Characterization and Antioxidant Activity of Mangosteen Peel Extracts

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DECLARATION

I declare that this thesis entitled “title of the thesis” is the results of my own research except as cited in the references.

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Pencirian dan Aktiviti Antioksidan Kulit Manggis untuk Penghasilan Scrub

ABSTRAK

Kajian ini bertujuan untuk mengekstrak kulit manggis daripada *Garcinia Mangostana L.*, menggunakan pelarut berbeza iaitu heksana, etil asetat, metanol, dan air suling. Pengekstrakan ini dilakukan dengan kaedah Soxhlet iaitu untuk menentukan pelarut terbaik untuk mengekstrak antioksidan daripada kulit manggis. Analisis aktiviti antioksidan mentah kulit manggis ditentukan oleh untuk Analisis Gas Chromatography-Mass Spectrometry (GC/MS), Analisis Kaedah Fourier Transform Infrared (FTIR), dan aktiviti antioksidan kulit manggis. Hasil kajian menunjukkan bahawa ekstrak mentah *Garcinia Mangsostana L.* Pengekstrakan menghasilkan peratusan hasil yang paling tinggi ialah 4.45% daripada etil asetat diikuti metanol pada 4.15% dan 1.90% daripada heksana dalam menggunakan 40 gram ekstrak kulit manggis serbuk. Manakala, dalam menggunakan 10 gram serbuk hasil adalah 7.60% dengan menggunakan air suling. Semasa ujian antioksidan, kehadiran IC_{50} untuk heksana yang berada pada kepekatan 25mg/ml, diikuti dengan pelarut lain iaitu etil asetat (12.5 mg/ml), metanol (12.5 mg/ml), dan air suling (200 mg/ml). Pelarut Etil asetat lebih berkesan kerana ia mempunyai aktiviti antioksidan yang tinggi. Ini disebabkan pelarut tersebut adalah pelarut sederhana polar. Kemudian, dengan menggunakan serbuk kulit manggis, ia boleh menghasilkan produk penjagaan kulit iaitu scrub. Scrub boleh merujuk kepada produk penjagaan kulit yang boleh digunakan untuk mengelupas dan membersihkan kulit.

Kata kunci: *Garcinia Mangostana L.*, Heksana, Etil Asetat, Metanol, Air Suling

Characterization and Antioxidant Activity of Mangosteen Peel for Scrub Production

ABSTRACT

The study aims to extract the mangosteen peel from *Garcinia Mangostana L.*, using different solvent which is hexane, ethyl acetate, methanol, and distilled water. The extraction of this was done by Soxhlation method which is to determine the best solvent for extracting antioxidants from mangosteen peel. The analyse the antioxidant activity of mangosteen peel crude was determine by Gas Chromatography-Mass Spectrometry (GC/MS) Analysis, Fourier Transform Infrared (FTIR) Method Analysis, and antioxidant activity of mangosteen peel. The results were shows that crude extract of *Garcinia Mangsostana L.* Extraction yield the highest yield percentage was stated at 4.45% from ethyl acetate followed by methanol at 4.15% and 1.90% from hexane in using 40 grams of the powdered mangostana peel extract. While, in using 10 grams of the powdered the yield was 7.60% by using distilled water. During the antioxidant test, the present of IC_{50} for hexane which is at 25mg/ml concentration, followed by other solvent which is ethyl acetate (12.5 mg/ml), methanol (12.5 mg/ml), and distilled water (200 mg/ml). Ethyl acetate solvent was more effective because it's have high antioxidants activity. This due to the solvents was a moderately polar solvents. Then, by using the mangosteen peel powder, it can be producing a skin care product which is scrub. Scrub can refer to a skin care product that can be used to exfoliate and cleanse the skin.

Keywords: *Garcinia Mangostana L.*, Hexane, Ethyl Acetate, Metahnol, Distilled Water

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LIST OF SYMBOLS

°C	Degree Celsius	15
g	Gram	15
mL	Millilitre's	15
cm^{-1}	Centimetre	17
nm	Nanometre	18
mm	Millimetre	18
g/ml	Grams per millilitres	18
%	Percentage	18

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Mangosteen (*Garcinia mangostana L.*) is a tropical fruit tree native to Southeast Asia that has been used for centuries in a traditional medicine. The fruit of the mangosteen tree is known for its sweet and tangy flavour and its deep purple rind. Its rind has been used as traditional medicines in Southeast Asia to treat abdominal pain, diarrhea, dysentery, cholera, infectious wounds, purulence, chronic ulcers, and other diseases. The anti-inflammatory, antioxidant, and anti-cancer capabilities of mangosteen are possible (Shan et al., 2011). It has been established that mangosteen contains a variety of active ingredients, including xanthones, phenolic acids, polysaccharides, and pigments (Abate et al., 2022). It also can be used as a drug for the treatment for weight loss, cardiovascular health, diabetes, and reduction of blood lipids. As a health care product, it has the function of antioxidant and anti-aging, and it is also used in cosmetics. For example, soap or scrub. α-Mangostin is a natural organic compound with low polarity (Guo, Wang, Lu, Wang, & Brodelius, 2016). This is because of the common technology of extraction and separation of α-mangostin includes silica gel column separation. However, this method is expensive, and it involves a large amount of toxic organic solvents in the separation process. *Garnicia Mangostana L.* is a powerhouse of an antioxidant, and it also known as catechin (Kusmayadi, 2018). The healthy cells in the skin can be protects by this molecule from deterioration and promotes the flow of bloods and nutrients to the skin cells (Abate et al., 2022).

Next, soxhlet extraction is a widely used method for extracting compounds from plant materials such as mangosteen peel. The procedure entails putting the sample in a thimble and repeatedly boiling and condensing a solvent through the sample, often an organic solvent like hexane, ethyl acetate, methanol, and distilled water. But water solvents are the best extraction for antioxidant. The solvent is then used to concentrate the extracted components so they can be further examined. The mangosteen (*Garcinia mangostana L.*) peel contains a variety of bioactive compounds which is include flavonoids, phenolic acids, and xanthones (Chaijan, 2019).

1.2 Problem Statement

Mangosteen is a highly perishable fruit, because there is often a large amount of waste generated during its processing. This waste, which includes the peel, is typically discarded, even though it contains a significant amount of potentially valuable bioactive compounds. In recent years, there has been growing interest in the potential health benefits of mangosteen peel, which is rich in xanthones and other polyphenolic compounds with antioxidant properties. Extraction can refer to the process of obtained and isolated a particular substances or components from a mixture or source material (Zhang, Lin, & Ye, 2018). Soxhlet extraction will used as a method for this extraction of mangosteen peel. It involves continuous extraction utilising a solvent and heat in combination.

Next, by shedding new light on the possible health advantages of this unusual tropical fruit, this study can decrease food waste and raise mangosteen fruit value. By using the mangosteen peel, it can be producing a skin care product which is scrub. Scrub can refer to a skin care product that can be used to exfoliate and cleanse the skin. These products benefits are to remove dead skin cells, unclog pores, and indirectly can improved the appearance of skin texture.

This mangosteen peel scrub will offer a new alternative for the consumers in skin care industry. This is because, some consumers seeking a more effective and organic skin care product make up our target market. Customers who appreciate the advantages of using organic products and how utilising them helps the environment can use this product to ensure that it is chemical-free. This will provide a better and more helpful service for both parties.

1.3 Objectives

i. To extract the mangosteen peel in hexane, ethyl acetate, methanol, and distilled water.
ii. To study the antioxidant activity of mangosteen peel crude extract.
iii. To formulate the scrub from the mangosteen peel.

1.4 Scope of Study

This part involved in examining various aspects of the mangosteen peel, which is included in the phytochemical content, and the antioxidant properties. First, collection and preparation of the mangosteen peel samples was obtained from fresh mangosteen fruits and then separate the peel from the inner fruit pulp. Mangosteen peels was clean to make sure the peel was removed from any contaminants and directly prepared it for analysis. Next, the mangosteen peel characterise were obtained. For example, physical properties. It can be measured the peel's colour, the texture and moisture content of the mangosteen peel (Wathoni, 2019). While the evaluation of the peel's nutritional composition such as vitamins, mineral, and dietary fibres are referring to the nutritional analysis of the mangosteen peel (Hussain, 2020).

Furthermore, phytochemical analysis also important because the analysis this of mangosteen peel can be utilises in variety of analytical procedures included FTIR, and UV-Vis spectroscopy, and GC/MS. The analysis will focus on the identification and quantification of bioactive compounds such as xanthones, flavonoids, and phenolic acids. Additionally, assessing the mangosteen peel's antioxidant activity provides information on the peel's capacity to scavenge free radicals and defend against oxidative damage (Agustin G, 2012). To further explore the differences in bioactive components and antioxidant characteristics.

1.5 Significant of Study

The peel was contained a high amount of xanthones, particularly alpha-mangosteen and gamma-mangosteen (Li, Inbaraj, & Chen, 2023). The peel also contained significant amounts of other bioactive compounds, such as flavonoids and phenolic acids (W. Suttirak & S. Manurakchinakorn, 2014). The peel, often discarded as waste, is known to contain various bioactive compounds with potential health benefits.

In terms of antioxidant activity, the researchers found that the peel extracts had a strong antioxidant capacity, as demonstrated by their ability to scavenge free radicals (Widowati et al., 2020). The antioxidant activity of the peel extracts was attributed to the presence of xanthones and other polyphenolic compounds. Extracts from mangosteen peel may have uses in the food and pharmaceutical industries. Additionally, the peel extracts can used to treat a variety of illnesses, such as cancer and inflammation, as well as serve as natural antioxidants

and food preservatives (Yin Sze Lee, 2013). The mangosteen peel's tremendous potential as a source of bioactive substances with antioxidant characteristics.

CHAPTER 2

LITERATURE REVIEW

2.1 Mangosteen Peel (*Garcinia Mangostana.L*)

Mangosteen is a tropical origin plants and its contains bioactive compounds such as tannin, xanthone, flavonoid, and anthocyanin. In fact, its has many important benefits for health according to their bioactive compounds that was show's in figure 2.1.

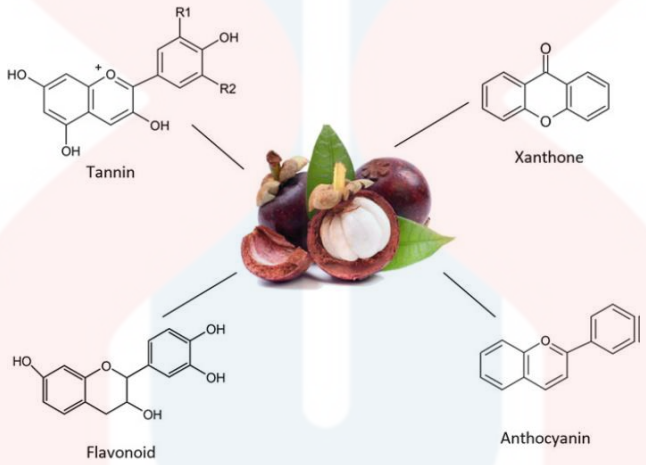


Figure 2.1 Mangosteen fruit

(Megawati Megawati et al., 2020)

A tropical fruit tree native to Southeast Asia called the mangosteen (*Garcinia mangostana L.*) has long been utilised in folk medicine. The mangosteen fruit is prized for its rich, deep purple rind and sweet, acidic taste. Southeast Asian traditional medicine has employed its rind to cure a variety of ailments including chronic ulcers, purulence, infected wounds, and cholera. Mangosteen may have anti-inflammatory, antioxidant, and anti-cancer properties. It has been demonstrated that mangosteen contains a variety of active substances, including xanthones, phenolic acids, polysaccharides, and pigments. (Ansori et al., 2020).

