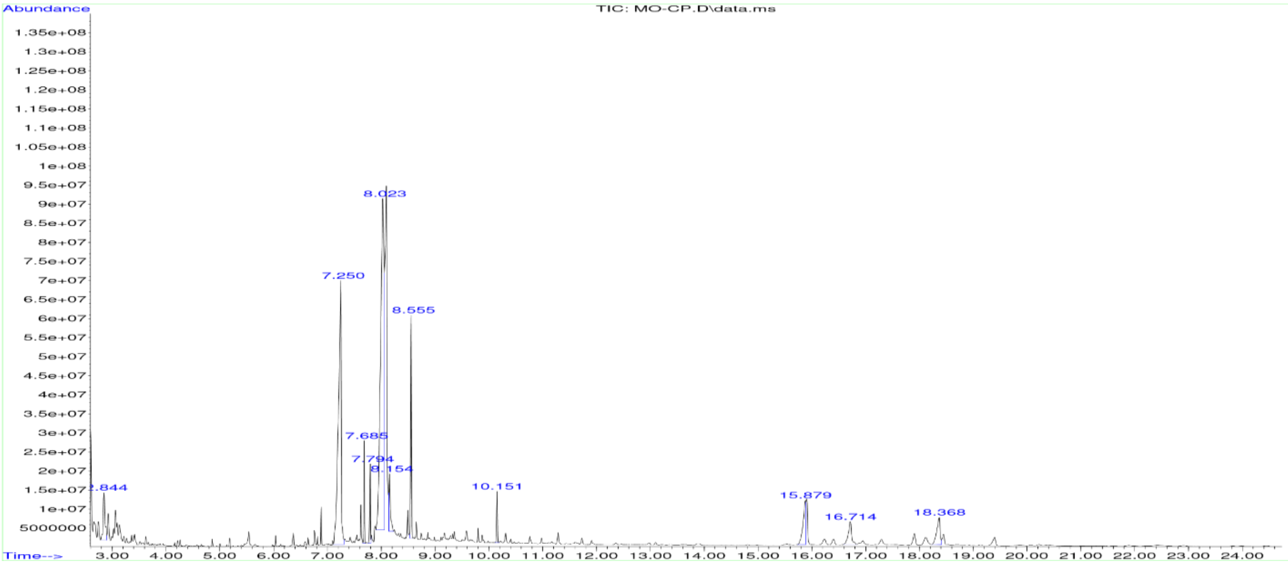

Fig 3.1 *(GAS CHROMATOGRAM OF THE VARIOUS COMPONENTS PRESENT IN THE RED COCYAM PEEL OIL)*

Table 3.1.1 *(Chemical Composition of Extracted Oil from Red Cocoyam Peel.)*

Peak	Components	(RT)min	Percentage
1	1,3,5-trimethyl benzene	2.844	3.342
2	n-hexadecanoic acid	7.250	26.395
3	9,12_octadecadienoic acid	7.685	2.036
4	1,1-dimethyl hexadecenoate	7.794	2.013
5	9-octadecenoic acid	8.023	44.142
6	9,12,15-octadecatrienal	8.154	2.819
7	Butyl 9,12-octadecadienoate	8.555	7.395
8	Squalene	10.151	1.417
9	Ergosta-5,22-diene-3-ol	15.879	4.482

10	**5-cholestene-3-ol,24-methyl**	**16.714**	**2.617**
11	**9,19-cyclolanost-24-en-3-ol**	**18.368**	**3.340**

From the gas chromatogram as seen above in fig 3.1 several components were identified:

The components identified include,1,3,5-trimethyl benzene (mesitylene), n-hexadecanoic acid(palmitic acid), 9,12-octadecadienoic acid, 1,1dimethyl hexadecenoate, 9-octadecenoic acid, 9,12,15-octadecatrienal,butyl 9,12-octadecadienoate, squalene,ergosta-5,22_dien-3-ol-5-cholestene-3-ol,24-methyl, 9,19- cyclolanost-24-en-3-ol, compound 1,3,5- trimethyl benzene, with a retention time (RT)min of 2.844, comprises approximately 3.342% of the sample, indicating its significant presence within the mixture, compound n-hexadecanoic, with retention time (RT)min of 7.250, comprises approximately 26.395% of the sample, indicating it's significant presence within the mixture, compound 9,12-octadecadienoate acid, with a retention time (RT)min of 7.685, comprises approximately 2.036% of the sample, indicating its significant presence within the mixture.1,1-dimethyl hexadecenoate, with a retention time (RT)min of 7.794, comprises approximately 2.013% of the sample, indicating its significant presence within the mixture, compound 9-octadecenoic acid, with a retention time (RT)min of 8.023, comprises approximately 44.142% of the sample, indicating its significant presence within the mixture, compound 9,12,15-octadecatrienal, with a retention time (RT)min of 8.154, comprises approximately 2.819% of the sample, indicating its significant presence within the mixture, compound butyl 9,12-octadecadienoate, with a retention time (RT)min of 8.555, comprises approximately 7.395% of the sample, indicating its significant presence within the mixture, compound squalene, with a retention time (RT)min of 10.151, comprises approximately 1.417% of the sample, indicating its significant presence within the mixture, compound Ergosta-5,12,22-dien-3-ol, with a retention time (RT)min of 15.899, comprises approximately 4.482% of the sample, indicating its significant presence within the mixture, compound 5-cholestene-3-ol,24- methyl, with a retention time (RT)min of 16.714, comprises approximately 2.617% of the sample, indicating its significant presence within the mixture, compound 9,19- cyclolanost-24-en-3-ol, with a retention time (RT)min of 18.368, comprises approximately 3.340% of the sample, indicating its significant presence within the mixture.

STRUCTURAL ANALYSIS AND FRAGMENTATION PATTERN

trimethyl benzene

1,3,5-trimethyl benzene also Known as Mesitylene was one of the compounds that was found in the red cocoyam peel oil, it is a colourless liquid that has sweet aromatic odor they occur naturally in coal tar and are prepared from acetone, it has diver's applications Mesitylene is a colourless liquid with a sweet odour, it has a melting point of 162 degree Celsius and a boiling point of 165 degree Celsius. mesitylene is insoluble in water but soluble in organic solvents like ether and alcohol, mesitylene was found by the GC in fig 3.0a and was identified by the MS in fig 3.1.1 which gives the comprehensive analysis of the chemical composition of mesitylene and also provide a valuable insight into its potential applications.

Mesitylene serves as a valuable solvent in organic synthesis due to its low reactivity with many common reagents, it can undergo electrophilic reactions at the ortho and para positions. Mesitylene exhibits high thermal stability, with decomposition occurring at temperature above 400 degree Celsius, Decomposition pathways include radical processes leading to the formation of various hydrocarbons and carbonaceous residue.

Mesitylene has a low potential for bioaccumulation and is readily biodegradable under aerobic conditions. However, it may pose risk to aquatic organisms due to its moderate toxicity. Mesitylene is utilized as a solvent in the production of various polymers, including polystyrene and polyethylene. Mesitylene serves as a key starting material in the synthesis of pharmaceuticals, agrochemicals and fragrances. Mesitylene is employed as a solvent and a reactant in various catalytic processes, including hydrogenation and Friedel-crafts reactions is utilized as a solvent in the formulation of coatings, for automotive applications, providing excellent compatibility with resins and superior performance in spray application. Mesitylene is employed as a heat transfer fluid in various industrial processes, including heat exchange system and thermal baths, due to its high thermal stability and low freezing point.

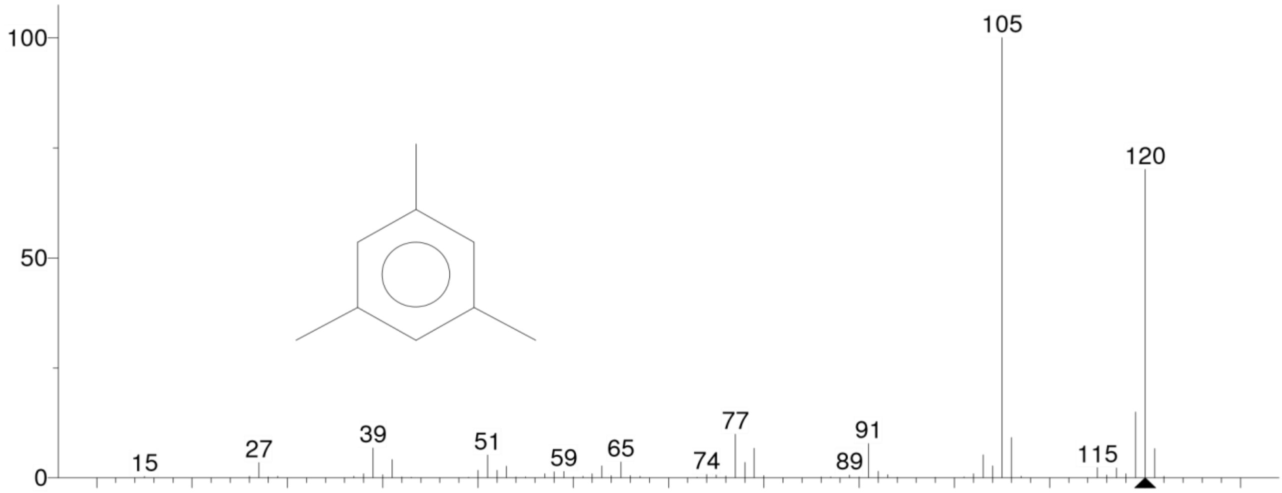

Fig 3.2.1*(Spectrum for 1,3,5- trimethyl benzene.)*

n- hexadecanoic acid

n-hexadecanoic acid, also known as palmitic acid, is a saturated fatty acid commonly found in both animals and plants. It is a major component of palm oil and animal fats. Chemically, it is a long-chain fatty acid with 16 carbon atoms as shown in fig 3.2.2 Palmitic acid is involved in various biological processes, including energy storage, membrane structure, and cell signaling. It has both beneficial and detrimental effects on health, depending on its intake and overall dietary context. High levels of palmitic acid consumption have been associated with increased risk of cardiovascular diseases, while moderate intake as part of a balanced diet is generally considered safe. Palmitic acid is used in the manufacturing of soaps, detergents, and cosmetics due to its cleansing properties; it is utilized in the production of lubricants and lubricating greases, Palmitic acid is employed as a softening agent in textile processing. Palmitic acid is used as an excipient in pharmaceutical formulations, especially in drug delivery systems such as lipid-based formulations and nanostructured lipid carriers, It is also incorporated into topical formulations such as creams and ointments due to its emollient properties, Palmitic acid is used in the production of dietary supplements and nutritional products, Palmitic acid is a common ingredient in skin care products such as moisturizers, lotions, and cream due to its emollient properties, which help to soften and hydrate the skin, It is also found in hair care products like conditioners and styling products to provide conditioning and smoothing effects, Palmitic acid is used in the formulation of lipsticks, foundations, and other cosmetic products to improve texture and stability.