2.1.1 Phytochemical Properties of Mangosteen Peel

Mangosteen (*Garnicia mangostana L.*) is the best tasting tropical fruits. This is because the mangosteen's edible aril is milky white, but the fruit's skin is dark red (Guo et al., 2016;

Shan et al., 2011). The traditional use of the mangosteen is manifold and its mainly consumed fresh as a dessert. The desired aril of the mangosteen is typically separated from the peel, which is thought of as waste, during processing. Additionally, mangosteen fruit extract is frequently utilised as a dietary supplement, while fruit peel extract has been used in cosmetic products like scrub. The mangosteen peel has been reported to contain a variety of bioactive compounds with potential applications as therapeutic agents (W. Suttirak & S. Manurakchinakorn, 2014).

Antioxidants are present in mangosteen peel antioxidant extract. (W. Suttirak & S. Manurakchinakorn, 2014). The conventional approach is the method to extract antioxidants from mangosteen peel, but it still has several drawbacks, including a lengthy extraction procedure that requires a lot of solvents and a low yield. According to their chemical structure, flavonoids are split into a number of classes, including flavones, flavanols, and anthocyanins. (Kumar & Pandey, 2013). However, tannins are plant-based polyphenol substances that have a bitter taste, chelate, and can clump proteins. D-glucose and digallic acid are the two monomers of tannin. The molecular formula for tannin is C76H52O46 (W. Suttirak & S. Manurakchinakorn, 2014). Anthocyanin is the final substance present in significant amounts in the mangosteen peel. Greek terms “anthos,” which means flower, and “kyanos,” which indicates blue, were used to create the word “anthocyanin.” (Nurtiana, 2019). Fruits, vegetables, and ornamental plants may present the colours red, blue, and purple due to a substance called anthocyanin (Agustin G, 2012).

2.1.2 Antioxidant Activity of Mangosteen Peel

Antioxidants are a class of substances that inhibit the oxidation process by starting an oxidation chain reaction (Jaisupa, 2018). Free radical, reducing activity, and chelating of metal ion is referred to as several mechanisms of antioxidants. Antioxidants also can be classified as the properties at different stages in the oxidation process and they act via different mechanisms. Based on the antioxidant measures, the four classes of the antioxidant capabilities of mangosteen peel extract include free radical scavenging, chelating ability, reducing power, and lipid oxidation. Based on the DPPH (2,2-Diphenyl-1-picrylhydrazyl) test, the potential of mangosteen peel extract to scavenge the stability of free radicals (Gondokesumo, 2019). The decrease in the absorbance indicates to the antioxidant that produce by the extraction of mangosteen peel.

2.3 Mangosteen Peel Extraction

Different components of a material are separated through the process of extraction. The chosen solvent needs to be effective in extracting the target component without evaporating the other components. There are the two main categories of extraction such as solid-liquid extraction and liquid-liquid extraction while, it also has two categories of extraction techniques which is conventional and nonconventional (Zhang et al., 2018). Even though conventional extraction is the simplest method because it only needs solvents and common heaters, it still has several disadvantages, including a high solvent need, a lengthy extraction time, and low yields.

To produce purer extract, the polarity of the substance that can be extracted must be taken consider while identifying the solvents to utilise in the extraction process. The solvent employed shouldn't cause any chemical alterations to the components of the extract. Solvents need to have a low boiling point to readily evaporate even at low temperatures. To stop equipment corrosion, the solvent being used must not be corrosive. Hexane, ethyl acetate, methanol, and decoction water have all been utilised as solvents to extract antioxidants.

2.3.1 Soxhlet Extraction

The preferred extraction utilises used in laboratory was the soxhlation method, which uses a continuous extraction procedure (Chung Loong, 2020). This is because it needs the desired compound to be soluble in the solvent at a high temperature. This method entails applying a material to the extractor's filter paper. The heater's temperature was set below the reflux temperature, and the utilised solvent was added to the boiling flask (Luque, 2010) .

The mangosteen peel was dried to prevent the growth of fungi and to maintain its quality while being preserved before use. Furthermore, mixing is made simpler by the drying process of the mangosteen peel. The mangosteen peel was dried at low temperatures, which can help to keep the component parts intact and prevent quality loss. The mangosteen peel will be combined to increased its surface area in contact with the ethanol solvents. Additionally, an extraction utilising Soxhlet and various solvents, including methanol, ethyl acetate, and hexane, was be used to assess the antioxidant content of mangosteen peel. The solvent will be

recovered by distillation after the extraction process, and the extracted material will then be further purified. The amount of the extract was determined by using a digital scale to weigh the extract.

Besides that, the decoction in water can be use in this extraction process. Decoction was a traditional method of the extraction process that involves in boiling plant. For example, the mangosteen peel was added in the boiling water. This process is an effective way to extract the water-soluble compound from the mangosteen peel.

2.4 Characterization of Mangosteen Peel Extracts

2.4.1 Gas Chromatography-Mass Spectrometry (GC/MS)

A technique called GC/MS was used to detect and measure the amount of volatile and semi-volatile compounds in a sample (Aizat, 2020). This technique can be employed to the characterization the chemical composition of mangosteen peel and indirectly know the ability to antioxidant activity.

2.4.2 Fourier Transform Infrared (FTIR)

FTIR, also known as Fourier Transform Infrared Spectroscopy, was a commonly used analytical technique that can offer details about the molecular make-up and functional groups present in a sample. These techniques involved the measurement of infrared light absorbed by a sample (Abdul Rohman, 2020). For example, the certain wavelengths will be absorbed by the molecular vibrations of the sample's constituents when the infrared light passes through a sample. Then, the absorbed radiation will convert into a rotational or vibrational energy by the sample molecules. Resulting signal can be found at the detector presents as a spectrum. Besides, FTIR analytical techniques also has a wide range of applications such as it can identify of organic and inorganic compounds and characterization of pharmaceuticals and drug formulations (Lin, 2012).

Furthermore, mangosteen peel can be analysed via FTIR spectroscopy. This method typically occurs when the mangosteen peel has been dried and ground into a fine powder. Then,

the powder of mangosteen peel can be directly applied on the sample holder or combined with an infrared transparent matrix. For example, potassium bromide (KBr) to create a pellet or thin film. These FTIR analysis can be provide information about the chemical composition that has present in the mangosteen peel.

2.5 Formulation of Mangosteen Peel Scrub

Antioxidants are frequently required to stop the deterioration of other oxidizable items, including skin care scrubs. Scrubs can remove dead skin cells and can provide several benefits. By using the scrubs, it can allow the skin to absorb moisturizer better and it can help to protect the skin against cross contamination. This scrub formula brings out the potentially beneficial bioactive qualities of mangosteen peel (Chen, 2021).

Mangosteen peel scrub was a natural exfoliating product made from the outer layer of the mangosteen fruit. These because of the granular texture of the scrub may help to remove the dead skin cells and indirectly impurities from the surface of the skin. This can lead to the smoother and brighter skin which may help to remove skin tone when used the mangosteen peel scrub regularly (Suwanseree, 2020). Besides, mangosteen contains a variety of antioxidants such as xanthones. These antioxidants can protect the skin damage from free radical which can contribute to premature aging. Mangosteen peel also may help combat certain bacteria on the skin’s surface because it contains compounds that exhibit antimicrobial properties.

CHAPTER 3

MATERIAL AND METHODS

3.1 Material

3.1.1 Extraction

The materials for extraction process with used 250 mL rounded bottom flask, reflux condenser, 100 mL Soxhlet extractor, extraction sleeve, glass wool, suction flask, Buechner funnel, hot plate, magnetic stir bar, desiccator, oil bath, mangosteen peel 40 g, ethyl acetate about 250 mL, methanol 250 mL, and hexane 250 mL (bp 65 °C). For the decoction in water, 10 grams of mangosteen powder was used and 200ml of distilled water.

3.1.2 Calculation

The calculation formula that used to calculated yields and antioxidant analysis by DPPH.

1. $yield\ of\ extraction = \frac{after\ drying - before\ drying}{initial\ mass\ of\ mangosteen\ powder} x\ 100\%$
2. Scavenging (%) = $\frac{A\circ - AT}{A0}$X 100 %

3.1.2 Material of Scrub

The material of scrub used dried mangosteen peel powdered, honey, and coconut oil. And a few dropped of essential oil was add on for optional.

3.2 Methods

3.2.1 Collection of Mangosteen Peel

The mangosteen fruit (*Garnicia mangostana L.*) was collected in Jeli's market. The mangosteen fruit had been washed and cutting to get the mangosteen peel.

3.2.2 Preparation of Sample

The mangosteen (*Garnicia mangostana L.*) was washed used a tapped water and rinsed with the distilled water. Then, the mangosteen was cut to take the mangosteen peel and washed it again with the distilled water. The sample was dried with dried tissue before put in the oven with the temperature 60°C until the mangosteen peel dried. After that, the sample had been grinded in the blender until it become powder form. The mangosteen peel was kept in the room temperature for the future extraction process.

3.2.3 Soxhlet Extraction

For the extraction methods, 250 mL of (methanol, hexane, ethyl acetate) which boiling point for methanol (64.7°C), hexane (68°C), and ethyl acetate (77.10°C) was filled in a 500 mL round bottom flask. Next, 40g of powdered mangosteen peel was placed in the extraction sleeve of a Soxhlet extractor and covered with a little glass wool. A reflux condenser was put on the Soxhlet extraction unit, then the reaction mixture was extract under strong reflux until the solvents leaving the extraction sleeve was colourless for 3 to 6 hours. The extract was evaporated at the rotary evaporator until crude extract consistency reached. Then, the crude extract of each solvent was put into the empty bottle to dried in a fume hood to get the precipitated solid of crude. After the solvent was dried and become the crude, the bottle that contained crude extract had been weighed to get the amount of the crude for each sample.

Next, the extraction of mangosteen peel using decoction in water. 200 ml of distilled water was boiled (100°C) and 10 grams of mangosteen's powder was put into the boiled distilled water. Then, once it reached a boil, the heat was reduced to low about 20 to30 minutes to make sure that the compound from the peel leach into the water. The mixture was stirred occasionally to prevent the peel from sticked to the beaker. After that, let the decoction cool down at room temperature about 15 to 20 minutes. The mixture was filter using a filter paper to separate the decoction from the solid peels until get the solvent of decoction. Then, the extract would evaporate at the rotary evaporator until crude extract consistency reached and the crude extract of solvent was out into the empty petri dish to dried in oven with temperature 40°C about a night to get the precipitated solid of crude.

3.2.4 Gas Chromatography-Mass Spectrometry (GC/MS)

These methods could identify the presence of active compound of the mangosteen peel extract. The GC/MS instrument would prepare by selecting a suitable capillary column based on the mangosteen peel compound and their expected boiling point. Then, selecting the appropriate ionization mode in the mass spectrometer. The formula, retention time, and peak area had been appeared by this method. The GC/MS analysis of mangosteen peel would reveal the presence of compounds that identified in the mangosteen peel extract for each solvent that was used which is hexane, ethyl acetate, methanol, and distilled water.