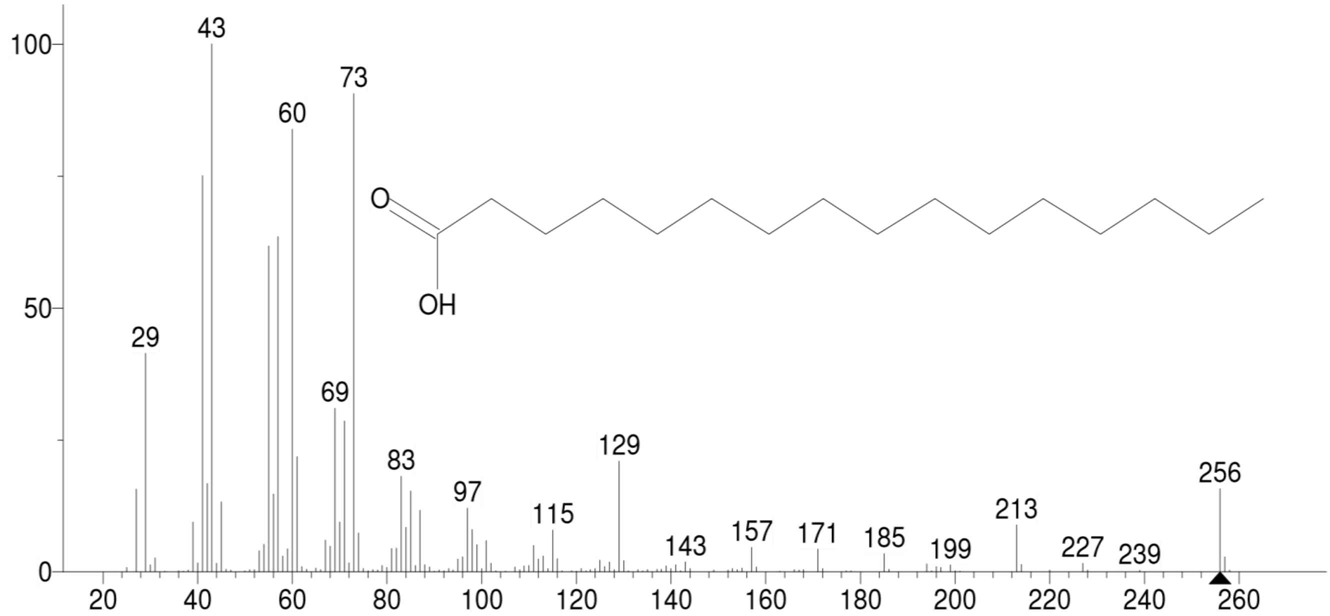

Fig 3.2.2 *(spectrum for n-hexadecanoic acid.)*

9,12-octadecadienoic acid

Is commonly known as methyl linoleate. Methyl linoleate is an ester derived from linoleic acid, which is a polyunsaturated omega-6 fatty acid. The (Z, Z)- configuration indicates that the double bonds are in a cis configuration at the 9th and 12th carbon atoms of the carbon chain as indicated in fig 3.2.3 Methyl linoleate is used as a lubricant and lubricant additive due to its lubricating properties. It is utilized in the formulation of cosmetics and personal care products such as creams, lotions, and serums due to its emollient properties, which help to soften and hydrate the skin. Methyl linoleate can be used in topical pharmaceutical formulations such as ointments and creams for its emollient and moisturizing effects on the skin. It may be included in dermatological treatments for conditions such as dry skin or eczema. Methyl linoleate is a common ingredient in skin care products due to its ability to nourish and moisturize the skin, making it suitable for use in moisturizers, serums, and facial oils. It may also be found in hair care products such as conditioners and hair oils to help condition and soften the hair

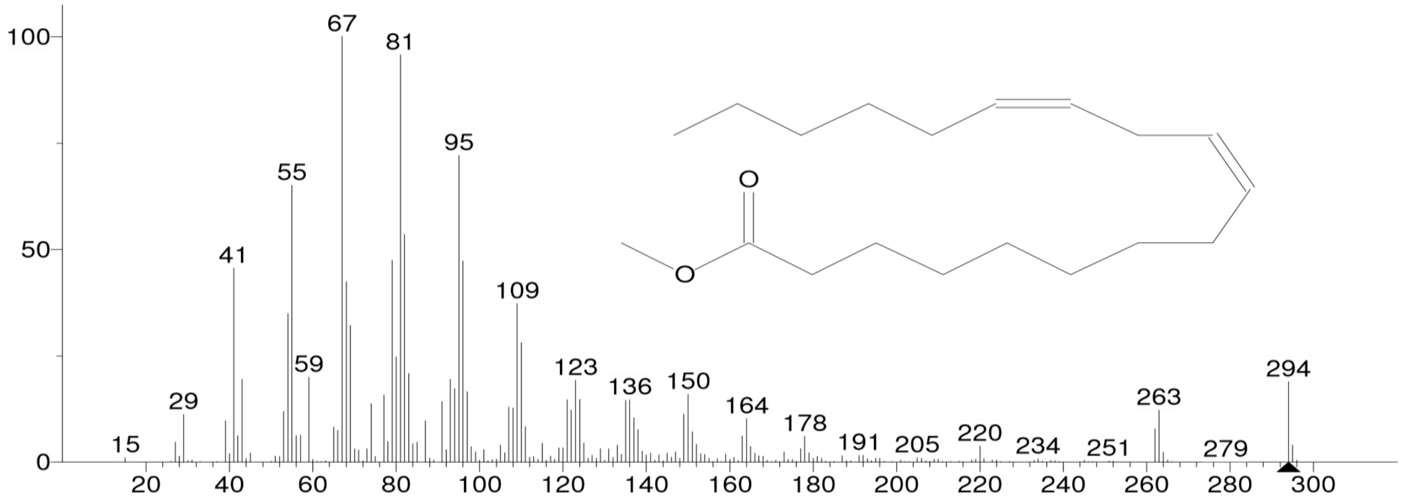

Fig 3.2.3 *(Spectrum of 9,12-octadecadienoic acid.)*

1,1-dimethly hexadecenoate

1,1-dimethyl hexadecenoate is a chemical compound also known as isosteric acid or is stearyl alcohol. is a monounsaturated fatty acid derivative with a methyl group attached to the carbon atom adjacent to the double bond, giving it its 1,1-dimethyl" designation. Isosteric acid is commonly used in the production of lubricants, coatings, and plastics due to its ability to enhance viscosity and provide lubrication. It serves as a raw material in the synthesis of esters, which are utilized as emollients, emulsifiers, and thickeners in various industrial applications, including cosmetics and personal care products.

Isosteric acid can be found in pharmaceutical formulations as an excipient or as part of topical formulations, providing emollient properties and enhancing the spread ability of creams and ointments. Isosteric acid is commonly used in cosmetics and personal care products such as lotions, creams, lipsticks, and hair care products due to its emollient properties. It helps improve the texture and spread ability of formulations while providing moisturization and skin conditioning benefits. Isosteric acid is a branched-chain fatty acid derivative, which affects its physical and chemical properties compared to straight-chain fatty acids like oleic acid. The presence of the double bond and methyl group in its structure influences its compatibility with other compounds and its overall functionality in various applications. Isosteric acid is generally considered safe for use in cosmetics and personal care products when formulated according to industry standards and guidelines. It is important to note that specific uses and regulations may vary depending on the region and intended application.

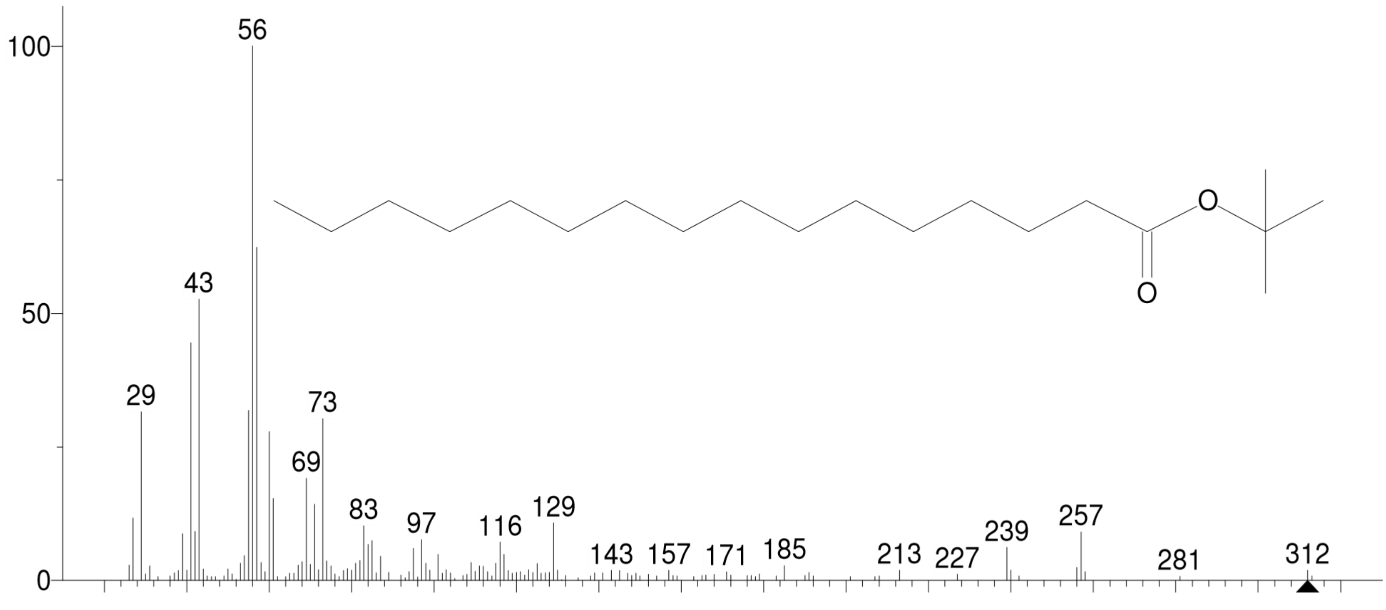

Fig 3.2.4 *(spectrum of 1,1dimethyl hexadecenoate.)*

9- octadecenoic acid

Oleic acid is a monounsaturated fatty acid, meaning it has one double bond in its hydrocarbon chain. The double bond is located at the 9th carbon atom from the terminal methyl end, hence the name 9-octadecenoic acid. This double bond gives oleic acid it's characteristic bend or kink in the molecule. The main components of oleic acid are carbon, hydrogen, and oxygen. It is composed of a long hydrocarbon chain with a carboxylic acid functional group at one end. The hydrocarbon chain consists of 18 carbon atoms bonded together in a linear fashion as seen in fig 3.2.5 below. varying numbers of hydrogen atoms attached to each carbon atom to satisfy their valency. Oleic acid has various industrial, pharmaceutical, and cosmetic uses: It is used in the production of soaps, detergents, and emulsifying agents due to its surfactant properties. Oleic acid is utilized in the manufacturing of lubricants, greases, and cutting fluids. It serves as a precursor for the synthesis of esters, which have applications in fragrances, flavors, and plasticizers. Oleic acid is employed in the synthesis of biodiesel due to its availability from renewable sources like vegetable oils, it is utilized as an excipient in pharmaceutical formulations, particularly in topical creams and ointments, due to its emollient properties. Oleic acid is also used as a penetration enhancer to facilitate the absorption of drugs through the skin. It is a common ingredient in skincare products such as lotions, moisturizers, and lip balms due to its emollient properties, which help soften and hydrate the skin, Oleic acid is used in hair care products like conditioners and hair oils to impart shine and manageability to the hair. Oleic acid is a key component of various dietary oils, including olive oil, which is associated with numerous health benefits due to its monounsaturated fat content. It plays a role in lipid metabolism and cellular function within the body. Oleic acid is generally recognized as safe by regulatory agencies when used in accordance with good manufacturing practices. However, excessive intake or exposure may have adverse health effects.