A Hewlett Packard 7890B Gas Chromatograph Mass Selective Detector was used o carry out the GC-MS analysis. The column was fused silica capillary, HP-5 column (30 m x 0.25 mm i.d x 0.25 µm film thickness). Then, the carrier gas was helium with a flow rate of 1.0 ml/min with the oven temperature programmed from 50°C which is held for 2 minutes to 280°C held for 10 minutes at a rate of 20°C/ min. At 250°C and 280°C, the injection and interface temperature were set respectively. A 1-ml of each sample was injected in split less mode and was analyzed in MS full scan mode which is *m/z* 40-650.

3.2.5 Fourier Transform Infrared (FTIR) Methods

This method could be used to characterize the functional groups that present in the bioactive compounds extracted from mangosteen peel. Firstly, the sample of mangosteen peel extract was prepared for extracting the bioactive compounds used an appropriate solvent extract by used the different solvents which is hexane, ethyl acetate, methanol, and distilled water. Then, the extract was dried and ground into a fine powder. Next, a small amount of the mangosteen peel powder was put directly into a sample holder or mixed it with the infrared transparent matrix such as KBr. The mangosteen peel extract sample was measured by infrared absorption spectrum using a suitable FTIR spectrometer. The infrared radiation absorbed was measured by the sample in the range of 400-4000 cm¯1.

Next, the presence of specific compounds that had in the mangosteen peel extract would determine by the analysis of the recorded FTIR. For example, carbonyl, hydroxyl, and phenolic groups, the absorbance peaks are compared with reference spectra. The functional groups that had been found as being connected with the antioxidant activity of mangosteen peel extract

include correlation with antioxidant activity. For instance, because they may scavenge free radicals, phenolic groups had been reported to have significant antioxidant action. The results of the FTIR technique were then interpreted. Results appeared to offer significant information about the composition of the bioactive substances that found in mangosteen peel extract.

3.3 Antioxidant Analysis by DPPH

Activity free radical scavenging have been used to assess antioxidant activity (DPPH) 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) would stable the free radicals. When antioxidants contribute hydrogen, the violet hue of the DPPH solution disappears. A spectrophotometer and the DPPH free radical was used to track the colour change. The activity of scavenging has been calculated. In methanol, a stock solution of 0.1 m DPPH was prepared. Test sample of the extract were prepared at 10 g/ml in the methanol for each solvent. The spectrophotometer, the pharma spec UV-1700, would use to detect the absorbance at 514 nm. The equation would compute the percent scavenging after 30 minutes.

According to the calculation methods at 3.1.2, where A0 = DPPH solution absorbance and AT = reference sample absorbance the percent scavenging then plotted versus concentration, and the IC_{50} were calculated by using the regression equation. The number of antioxidants be required as much as 50% or also known as IC_{50} to reduce the first DDPH radical.

3.4 Scrub Preparation

The dried mangosteen peel was grinded into a fine powder by using a blender to ensure that there are no large particles remaining. Next, the ground mangosteen peels and three spoon of honey was combined into a mixing bowl. Then, coconut oil was added into the bowl and mixed them well until all the ingredients are thoroughly combined. Then, a few drops of essential oil were added for fragrance and additional benefits. Then, the ingredients were mixed again. After that, the scrub was transfer into a clean jar. The exfoliating sugar granules and cooling the mangosteen peel which can help leave the skin noticeably softer.

CHAPTER 4

4.1 Result and Discussion

4.1.1 Yield of *Garcinia mangostana L.* extracts

The result of the antioxidant analysis of *Garcinia mangostana L.* are presented in this chapter as a summary of the findings from the study. The discussion of the data follows both its presentation of calculation yield based on the formulation and its analysis.

Table 4.1. Yield of *Garcinia Mangsostana L.* Extraction

Types of solvent	Weight of mangosteen peel crude (gram)	Yield of the mangosteen peel extract (%)
Hexane	20.44	1.90
Ethyl acetate	21.28	4.45
Methanol	21.36	4.15
Distilled water	12.38	7.60

Following the extraction process, the obtained extracts were subjected to evaporation using a rotary evaporator until a crude extract consistency was achieved. Subsequently, the crude extract from each solvent was subjected to drying in a fume hood to dry the extract. The resulting crude material was then accurately weighed to determine the quantity of each sample.

The powder was weighed at 10 grams and incorporated into a 200ml solution of distilled water for extraction through a decoction process. The distilled water was brought to a boil at 100°C, and the powdered material was then added to a beaker, where it was thoroughly stirred to facilitate the extraction process. Subsequently, the mixture was allowed to sit at room temperature for approximately 15 to 20 minutes before undergoing filtration using filter paper. After filtration, the obtained extracts underwent processing in a rotary machine until a crude extract consistency was achieved. The resulting crude extract from each solvent extraction was then transferred to a petri dish and subjected to drying in an oven until it reached a crude state. These crude samples were subsequently submitted to an FTIR machine for analysis to determine the percentage yield of the crude extract. Following this analysis, 0.1 grams of each crude extract were taken and diluted with 10 ml of methanol for the antioxidant test, while 1

gram of each crude extract was diluted with 10 ml of ethanol for the Gas Chromatography-Mass Spectrometry (GC/MS) test.

The extraction of bioactive compounds from *Garcinia Mangostana L*. extract has garnered significant attention due to their potential health benefits, particularly in its peel, which is rich in these compounds. A comparative analysis presented in Table 1 highlights the yield of mangosteen peel using various solvents, with ethyl acetate emerging as the most effective solvent for extraction. Ethyl acetate demonstrated exceptional efficiency, yielding a crude extract of 4.45%. This result underscores its superior ability to extract bioactive compounds from the mangosteen peel. Following ethyl acetate, methanol and hexane also yielded respectable results of 4.15% and 1.90% respectively. Interestingly, distilled water exhibited the highest yield of crude extract at 7.60%.

The effectiveness of ethyl acetate in extracting bioactive compounds can be attributed to its unique properties, such as high volatility and low solubility in water. These characteristics render ethyl acetate an ideal solvent for extracting compounds that are not readily soluble in aqueous environments. Consequently, the extraction method becomes more efficient in producing a concentrated and potent extract from the mangosteen peel when ethyl acetate is utilized as a solvent. Moreover, despite having a lower powder concentration, the high yield obtained with distilled water suggests successful extraction of water-soluble chemicals from the mangosteen peel using this solvent.

4.1.2 Gas Chromatography-Mass Spectrometry (GC/MS) Analysis of *Garcinia Mangostana L.* extracts.

The result GCMS analysis showed the classification of compound identified in *Garcinia Mangostana L.* extract by using different solvents which is hexane, ethyl acetate, methanol, and distilled water. The GC-MS chromatogram obtained for hexane is presented in Figure 1, revealing the identification of sixteen chemical compounds as listed in Table 2. In Figure 2 (ethyl acetate) and Figure 3 (methanol), nine and four chemical compounds are respectively identified and listed in Table 2. Figure 4, representing distilled water, did not show the presence any of compounds. The chemical structure and molecular weight of each identified compound were listed in Table 3.

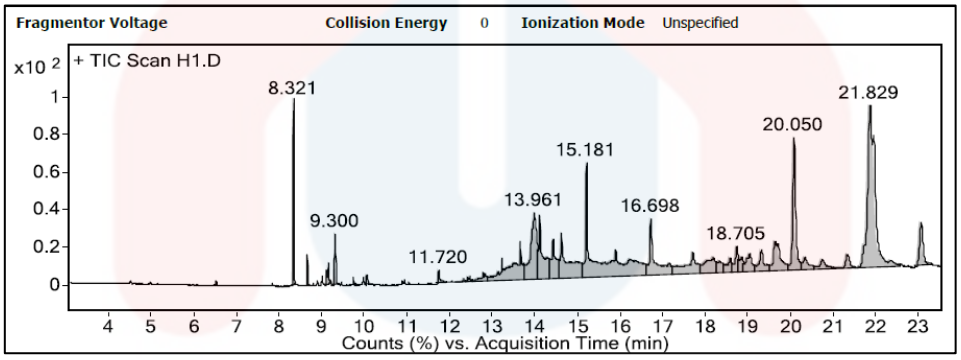


Figure 4.1. GC-MS Chromatogram of *Garcinia Mangostana L.* extract of hexane

Table 4.2.

Compounds found present in the hexane solvents of *Garcinia Mangostana L.* extract using GC-MS

No	Retention Time (Min)	Name Of Compound	(Abate et al., 2022)	Area (%)	References
1	8.321	Copaene	- Antioxidant and anticarcinogenic activity - Used in Flavor and Food Industry. - Used in Aromatherapy. - Used in Food Industry.	9.48	(“Copaene - an Overview | ScienceDirect Topics”) (“Copaene”)

2	9.3	Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylethenyl)-, [1R-(1.alpha.,7.beta.,8a.alpha.)]-	-	Many chronic diseases in human beings, include diabetes, cancer, cardiovascular diseases, and inflammations.	5.1	(PubChem)
3	13.961	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	-	Known as δ-cadinene.	33.24	PubChem (“Naphthalene, 1,2,3,4,5,6-Hexahydro-4,7-Dimethyl-1-(1-Methylethyl)-”) (“Cadinenes”) (“(+)-δ-Cadinene (CAS 483-76-1)”)
			-	Occur in a wide variety of essential oil by producing plants.		
			-	It has antibacterial, insecticidal, and anticancer activities.		
			-	used to treat malarial fever, headache, toothache, burns, ischuria and skin infections.		
			-	Bioenergy, biomedicine, cosmetics, skin care products and spices		
4	14.092	4-epi-cubedol	-	It is a sesquiterpenoid, a tertiary alcohol and a carbotricyclic compound.	21.89	(PubChem, “4-Epi-Cubebol”)
			-	natural product found in Taonia atomaria.		
			-	In traditional medicine against ulcers, snake bite, as well as headache and diseases		
5	14.595	1,2-Benzenedicarboxylic acid, butyl octyl ester	-	Also known as phthalic acid	29.22	(PubChem, “Butyl Octyl Phthalate”) (“Phthalic Acid”)
			-	used as plasticizers in products such as		

				nail polishes and hair sprays, and as solvents and perfume fixatives in many other products.		("Phthalic Acid - an Overview | ScienceDirect Topics")
6	15.181	Octadecanal, 2-bromo-	-	anti-inflammatory and anti-apoptotic effects - Antibacterial, antifungal, and antimicrobial activities are reported	76.72	(PubChem, "2-Bromooctadecanal")
7	16.698	Ethyl iso-allocholate	-	Compound nature: steroid derivative - Anticancer - Anti inflammatory - Antimicrobial activity	25.55	(PubChem, "Ethyl Iso-Allocholate") (Thakur and Ahirwar)
8	20.05	8,14-Seco-3,19-epoxyandrostane-8,14-dione, 17-acetoxy-3.beta.-methoxy-4,4-dimethyl-	-	New chemical compound	32.88	(PubChem, "8,14-Seco-3,19-Epoxyandrostane-8,14-Dione, 17-Acetoxy-3beta-Methoxy-4,4-Dimethyl-")
	21.829	8,14-Seco-3,19-epoxyandrostane-8,14-dione, 17-acetoxy-3.beta.-methoxy-4,4-dimethylz			100	
9	23.022	2,5-Cyclohexadien-1-one, 4-[3,5-bis(1,1-dimethylethyl)-4-oxo-2,5-cyclohexadien-1-ylidene]-2,6-bis(1,1-dimethylethyl)-	-	Butylated hydroxyanisole and related antioxidants	13.83	(PubChem, "2,5-Cyclohexadien-1-One, 2,6-Bis(1,1-Dimethylethyl)-4-Ethylidene-")
10	12.809	7,8-Epoxylanostan-11-ol, 3-acetoxy-	-	Antimicrobial - Anti-inflammatory		(PubChem, "7,8-Epoxylanostan-11-Ol, 3-Acetoxy-")
	12.809	7,8-Epoxylanostan-11-ol, 3-acetoxy-				
	12.809	7,8-Epoxylanostan-11-ol, 3-acetoxy-				
11	12.492	9-Desoxo-9x-hydroxy-7-ketoingol 3,8,9,12-tetraacetate	-	New chemical compound		(PubChem, "9-Desoxo-9x-Hydroxy-

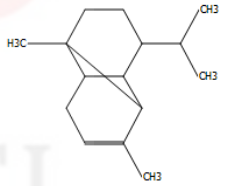
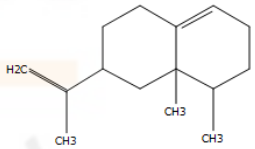
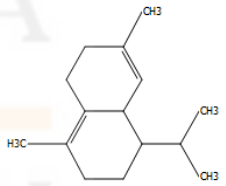
					7-Ketoingol 3,8,9,12-Tetraacetate")
12	9.141	4H-Cyclopropa[5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one, 8,8a-bis(acetyloxy)-2a-[(acetyloxy)methyl]-1,1a,1b,1c,2a,3,3a,	-	New chemical compound	(PubChem, "4H-Cyclopropa[5',6']Benz[1',2':7,8]Azuleno[5,6-b]Oxiren-4-One, 8,8a-Bis(Acetyloxy)-2a-[(Acetyloxy)Methyl]-1,1a,1b,1c,2a,3,3a,6a,6b,7,8,8a-Dodecahydro-3,3a,6b-Trihydroxy-1,1,5,7-Tetramethyl-")
	9.141	4H-Cyclopropa[5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one, 8,8a-bis(acetyloxy)-2a-[(acetyloxy)methyl]-1,1a,1b,1c,2a,3,3a,			
13	14.209	5H-Cyclopropa[3,4]benz[1,2-e]azulen-5-one, 3,9,9a-tris(acetyloxy)-3-[(acetyloxy)methyl]-2-chloro-1,1a,1b,2,3,4,4a,7a,7b,8,9,9a-	-	inhibits IgE synthesis. (Even in the presence of anti-IFN monoclonal antibody)	(PubChem, "5H-Cyclopropa[3,4]Benz[1,2-e]Azulen-5-One, 4,9,9a-Tris(Acetyloxy)-3-[(Acetyloxy)Methyl]-1,1a,1b,4,4a,7a,7b,8,9,9a-Decahydro-4a,7b-Dihydroxy-1,1,6,8-Tetramethyl-")
14	23.028	Olean-13(18)-ene	-	Natural product that found in streptomyces	(PubChem, "Olean-13(18)-Ene")
			-	Compound nature: triterpenoids	
			-	Antitumor activity	
15	20.718	4H-1-Benzopyran-4-one, 8-.beta.-D-glucopyranosyl-5,7-dihydroxy-2-(4-hydroxyphenyl)-	-	Natural product that found in gardenia obtusifolia, gardenia urvillei and other organisms	(PubChem, "4H-1-Benzopyran-4-One, 5,7-Dihydroxy-2-(4-Hydroxyphenyl)-3,6,8-Trimethoxy-") (PubChem, "Vitexin")
			-	Also known as vitexin	
			-	Used in antioxidant, anti-inflammatory,	

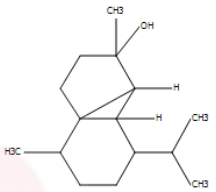
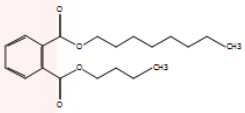
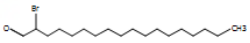
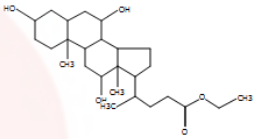
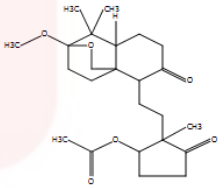
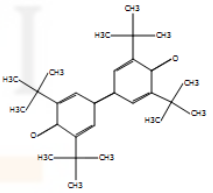
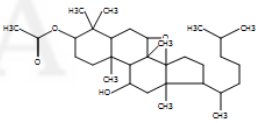
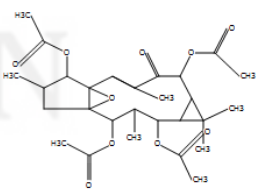
			anticancer and antidiabetic.	
16	23.442	. gamma. -Sitosterol	- Also known as clionasterol - a naturally occurring plant steroid isolatable from plants of the genus Lagerstroemia. - a stereoisomer of beta-sitosterol, which sees wide use as an over-the-counter natural supplement. - Uses as Anti-inflammatory, antidiabetic and anticancer.	(PubChem, "Clionasterol") ("NCATS Inxight Drugs — .GAMMA.-SITOSTEROL")

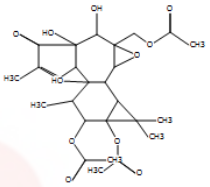
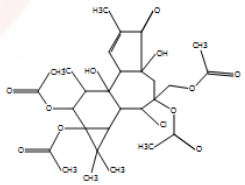
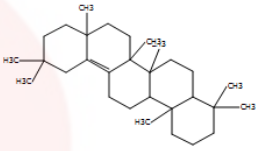
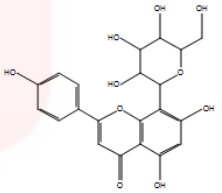
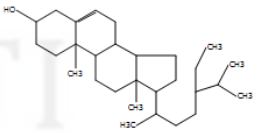
**Source Of References*: (NCBI)

Table 4.3.

Compounds found present in the hexane solvents of *Garcinia Mangostana L.* extract using GC-MS

No	Name of compound	Molecular weight (g/mol)	Chemical structure
1	Copaene	204.35	 C15H24
2	Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylethenyl)-, [1R-(1.alpha.,7.beta.,8a.alpha.)]-	204.3511	 C15H24
3	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	204.3511	 C15H24

4	4-epi-cubedol	222.37		C15H26O
5	1,2-Benzenedicarboxylic acid, butyl octyl ester	334.4		C20H30O4
6	Octadecanal, 2-bromo-	347.4		C18H35BrO
7	Ethyl iso-allocholate	452.7		C27H48O5
8	8,14-Seco-3,19-epoxyandrostane-8,14-dione, 17-acetoxy-3.beta.-methoxy-4,4-dimethyl- 8,14-Seco-3,19-epoxyandrostane-8,14-dione, 17-acetoxy-3.beta.-methoxy-4,4-dimethylz	420.5		C24H36O6
9	2,5-Cyclohexadien-1-one, 4-[3,5-bis(1,1-dimethylethyl)-4-oxo-2,5-cyclohexadien-1-ylidene]-2,6-bis(1,1-dimethylethyl)-	232.36		C16H24O
10	7,8-Epoxylanostan-11-ol, 3-acetoxy- 7,8-Epoxylanostan-11-ol, 3-acetoxy- 7,8-Epoxylanostan-11-ol, 3-acetoxy-	502.8		C32H54O4
11	9-Desoxo-9x-hydroxy-7-ketoingol 3,8,9,12-tetraacetate	534.6		C28H38O10

12	4H-Cyclopropa[5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one, 8,8a-bis(acetyloxy)-2a-[(acetyloxy)methyl]-1,1a,1b,1c,2a,3,3a, 4H-Cyclopropa[5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one, 8,8a-bis(acetyloxy)-2a-[(acetyloxy)methyl]-1,1a,1b,1c,2a,3,3a,	522.5		C26H34O11
13	5H-Cyclopropa[3,4]benz[1,2-e]azulen-5-one, 3,9,9a-tris(acetyloxy)-3-[(acetyloxy)methyl]-2-chloro-1,1a,1b,2,3,4,4a,7a,7b,8,9,9a-	548.6		C28H36O11
14	Olean-13(18)-ene	410.7		C30H50
15	4H-1-Benzopyran-4-one, 8-.beta.-D-glucopyranosyl-5,7-dihydroxy-2-(4-hydroxyphenyl)-	360.3		C18H16O8
16	.gamma.-Sitosterol	414.7067		C29H50O

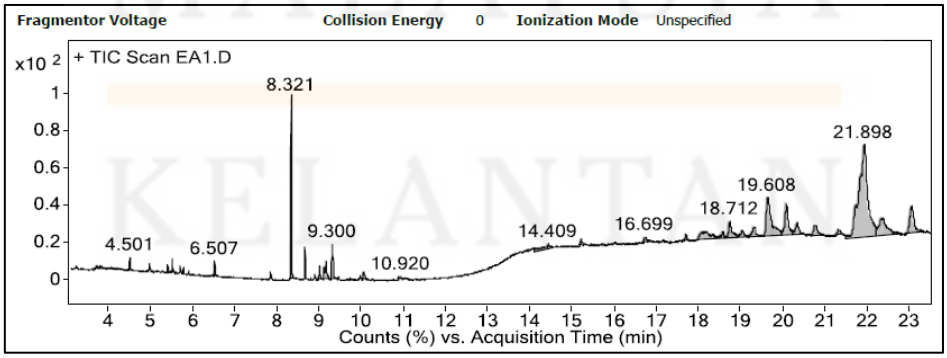


Figure 4.2. GC-MS Chromatogram of *Garcinia Mangostana L.* extract of ethyl acetate

Table 4.4.

Compound found present in the ethyl acetate solvents of *Garcinia Mangostana L.* extract using GC-MS

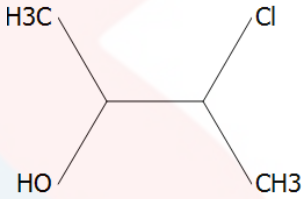
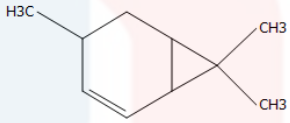
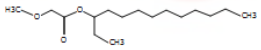
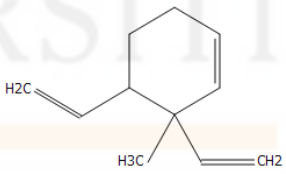
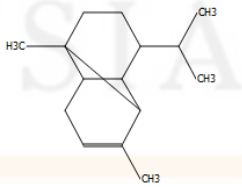
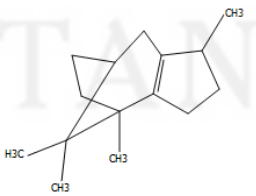
No	Retention time (min)	Name of compound	Biological uses	Area (%)	References
1	6.507	2-Butanol, 3-chloro-, (R*,R*)-	- Soluble in water and moderately soluble in organic solvents - May used as a precursor for other pharmaceutical or agrochemical compounds	1.26	(NIST)
2	8.321	(+)-4-Carene (suitable for scrub but have pros and cons)	- Belongs to the class of organic compounds known as bicyclic monoterpenoids. It neutral. 1. Fragrance industry - Perfumes - Air fresheners - Cleaning products 1. Pharmaceutical industry - Anti-inflammatory effects - Anti-cancer properties - Neuroprotective effects - Anti-anxiety effects	13.32	("Showing Compound Delta-4-Carene (FDB006928) - FooDB") (Woo et al., "3-Carene, a Phytoncide from Pine Tree Has a Sleep-Enhancing Effect by Targeting the GABAA-Benzodiazepine Receptors")
3	9.141	Methoxyacetic acid, 3-tridecyl ester	- the major metabolite of ester phthalates widely used in industry as gelling, viscosity, and stabilizer reagents	4.37	(Sigma Aldrich, "IR Spectrum Table & Chart")
4	9.3	Cyclohexene, 3,4-diethenyl-3-methyl-	- It could serve as a precursor for the synthesis of other valuable chemicals or pharmaceuticals.	5.63	(Sigma Aldrich)
5	18.712	Copaene	- Antioxidant and anticarcinogenic activity	8.58	("Copaene - an Overview |