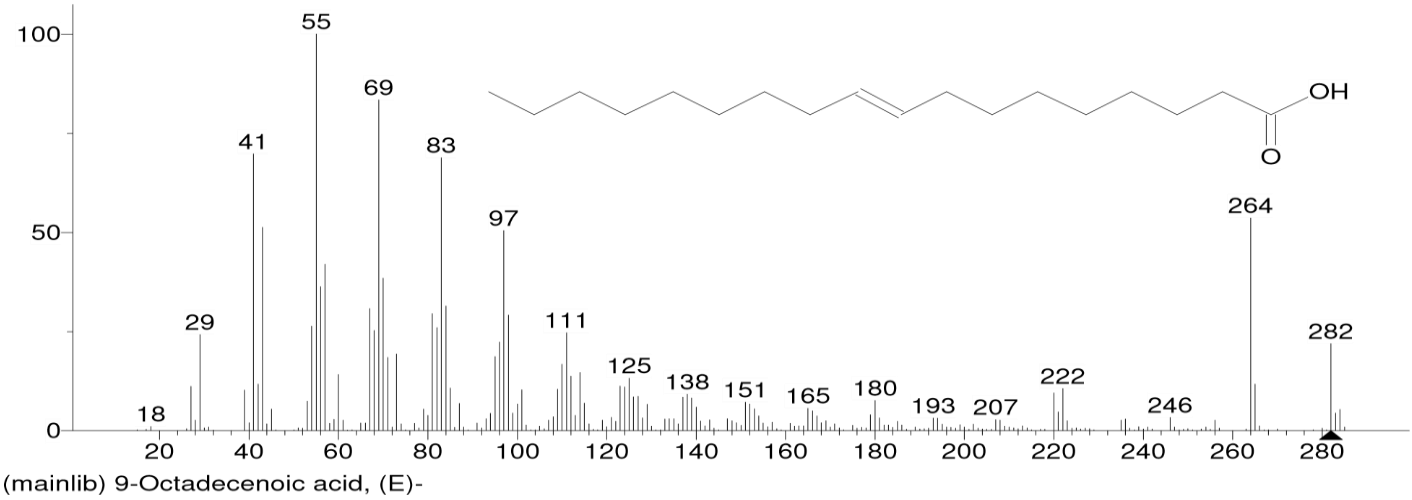

Fig 3.2.5 *(spectrum of 9-otacdecenoic acid)*

9,12,15-Octadecatrienal

commonly known as alpha-linolenic acid (ALA), is an essential omega-3 fatty acid. LA is a polyunsaturated fatty acid (PUFA) with a chain length of 18 carbon atoms and three double bonds located at the 9th, 12th, and 15th carbon positions. It is an essential fatty acid, meaning it cannot be synthesized by the human body and must be obtained from the diet. Alpha-linolenic acid is primarily found in plant-based sources such as flaxseeds, chia seeds, walnuts, hemp seeds, and certain vegetable oils (flaxseed oil, canola oil, soybean oil).It serves as a precursor for the synthesis of longer-chain omega-3 fatty acids, including eicosatetraenoic acid (EPA) and docosahexaenoic acid (DHA), which are found in fish and seafood. LA plays crucial roles in various physiological processes, including cell membrane structure and function, neural development, cardiovascular health, and inflammatory responses, it serves as a precursor for the synthesis of EPA and DHA, which are important for brain function, vision, and reducing inflammation. Consumption of alpha-linolenic acid is associated with numerous health benefits, including reduced risk of cardiovascular disease, improved lipid profiles, and anti-inflammatory effects. It may also play a role in supporting brain health, cognitive function, and mood regulation. Dietary guidelines recommend consuming foods rich in alpha-linolenic acid as part of a balanced diet to meet essential fatty acid requirements. The recommended daily intake of ALA varies but typically ranges from 1.1 to 1.6 grams for adult men and 0.8 to 1.1 grams for adult women. acid supplements are available in the form of capsules or oils and may be used to increase omega-3 intake in individuals who do not consume adequate amounts through diet, particularly those following vegetarian or vegan diets.

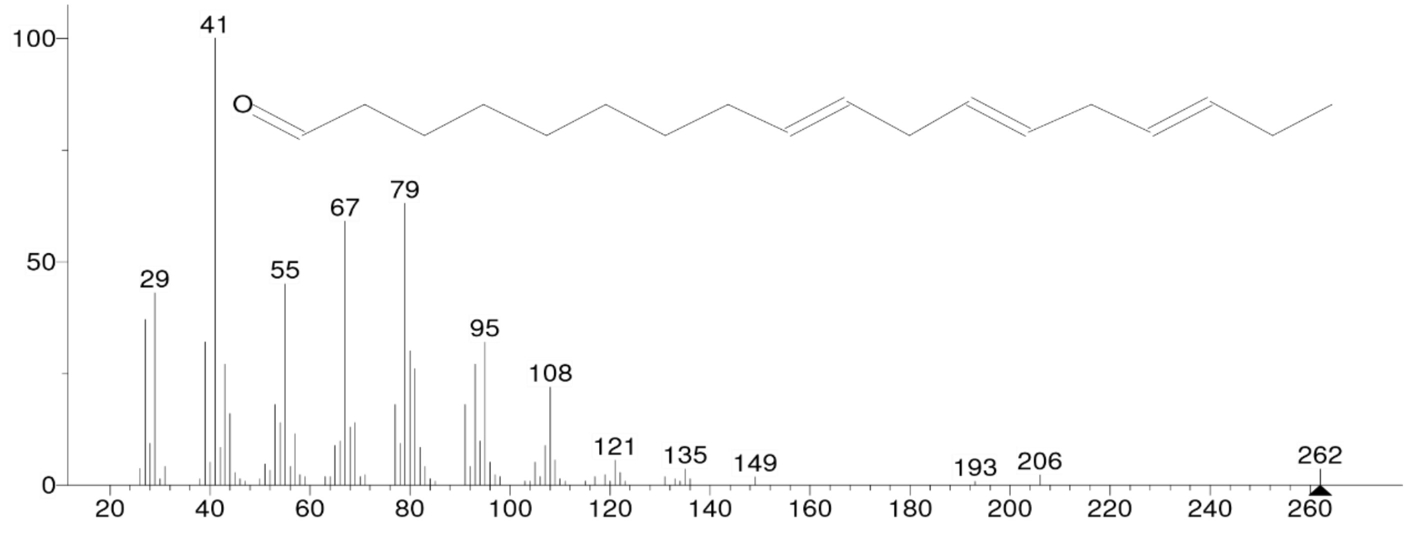

Fig 3.2.6 (spectrum of 9,12,15-octadecatrienal.)