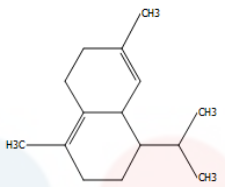
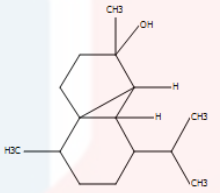
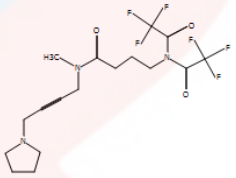
			- Used in Flavor and Food Industry. - Used in Aromatherapy. - Used in Food Industry.		ScienceDirect Topics") ("Copaene")
6	20.05	Patchoulene	- A tricyclic sesquiterpene isolated from the oil of Pogostemon cablin (pathchouli oil) - Used in traditional Chinese medicine for the treatment of inflammatory disease. - Could be beneficial for treatment skin conditions like eczema and psoriasis.	14.1	(PubChem, "Beta-Patchoulene") (Zhang et al.)
7	21.898	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	- Known as δ-cadinene. - Occur in a wide variety of essential oil by producing plants. - It has antibacterial, insecticidal, and anticancer activities. - used to treat malarial fever, headache, toothache, burns, ischuria and skin infections. - Bioenergy, biomedicine, cosmetics, skin care products and spices	100	(PubChem, "Naphthalene, 1,2,3,4,5,6-Hexahydro-4,7-Dimethyl-1-(1-Methylethyl)-") ("Cadinenes") ("Delta Cadinene - an Overview | ScienceDirect Topics")
8	22.325	4-epi-cubedol	- It is a sesquiterpenoid, a tertiary alcohol and a carbotricyclic compound. - natural product found in Taonia atomaria. - In traditional medicine against ulcers, snake bite, as well as headache and diseases	18.57	(PubChem, "4-Epi-Cubebol") (PubChem, "Taonia Atomaria")
9	23.008	4-Aminobutyramide, N-methyl-N-[4-(1-pyrrolidinyl)-2-	- It belongs to the class of amides that contain a central -CONH2 groups.	15.17	(McElhinny et al.) (Wikipedia

	butynyl]-N',N'-bis(trifluoroacetyl) -	-	An aminobutyramide backbone, potentially related to the neurotransmitter GABA (gamma-aminobutyric acid).	Contributors, "γ-Aminobutyric Acid")

**Source Of References*: (NCBI)

Table 4.5.
Compound found present in the ethyl acetate solvents of *Garcinia Mangostana L.* extract using GC-MS

No	Name of compound	Molecular weight (g/mol)	Chemical structure
1	2-Butanol, 3-chloro-, (R*,R*)-	108.57	 C4H9ClO
2	(+)-4-Carene (suitable for scrub but have pros and cons)	136.23	 C10H16
3	Methoxyacetic acid, 3-tridecyl ester	272.42	 C16H32O3
4	Cyclohexene, 3,4-diethenyl-3-methyl-	148.24	 C11H16
5	Copaene	204.35	 C15H24
6	Patchoulene	204.35	 C15H24

7	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	204.35		C15H24
8	4-epi-cubedol	222.37		C15H26O
9	4-Aminobutyramide, N-methyl-N-[4-(1-pyrrolidinyl)-2-butynyl]-N',N'-bis(trifluoroacetyl)-	429.36		C17H21F6N3O3

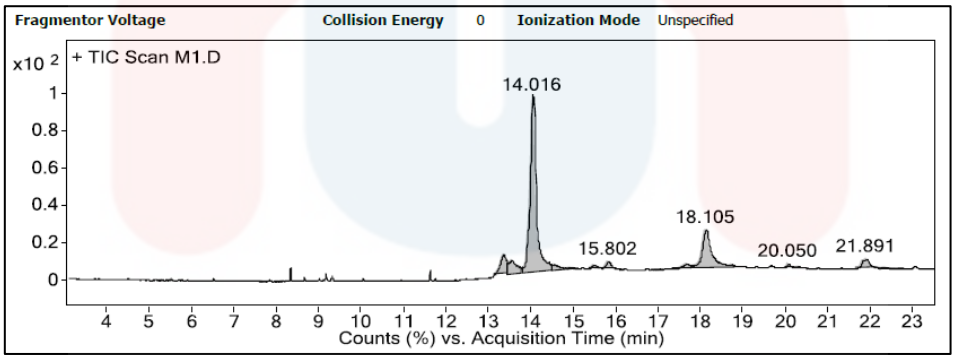


Figure 4.3. GC-MS Chromatogram of *Garcinia Mangostana L.* extract of methanol

Table 4.6.

Compound found present in the methanol solvents of *Garcinia Mangostana L.* extract using GC-MS

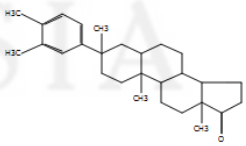
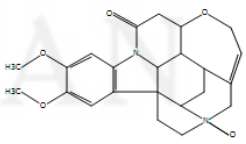
No	Retention Time (Min)	Name Of Compound	Biological Uses	Area (%)	References
1	13.347	17-Androstanone, 3-(3,4-dimethylphenyl)-3-methylz	- a synthetic anabolic steroid with androgenic and anabolic properties - potential health risk and lack of approval medical uses	10.59	(PubChem, "17-Androstanone, 3-(3,4-Dimethylphenyl)-3-Methyl-") (Wikipedia Contributors, "Androsterone")

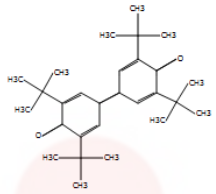
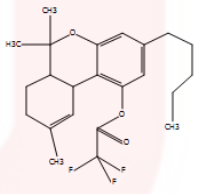
2	13.547	Strychnidin-10-one, 2,3-dimethoxy-, 19-oxide	-	Highly toxic, colorless, bitter, crystalline alkaloid - Used as pesticide for killing small vertebrates such as birds and rodents. - the use of strychnine in modern medicine is non-existent.	11.04	(Wikipedia Contributors)
3	14.016	2,5-Cyclohexadien-1-one, 4-[3,5-bis(1,1-dimethylethyl)-4-oxo-2,5-cyclohexadien-1-ylidene]-2,6-bis(1,1-dimethylethyl)-	-	Butylated hydroxyanisole and related antioxidants	100	(PubChem, "2,5-Cyclohexadien-1-One, 2,6-Bis(1,1-Dimethylethyl)-4-Ethylidene-")
4	18.105	.DELTA.9-THC TFA	-	Delta-9-tetrahydrocannabinol (THC) is a medical compound. - Used in forensic toxicology and drug testing laboratories. - It not good for organic product because it could potentially damage sensitive surfaces.	34.46	(Ng and Gupta)

**Source Of References*: (NCBI)

Table 4.7.

Compound found present in the methanol solvents of *Garcinia Mangostana L.* extract using GC-MS

No	Name Of Compound	Molecular weight (g/mol)	Chemical structure
1	17-Androstanone, 3-(3,4-dimethylphenyl)-3-methylz	392.6	 C28H40O
2	Strychnidin-10-one, 2,3-dimethoxy-, 19-oxide	334.419	 $C_{21}H_{22}N_2O_2$

3	2,5-Cyclohexadien-1-one, 4-[3,5-bis(1,1-dimethylethyl)-4-oxo-2,5-cyclohexadien-1-ylidene]-2,6-bis(1,1-dimethylethyl)-	232.36		C16H24O
4	.DELTA.9-THC TFA	410.5		C23H29F3O3

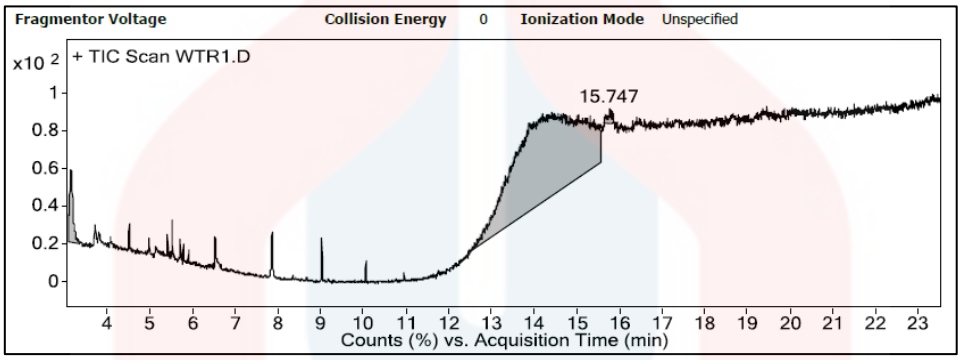


Figure 4.4. GC-MS Chromatogram of *Garcinia Mangostana L.* extract of distilled water

Table 4.8.

Compound found present in the distilled water solvents of *Garcinia Mangostana L.* extract using GC-MS

Name of Compound
-

As shown in figure 4.2 to 4.4, there are the GC-MS chromatograms of hexane, ethyl acetate, methanol, and distilled water extract, respectively. The chemical compounds of the four extracts of *Garcinia Mangostana L.* were determined by the qualitative analysis of CG-MS. GC-MS were used to analyse the chromatographic spectrum of the extract (reference). The relative of percentage of each component were calculated by are normalization methods. GC-MS also was used to analyse the mass spectrometry data of each extract. Table 4.2 to 4.8 were the results of GC-MS analysis of hexane, ethyl acetate, methanol, and distilled water.

A total of 227 peaks were isolated and 16 compound were identified by GC-MS chromatographic analysis of hexane extract of *Garcinia Mangostana L.* which is copaene (9.48%), Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylethenyl)-, [1R-(1.alpha.,7.beta.,8a.alpha.)]- (5.1%), Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)- (33.24%), 4-epi-cubedol (21.89%), 1,2-Benzenedicarboxylic acid, butyl octyl ester (29.22%), Octadecanal, 2-bromo- (76.72%), Ethyl iso-allocholate (25.55%), 8,14-Seco-3,19-epoxyandrostane-8,14-dione, 17-acetoxy-3.beta.-methoxy-4,4-dimethyl- (32.88%)(100%), 2,5-Cyclohexadien-1-one, 4-[3,5-bis(1,1-dimethylethyl)-4-oxo-2,5-cyclohexadien-1-ylidene]-2,6-bis(1,1-dimethylethyl)- (13.83%), 7,8-Epoxylanostan-11-ol, 3-acetoxy-, 9-Desoxo-9x-hydroxy-7-ketoingol 3,8,9,12-tetraacetate, 4H-Cyclopropa[5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one, 8,8a-bis(acetyloxy)-2a-[(acetyloxy)methyl]-1,1a,1b,1c,2a,3,3a, 5H-Cyclopropa[3,4]benz[1,2-e]azulen-5-one, 3,9,9a-tris(acetyloxy)-3-[(acetyloxy)methyl]-2-chloro-1,1a,1b,2,3,4,4a,7a,7b,8,9,9a-, Olean-13(18)-ene , 4H-1-Benzopyran-4-one, 8-.beta.-D-glucopyranosyl-5,7-dihydroxy-2-(4-hydroxyphenyl)-, and . gamma. -Sitosterol.