Butyl 9,12- octadecadienoate

Butyl 9,12-octadecadienoate, also known as butyl linoleate, is an ester compound derived from butanol and linoleic acid. Its chemical formula is C22H40O2. This compound is commonly found in nature, particularly in various plant oils. Butyl linoleate is used in cosmetic formulations such as lotions, creams, and moisturizers due to its emollient properties, which help soften and smooth the skin. It may be used in pharmaceutical preparations as an excipient or as a carrier for active ingredients. Butyl linoleate can be used as a food additive or flavoring agent in some food products. It may find applications in industrial processes such as lubricants or as an ingredient in coatings and paints.

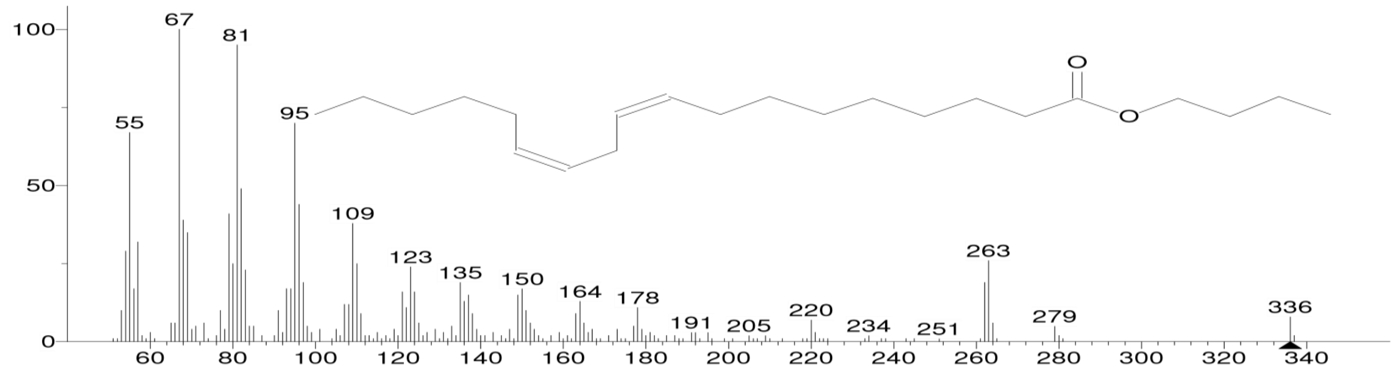

Fig. 3.2.7 *(Spectrum of Butyl 9,12- octadecadienoate.)*

SQUALENE

is a natural organic compound classified as a triterpene, a precursor to the synthesis of steroids in plants and animals. Its chemical formula is C30H50. Squalene is primarily found in shark liver oil, as well as in human sebum, olive oil, wheat germ oil, and other vegetable oils. It's used in skincare products like moisturizers, as it can hydrate and soften the skin without leaving a greasy residue Squalene is used as an adjuvant in some vaccines to enhance the body's immune response. It's used in certain drug formulations due to its emollient properties. Squalene is available as a supplement, often derived from shark liver oil, for its potential health benefits. Squalene is also used in the manufacture of surfactants, lubricants, and other industrial products.

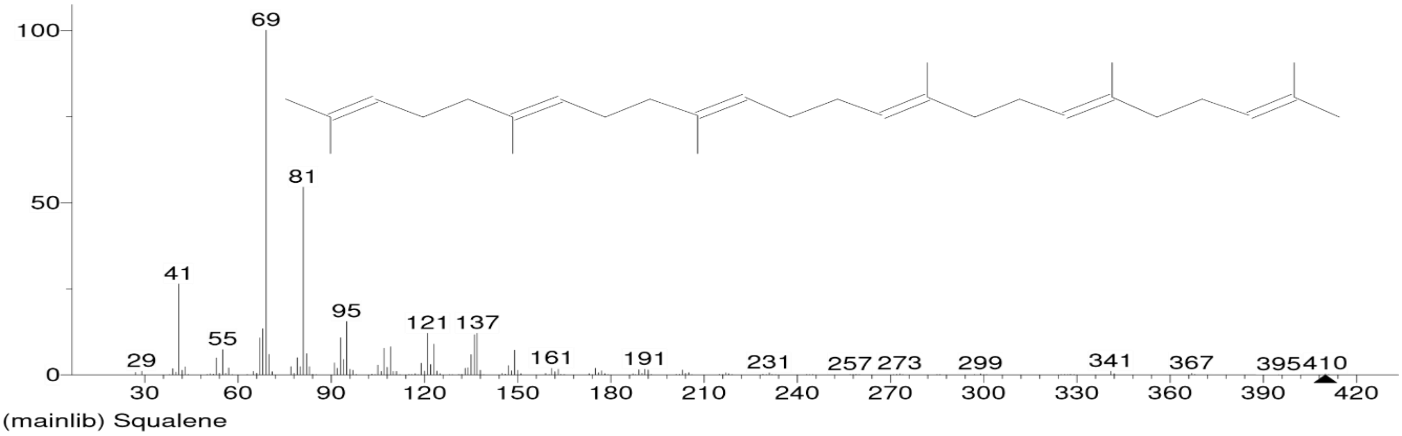

Fig. 3.2.8 *(Spectrum of squalene.)*

Ergosta-5,22-dien-3-ol

Ergosta-5,22-dien-3-ol is a compound belonging to the group of sterols. It's a precursor to vitamin D2 and is found in various fungi and plants. Ergosta-5,22-dien-3-ol has the chemical formula C28H44O and a molecular weight of 396.65 g/mol. It's a type of sterol, which is a subgroup of steroids. It's utilized as a precursor in the synthesis of vitamin D2 (ergocalciferol), which is important for bone health and calcium absorption. It's used in cosmetics as a skin conditioning agent, providing moisturizing properties and potentially improving skin barrier function. Ergosta-5,22-dien-3-ol can be used in the production of various pharmaceuticals, as well as in the synthesis of other sterols and related compounds. In pharmaceuticals, it's primarily used as a precursor in the synthesis of vitamin D2 supplements. Vitamin D2 is used to treat and prevent vitamin D deficiency, which can lead to bone disorders such as osteoporosis. In cosmetics, ergosta-5,22-dien-3-ol is often included in formulations for its skin conditioning properties. It can help hydrate and nourish the skin, potentially improving its overall appearance and texture. Industrially, this compound can be used in the synthesis of various pharmaceuticals and related compounds. Additionally, it may have applications in the production of certain types of plastics or polymers, although its industrial uses may be more limited compared to its pharmaceutical and cosmetic applications.

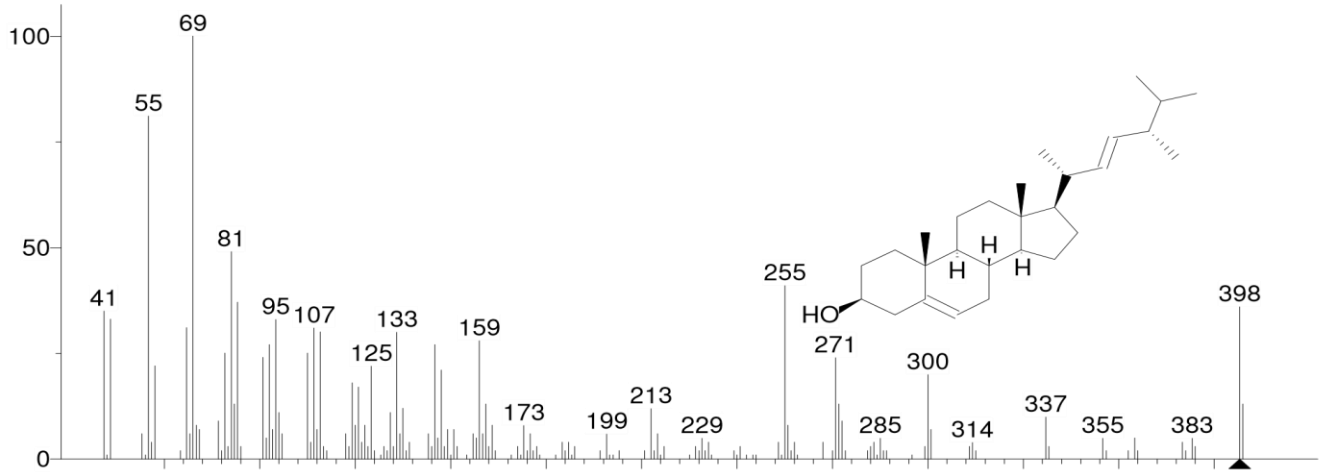

Fig 3.2.9 *(Spectrum of Ergosta-5,22-dien-3-ol)*

5- cholestene-3- ol,24- methyl

5-cholestene-3-ol,24-methyl is a sterol compound with various applications. The compound has the chemical formula C28H48O and a molecular weight of 400.68 g/mol. It's a derivative of cholesterol with a methyl group attached at the 24th carbon position. It's utilized in the pharmaceutical industry as a precursor in the synthesis of various steroids and hormones. It may also have potential therapeutic applications, although these would depend on specific research and development. In cosmetics, it may be employed as a skin conditioning agent, providing moisturizing properties and potentially enhancing the overall texture of the skin. Industrially, it can be used as a starting material in the synthesis of pharmaceuticals, as well as in the production of certain types of plastics or polymers. In pharmaceuticals, 5-cholestene-3-ol,24-methyl can serve as a precursor in the synthesis of various steroids and hormones, which have diverse therapeutic applications including anti-inflammatory, immune suppressive, and hormone replacement therapies.in cosmetics, it's commonly used as a skin conditioning agent. It helps to hydrate and soften the skin, improving its overall appearance and feel. It may also have emollient properties, which can further enhance its moisturizing effects. Industrially, this compound can be used in the synthesis of pharmaceuticals, particularly those related to hormone therapy or corticosteroids. Additionally, it may have applications in the production of certain types of plastics or polymers, although its industrial uses may be more limited compared to its pharmaceutical and cosmetic applications.