Next, a total of 281 peaks were isolated and nine compound were identified by GC-MS chromatographic analysis of ethyl acetate extract of *Garcinia Mangostana L.* which is 2-Butanol, 3-chloro-, (R*,R*)- (1.26%), (+)-4-Carene (13.32%), Methoxyacetic acid, 3-tridecyl ester (4.37%), Cyclohexene, 3,4-diethenyl-3-methyl- (5.63%), Copaene (8.58%), Patchoulene (14.1%), Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)- (100%), 4-epi-cubedol (18.57%), and 4-Aminobutyramide, N-methyl-N-[4-(1-pyrrolidinyl)-2-butynyl]-N',N'-bis(trifluoroacetyl)- (15.17%).

However, a total of 265 peaks were isolated and four compound were identified by GC-MS chromatographic analysis of methanol extract of *Garcinia Mangostana L.* which is 17-Androstanone, 3-(3,4-dimethylphenyl)-3-methylz (10.59%), Strychnidin-10-one, 2,3-dimethoxy-, 19-oxide (11.04%), 2,5-Cyclohexadien-1-one, 4-[3,5-bis(1,1-dimethylethyl)-4-oxo-2,5-cyclohexadien-1-ylidene]-2,6-bis(1,1-dimethylethyl)- (100%), DELTA.9-THC TFA (34.46).

Lastly, the absence of identified compound despite the isolation of 259 peaks in the GC-MS chromatographic analysis of the distilled water extract of *Garcinia Mangostana L.* The wide range of peaks found in the chromatographic analysis suggests that the distilled water extract contains a variety of chemical entities. GC-MS may not be able to separate or identify

certain molecules well, particularly those with high molecular weights, low volatility, or weak ionization properties. Furthermore, as the availability of genuine standards is necessary for the comparison of retention periods and mass spectra, the absence of reference standards for some compounds may prevent proper identification.

4.1.3 Fourier Transform Infrared (FTIR) Analysis of *Garcinia Mangostana L.* Extracts

The result FTIR analysis or FTIR spectroscopy was recorded which is the extract of hexane, ethyl acetate, methanol, and distilled water.

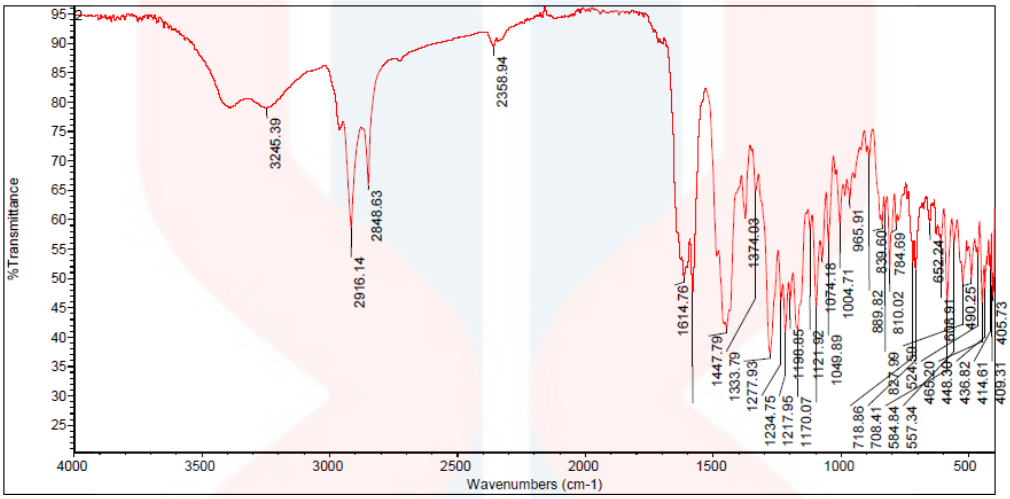


Figure 4.5. FTIR of *Garnicia Mangostana L.* extract of Hexane

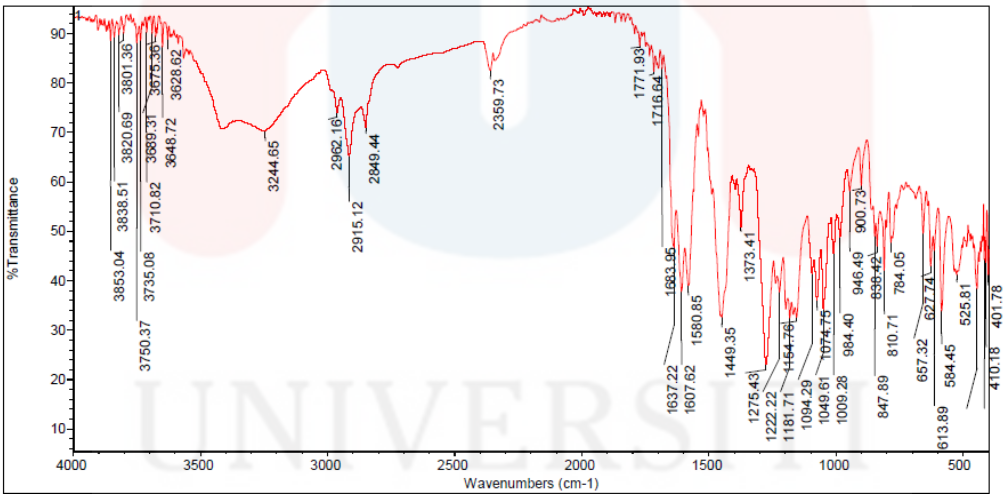


Figure 4.6. FTIR of *Garnicia Mangostana L.* extract of Ethyl Acetate

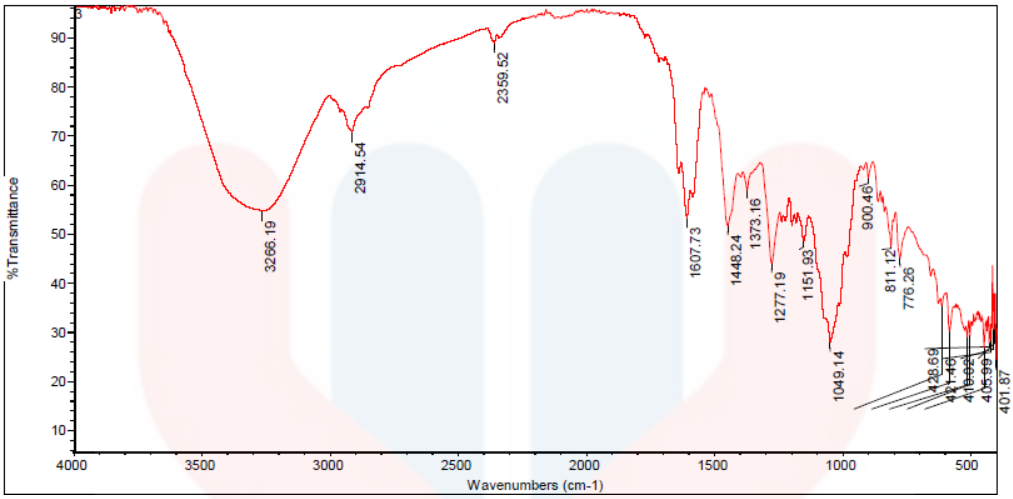


Figure 4.7. FTIR of *Garnicia Mangostana L.* extract of Methanol

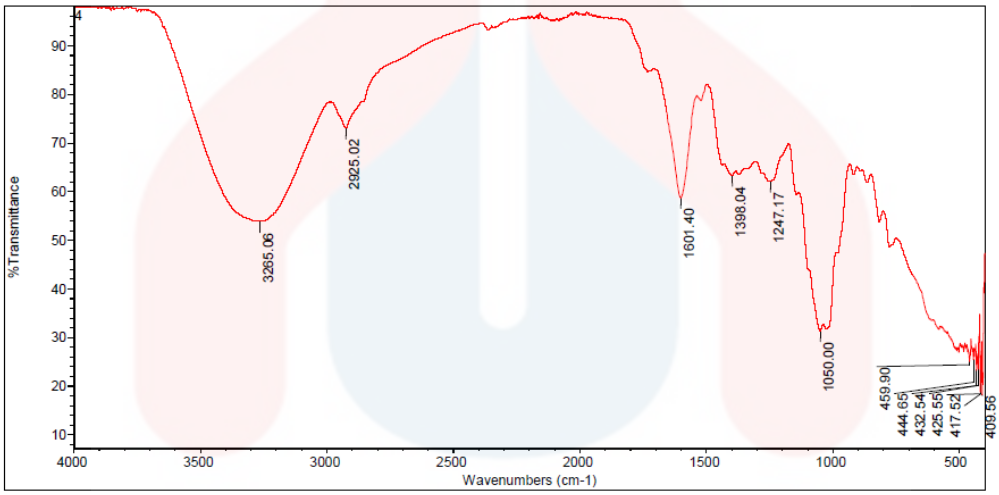


Figure 4.8. FTIR of *Garnicia Mangostana L.* extract of Distilled Water

The FTIR spectrum was used to identify the functional groups of the bioactive compounds based on the peak value in the region of infrared radiation. The analysis using FTIR spectroscopy of different solvent which is hexane, ethyl acetate, methanol, and distilled water was performed at wavenumber 400-4000 cm¯1. The FTIR spectrum of *Garcinia Mangostana L.* extract in the form of KBr pallet is shown in figure 4.5 to 4.8.

Firstly, the outcomes of the FTIR analysis of this hexane crude extract are represented based on the types of chemical bonds and its different funtional groups that presents characteristics the peak at specific wavenumbers in FTIR spectroscopy. The peak at 3245.39 cm¯1 in a FTIR spectrum indicates chemical bonding is hydrocarbons. This peak is commonly associated with hydrocarbons (C-H) groups that can be used to distinguish between alkane, alkene, and alkyne. This peak identified the C-H stretch, indicates the existence of aliphatic hydrocarbons. The aliphatic hydrocarbons often have strong and abroad C-H stretching around

3000 cm¯1 and represent of -CH around 1447.79 cm¯1, 1374.03 cm¯1, and 1333.79 cm¯1. The atom was directly attached to the aliphatic groups may resulted in the significant shifts from the standards frequencies and the adjacent of atom with high electro negativity will sift the band locations to the higher frequencies. The exact position of the peak can vary significantly depending on molecule structure and the presence of adjacent functional groups. Besides, there are two methyl groups on a single carbon which is t-butyl and isopropyl. The presence of the t-butyl groups can be confirmed by the presence of band around 1277.93, 1234.75, and 1217.95 cm¯1 while the presence of the isopropyl groups shows the bands near 1198.85, 1170.07, 1121.92 cm¯1.

Secondly, the outcomes of the FTIR analysis of this ethyl acetate crude extract are represented based on the identification of specific chemical bonds and their associated functional groups, which manifest as characteristic peaks at specific wavenumbers in FTIR spectroscopy. In this analysis, two significant peaks were observed at 1771.93 cm^{-1} and 1716.64 cm^{-1}, indicating the presence of chemical bonding related to carboxylic acid groups. These peaks are commonly associated with carbonyl (C=O) groups and specifically represent the stretching vibration of C=O bonds, suggesting the existence of aromatic phenones compounds. Ketones, such as aromatic phenones, exhibit strong absorption in these peaks, with only a slight low-frequency shift for the carbonyl stretching absorptions in aryl ketones. For instance, compounds like acetophenone typically show a C=O stretch around 1690 cm^{-1}. Furthermore, the analysis also identified the presence of CH_3 (methyl) and CH_2 (methylene) stretching vibrations, indicating the existence of aliphatic hydrocarbons. Aliphatic hydrocarbons often exhibit strong and broad CH_3 asymmetric stretching and CH_2 absorption stretching, which occur at wavenumbers around 2962.16 cm^{-1}, 2915.12 cm^{-1}, 2849.44 cm^{-1}, 1449.35 cm^{-1}, and 1373.41 cm^{-1}.