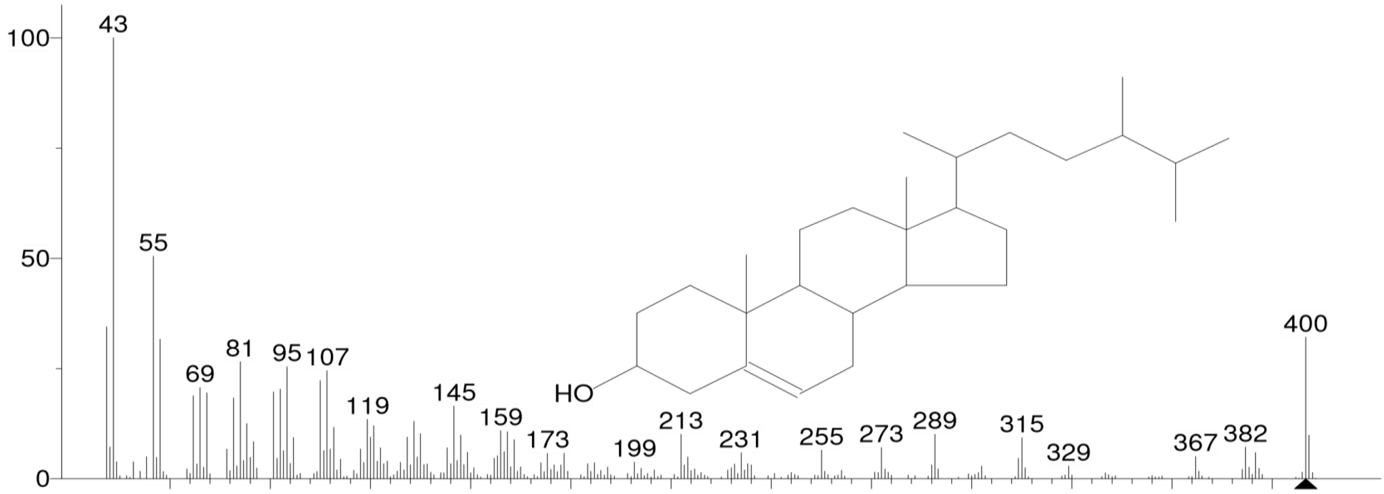

Fig 3.2.10 *(spectrum of 5-cholestene-3-ol,24-methyl)*

9,19- cyclolanost-24- en-3- ol

9,19-cyclolanost-24-en-3-ol is a compound with diverse application. The compound has the chemical formula C30H50O and a molecular weight of 426.72 g/mol. It belongs to the family of triterpenoids and is structurally similar to sterols like cholesterol. It may be utilized in pharmaceuticals as a precursor in the synthesis of various steroids and hormones. Additionally, it could have potential therapeutic applications, though specific uses would depend on further research. In cosmetics, it's employed as a skin conditioning agent, providing moisturizing properties and potentially improving skin texture. Industrially, it can serve as a starting material in the synthesis of pharmaceuticals, as well as in the production of certain types of plastics or polymers. In pharmaceuticals, 9,19-cyclolanost-24-en-3-ol can be utilized as a precursor in the synthesis of various steroids and hormones, which have diverse therapeutic applications including anti-inflammatory, immunosuppressive, and hormone replacement therapies. In cosmetics, it functions as a skin conditioning agent, helping to hydrate and soften the skin. It may also have emollient properties, improving skin texture and appearance. Industrially, this compound can be used in the synthesis of pharmaceuticals, particularly those related to hormone therapy or corticosteroids. Additionally, it may have applications in the production of certain types of plastics or polymers, although its industrial uses may be more limited compared to its pharmaceutical and cosmetic applications.

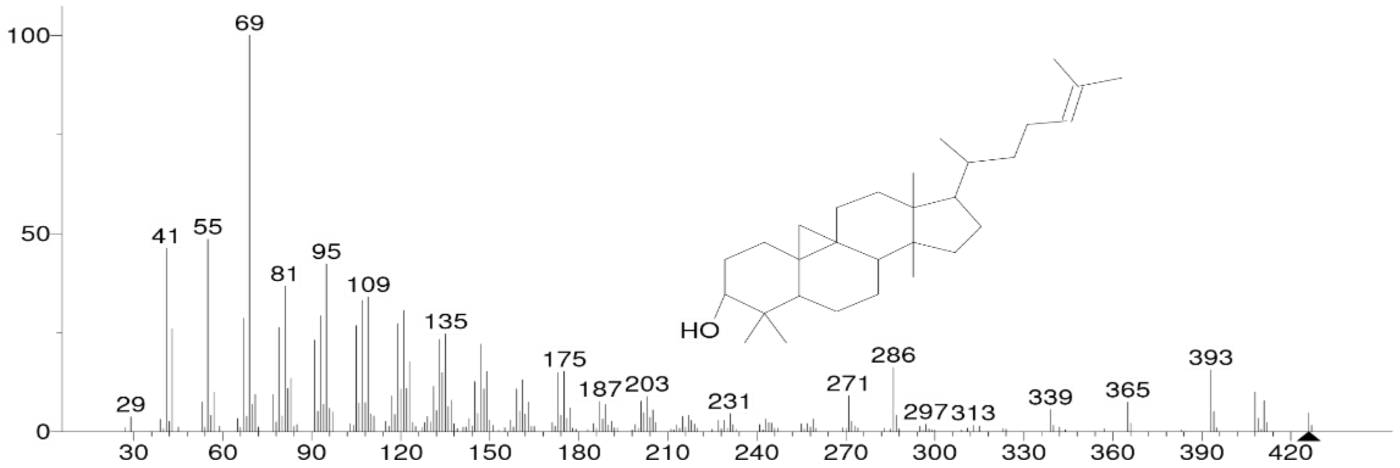

Fig 3.2.11 *(spectrum of 9,19-cyclolanost-24-en-3-ol)*

CONCLUSION, RECOMMENDATION AND CONTRIBUTION TO KNOWLEDGE

CONCLUSION

The extraction of oil from red cocoyam peel has yielded valuable insights into its chemical composition and potential applications. Through Gas Chromatography-Mass Spectrometry (GC--MS) analysis, key compounds identified in the extracted oil include 1,3,5 trimethyl benzene, n-hexadecanoic, and various other constituents. These findings underscore the potential of red cocoyam peel as a promising source of diverse bioactive compounds with various industrial applications. Future studies could focus on optimizing extraction methods to enhance oil yield and purity, this study underscores the importance of sustainable utilization of agricultural byproducts and highlights the potential of red cocoyam peel as a valuable resource for the production of bioactive compounds with diverse industrial applications. By harnessing the potential of red cocoyam peel oil, we can contribute to the development of sustainable solutions for waste management and resource utilization, while also creating new opportunities for economic growth and innovation in various industries.

RECOMMENDATION

Further research should focus on optimizing the extraction process of red cocoyam peel oil to enhance its yield and quality. Additionally, exploring the functional properties and potential applications of the oil in various industries, such as food, pharmaceuticals, and cosmetics, will provide valuable insights into its commercial viability. Collaboration with industry partners and stakeholders is essential to facilitate the development of innovative products and sustainable practices for cocoyam cultivation and processing. By leveraging multidisciplinary expertise and fostering knowledge sharing, we can unlock the full potential of red cocoyam peel as a valuable resource for economic development and environmental sustainability.

CONTRIBUTION TO KNOWLEDGE

By focusing on the extraction of oil from red cocoyam peel, a byproduct of cocoyam processing, the study sheds light on the potential of an underutilized agricultural waste material. This contributes to the broader understanding of sustainable resource management and the valorization of agricultural byproducts. Through experimentation and optimization of extraction parameters such as solvent-to-sample ratio, extraction time, and temperature, the study enhances our understanding of efficient oil extraction methodologies. This knowledge can be applied to optimize extraction processes for other similar agricultural byproducts, thereby improving resource efficiency and reducing waste.

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