Thirdly, the outcomes of the FTIR analysis of this methanol crude extract are represented based on the types of chemical bonds and its different funtional groups that presents characteristics the peak at specific wavenumbers in FTIR spectroscopy. The peak at 3266.19 cm¯1 in a FTIR spectrum indicates chemical bonding is amine and amide. This peak is commonly associated with amine and amides (NH) groups. This peak identified the NH stretch, indicates the existence of aliphatic primary amines. Amines are classified as a primary due to the number of groups that attached to the nitrogen atoms. Amines also important class of organic compounds. Besides, there also have another functional group which is primary aliphatic alcohols. The peaks at 1373.16 cm¯1 indicates chemical bonding is hydroxyl (-OH)

groups. These compounds are classified as primary due to its number of other carbon atoms that attached to the oxygen bound carbon. This is cause by the alcohols that contain the very polar -OH groups. So, this allows that hydrogen bonding between the molecules in the condensed phase.

Lasty, the outcomes of the FTIR analysis of this distilled water crude extract are based on the identification of specific chemical bonds and their associated functional groups, as indicated by characteristic peaks at specific wavenumbers in the FTIR spectroscopy spectrum. In this analysis, a peak at 3265.06 cm^{-1} was observed, which is commonly associated with chemical bonding related to amine and amide groups (NH). This peak signifies the stretching vibration of NH bonds, indicating the presence of aliphatic primary amines within the sample. These amines are classified as primary due to the number of groups attached to the nitrogen atoms, and they are an important class of organic compounds. Besides, another functional group identified in the analysis is primary aliphatic alcohols, which is represented by peaks at 2925.02 cm^{-1}. This peak corresponds to chemical bonding associated with hydroxyl (-OH) groups. These compounds are categorized as primary aliphatic alcohols because of the specific arrangement of other carbon atoms attached to the oxygen-bound carbon. The high polarity of alcohols containing the -OH group allows for hydrogen bonding between molecules in the condensed phase.

4.2 Antioxidant Activity of *Garcinia Mangostana L.* Extracts

The result of antioxidant activity of *Garcinia Mangostana L.* Extract by using different solvents which is hexane, ethyl acetate, methanol, and distilled water. Different solvents have varying degrees of polarity, which can affect the types and amounts of compounds extracted from the plant material. Antioxidant activity is often attributed to the presence of bioactive compounds such as xanthones and polyphenols in *Garcinia mangostana L.*

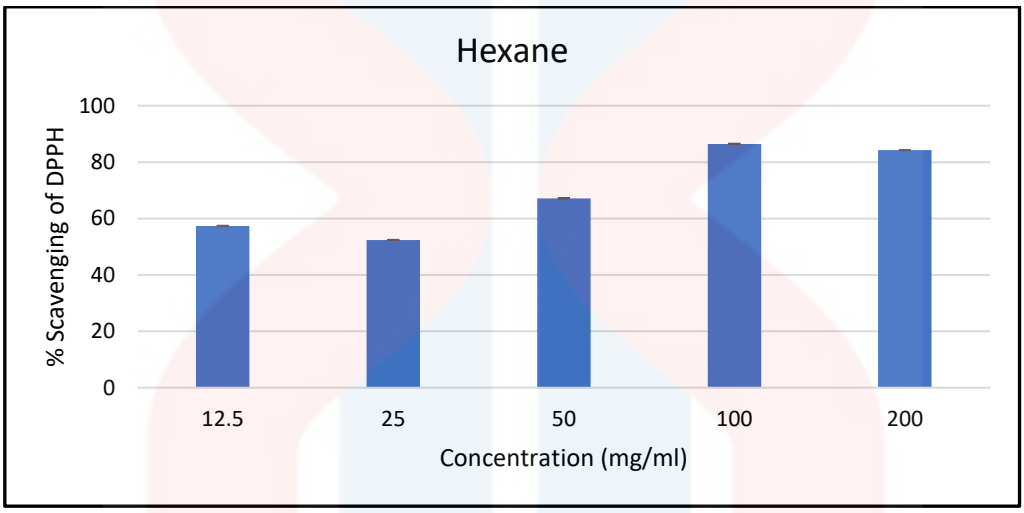


Figure 4.9. Comparison of % scavenging of DPPH at different concentration in extraction of hexane.

The figure 4.9, shows the comparison of scavenging of DPPH at different concentration in extraction of hexane. At the concentration of 12.5 mg/ml, the sample was exhibited a scavenging activity of 57.36% with a relatively high standard deviation of 15.42, indicated some variability in the measurements. However, the IC_{50} represent the concentration at which 50%of the DPPH radicals were scavenged, was observed at 25 mg/ml. This suggested that the antioxidant activity of the sample significant which is it was achieves half maximal scavenging of the DPPH radicals at this concentration.

Then, the concentration of the sample increased to 25 mg/ml, the scavenging activity decreased slightly to 52.40%. This was decreased in the scavenging activity because of the attributed to the saturation effect due to the increased the concentration of antioxidant that beyond to a certain point that doesn't necessarily lead to a proportional increased in scavenging activity. However, as the concentration continue to be increased at 50 mg/ml followed by 100 mg/ml, and 200 mg/ml, the scavenging activity increased substantially at 67.15%, 86.47%, and 84.25% respectively. The highest concentration shows a clear improvement in scavenging activity and it's demonstrating a dose-dependent response. The antioxidant activity, in terms

of DPPH scavenging, increases with higher concentrations of *Garcinia Mangostana L.* extract, but this increase in activity seems to plateau or even slightly decrease at the highest concentrations tested. This was due to the Hexane solvent was a nonpolar solvent, and it is typically used for extracting nonpolar compounds such as lipids and certain volatile compounds. While hexane may be extracting some compounds from *Garcinia mangostana L.*, it is unlikely to yield a high concentration of antioxidant compounds and the antioxidant activity of hexane extract may be relatively low.

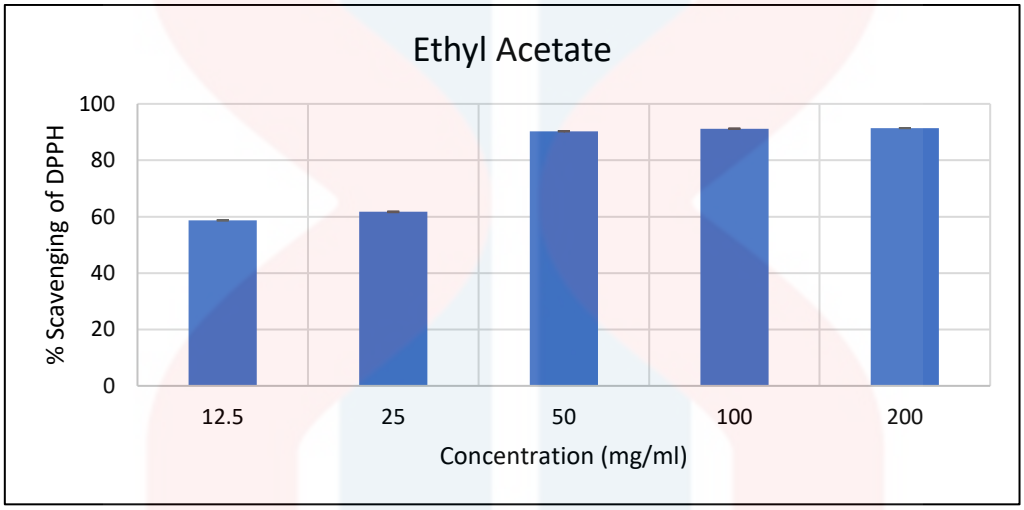


Figure 4.10. comparison of % scavenging of DPPH at different concentration in extraction of ethyl acetate.

The figure 4.10, shows the comparison of scavenging of DPPH at different concentration in extraction of ethyl acetate. At the concentration of 12.5 mg/ml, the ethyl acetate extract exhibited a scavenging activity of 58.70% with a standard deviation of 16.88 which is indicative of some variability in the measurements. The IC_{50} value of this ethyl acetate represents the concentration at which 50% of the DPPH radicals were scavenged. This suggest that the antioxidant activity of this solvent extract was significant and achieved half maximal of scavenging of the DPPH radicals at 12.5 mg/ml. This suggest that the scavenging DPPH radicals at this concentration was particularly effective.

As the concentration of these extract was increased to 25 mg/ml, 50 mg/ml, 100 mg/ml, and 200 mg/ml, the scavenging activity also continued increased substantially. At 25 mg/ml, the scavenging activity increased to 61.73%, indicating an improvement in the antioxidant activity. Further increased in the concentration led to higher scavenging activities reached 90.30% at 50 mg/ml, 91.21% at 100 mg/ml, and 91.41% at 200 mg/ml. These shows that a clear dose dependent response, suggest that the higher concentrations of the ethyl acetate

extract that was resulted in enhanced antioxidant activity. This was due to the Ethyl acetate solvent was a moderately polar solvent. It can extract a wider range of compounds compared to hexane, including some antioxidant compounds like xanthones. The antioxidant activity of the ethyl acetate extract may be moderate to high, depending on the specific extraction conditions.

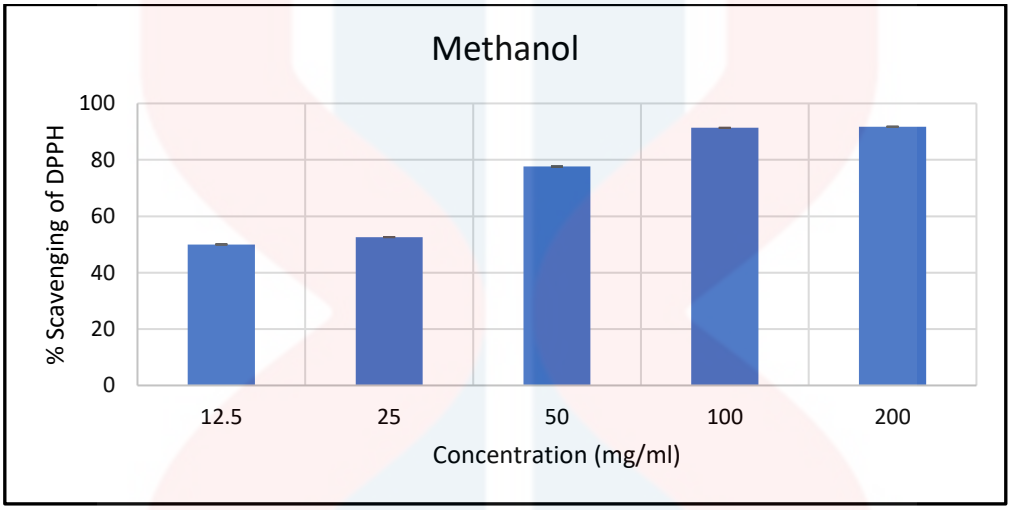


Figure 4.11. comparison of % scavenging of DPPH at different concentration in extraction of methanol.

The figure 4.11, shows the comparison of scavenging of DPPH at different concentration in extraction of methanol. At the concentration of 12.5 mg/ml, the sample that exhibited a scavenging activity of 50% with a standard deviation of 20.34, that was indicated some variability in the measurements. The IC_{50} value was calculated at the concentration which is 50% of DPPH radicals were scavenged. This was suggested that the antioxidants activity of the sample was significant, and it was achieved half maximal scavenging of the DPPH radicals at 12.5 mg/ml.

Next, the concentration of the sample was increased to 25 mg/ml, 50mg/ml, 100 mg/ml, 200 mg/ml, and the scavenging activity also improved. At the concentration 25 mg/ml, it increased to 52.60% indicated a slight enhancement in the antioxidant activity compared to the 12.5 mg/ml. While, at 50 mg/ml the scavenging activity further increased to 77.63%, signifying an improvement in the antioxidant potential. The highest scavenging activities were observed at 100 mg/ml (91.35%), and 200 mg/ml (91.75%) respectively. These results show a clear dose dependent response which is higher concentrations of the samples led to the enhancement antioxidant activity. This was due the methanol solvent is a polar solvent and that can extract a broad spectrum of compounds, including polar antioxidants like polyphenols. The methanol

extracts from *Garcinia Mangostana L.* may have a relatively high antioxidant activity due to the extraction of a wide range of bioactive compounds.

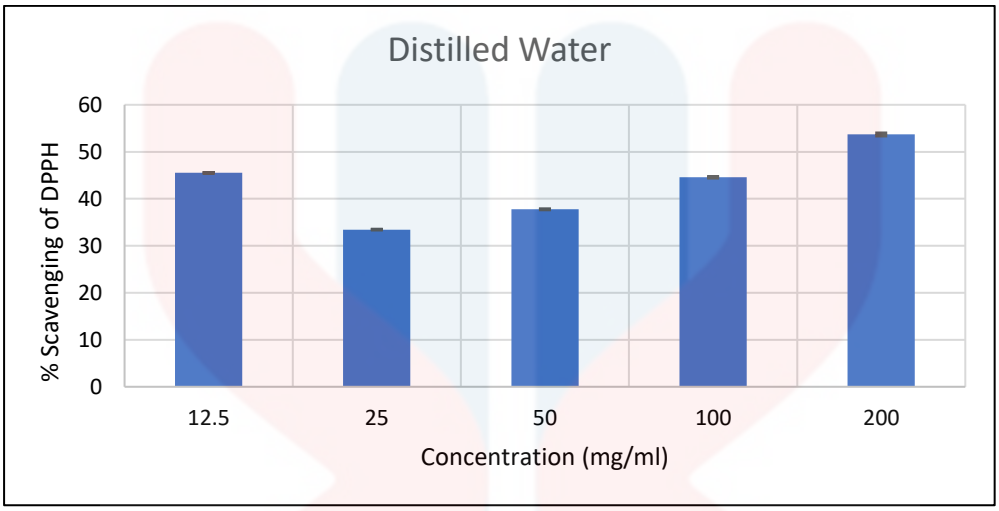


Figure 4.12. comparison of % scavenging of DPPH at different concentration in extraction of distilled water.

The figure 4.12, shows the comparison of scavenging of DPPH at different concentration in extraction of distilled water. At the concentration of 12.5 mg/ml, the sample was exhibited a scavenging activity of 45.52% with a relatively low standard deviation which is 7.77 that indicates relatively low variability in the measurements. The IC_{50} value was observed at the concentration of 50% of DPPH radicals were scavenged, it was observed at the highest concentration which is 200 mg/ml. This suggests that the antioxidant activity of the sample was primarily concentrated at this higher concentration which it achieves the half maximal scavenging of the DPPH radicals at 200 mg/ml.

Then, the concentration of the sample increased from 12.5 mg/ml to 25 mg/ml, 50 mg/ml, and 100 mg/ml, the scavenging activity remained relatively low, which from 33.45% to 44.58%. This concentration showed limited antioxidant activity compared to the IC_{50} value at the 200 mg/ml. While, at the concentration of 200 mg/ml, the scavenging activity was increased to 53.68%. Distilled water solvent was a polar solvent, but it may not extract as many nonpolar compounds as organic solvents like hexane and ethyl acetate. However, it can still extract some water-soluble antioxidants like polyphenols and flavonoids. The antioxidant activity of the water extract may be moderate.

Furthermore, the variability in the antioxidant activity by using the different solvents which is hexane, ethyl acetate, methanol, and distilled water. It was suggested that the choice

of the solvents was significantly impacted by the outcome of phytochemicals extraction and subsequent antioxidants testing. The hexane solution initially shows the inverse relationships between the concentrations of the DPPH scavenging, which may be due to the fact of the selectively extracts certain compounds with the lower antioxidant properties, while excluding others with the higher antioxidant potential. Moreover, the methanol and ethyl acetate solution exhibited a more linear increased in the scavenging activity with the increased of the extract concentration.

Finally, the observations of the saturation points where an optimal concentration range in exist beyond on the further increased in the concentration that do not significantly enhance the scavenging activity. This will cause of the factors such as saturation of the active binding sites on the DPPH radicals or the presence of the pro-oxidant effects at the higher concentration. While, the distilled water solution, tend to be less effective because of the phytochemicals that are hydrophobic in the nature and may not readily dissolve in the water. In the observed scavenging activity can attributed that the distilled water was lack of antioxidant properties.

4.3 Scrub

The scrub was formulated by the mangosteen peel powder. The ingredient was due to its rich antioxidant's properties which is include of the ethyl acetate crude extract.

Figure 4.13. The Formulated of Scrub

Table 4.9. The Characteristics of Scrub

TYPES	CHARACTERISTICS
Colour	Brown
Texture	Semi solid
Aroma	Tangy
Effects	- A bit oily - Can remove a dirt. - Can moisture the skin. - Give brightening effects

The characteristics of this mangosteen peel scrub, the colour was brown which presence of natural ingredient that was used which is the fine powder of mangosteen peel. The use of mangosteen peel as an ingredient is due to its rich antioxidant's properties (Weerayuth Suttirak & Supranee Manurakchinakorn, 2014). Antioxidants play a crucial in role skincare as its help combat free radicals which is are harmful molecules that can damage the skin accelerate the aging process. In addition, this brown mangosteen peel scrub not only serves as an effective exfoliant but also contributes to the improvement of skin quality and the maintenance of a youthful and radiant complexion (Bodeker & Shekar, 2009).

Next, the texture of scrub was semi solid. This texture was allowing the scrub to adhere effectively to the skin's surface which is ensuring the active ingredients such as the antioxidant of the mangosteen peel powder are indirect contact with the consumer's skins. This adherence was crucial for maximizing the benefits of exfoliation and the delivery of these beneficial

compounds to the skins. Moreover, the semi solid texture also makes the application of process more controlled and less messy. This characteristic will make it easier for users to apply the scrub evenly without dripping or running off the skin. So, the controlled applications will enhance the effectiveness of the products.

Furthermore, the aroma of this scrub was tangy. Aromas in cosmetic products, especially pleasant and indulgent scents like sweet chocolate by using essential oil, play a significant role in the sensory experience for consumers. These aromas also can promote relaxation and reduce stress during the skincare routine (Anthis, 2020).

Finally, the effects of which is it's a bit oily. This indicates that the presence of oils such as coconut oil that are excellent for moisturizing the skins (Mank & Polonskaya, 2016). These ingredients can help to nourish the skin and leaving it feeling soft. The oily texture also can help in applying the products smoothly over the skins. Next, the scrubs also can remove the dirt and can moisturize the skin. The ingredients such as honey can help in exfoliating property. Exfoliation was the main key to removing dead skin cells and improved skin renewal which can lead to a fresher and cleaner complexion (Bodeker & Shekar, 2009). These ingredients can provide a barrier that can helps to lock in moisture and keep the skin hydrated. Lastly, it also gives brightening affects which is it contains the flavonoids that can help to improve skin complexion by promoting blood flow to the skin (Michalak, 2023). This will increase the circulations which can help in making the skin appear more radiant and brighter.

CHAPTER 5

5.1 Conclusion

In summary, the objective of this experimental has achieved. The characterization and evaluation of antioxidant activity in Mangosteen Peel extract, its has potential application in scrub production cause its have reveal the significant influence of the extraction solvent on the efficacy of the extract's antioxidant properties by using different solvents which is hexane, ethyl acetate, methanol, or distilled water. Interestingly, distilled water crude extracts yielded the highest yield, its proved ineffective in detecting antioxidant properties through GC-MS analysis and distilled water proves less effective in extracting these antioxidant compounds, as evidenced by overall lower scavenging percentages. Conversely, ethyl acetate crude extracts successfully identified compounds with antioxidant activity, such as copaene, specific cyclohexadienones, and benzopyran glucoside. These results underscore the critical importance of employing optimal extraction methods that effectively preserve beneficial compounds, which are essential for the production of antioxidant-rich scrubs. Its also emphasizes the necessity of identifying and preserving key antioxidant compounds for practical applications in skincare product development. Moreover, it elucidates that while organic solvents exhibit varying degrees of antioxidant extraction efficiency, methanol and ethyl acetate demonstrate an increase in DPPH scavenging with higher extract concentrations, followed by hexane showing initial increments. In conclusion, its provides valuable insights into the complex relationship between solvent selection, extraction efficiency, and antioxidant potency, which are vital considerations for the development of high-quality skincare products with potent antioxidant properties.

5.2 Recommendation

Several recommendations can enhance the scope and efficacy of this study aimed at optimizing the extraction of antioxidant compounds from Mangosteen peel for scrub production. Firstly, it is imperative to determine the ideal solvent or combination of solvents that can maximize the extraction efficiency of these compounds. Exploring the effects of solvent mixtures on extraction could yield higher yields and enhance antioxidant activity, thus improving the overall quality of the scrub product. Additionally, further investigation into the bioavailability and skin absorption rates of the extracted compounds is crucial for assessing the

practical efficacy of the scrub. Understanding how effectively these antioxidants penetrate the skin and exert their beneficial effects will inform formulation decisions and potential therapeutic applications. Moreover, scaling up the production process and assessing the stability of the antioxidant properties over time are essential steps for commercial application. Ensuring that the scrub maintains its antioxidant potency throughout its shelf life is vital for consumer satisfaction and product efficacy. Finally, considering the environmental impact and sustainability aspects, selecting green solvents or implementing green extraction methods is paramount. By prioritizing environmentally conscious production processes, such as using renewable solvents or reducing waste generation, the scrub production can align with sustainability goals while maintaining efficiency and quality. Overall, by incorporating these recommendations, the study can yield valuable insights and contribute to the development of antioxidant-rich scrubs with practical efficacy and environmental responsibility.

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APPENDIX A

CALCULATION

1. Yield percentage of each sample

$$yield\ of\ extraction = \frac{after\ drying - before\ drying}{initial\ mass\ of\ mangosteen\ powder} x\ 100\%$$

a) Hexane

Initial weight = 40 g
Final weight of extract = 20.44 g
Yield (%) = 2.10 %

b) Ethyl acetate

Initial weight = 40g
Final weight of extract = 21.28 g
Yield (%) = 7.6 %

c) Methanol

Initial weight = 40 g
Final weight of extract = 21.36 g
Yield (%) = 4.15 %

d) Distilled water

Initial weight = 10g
Final weight of extract = 12.38 g
Yield (%) = 4.45 %

2. FTIR functional group.

FTIR peak value of *Garnicia Mangostana L.* extact of Hexane

Peak (wavenumber cm¯1)	Assignments
3245.39	-OH
2916.14	CH_{2}-
2848.63	CH_3
2358.94	C=C
1614.76	C=C
1580.59	C=C
1447.79	CH_{2}-
1374.03	CH_{3}-
1333.79	CH_{3}-
1277.93	C-O
1234.75	C-O
1217.95	C-O
1198.85	C-O
1170.07	C-O
1121.92	C-O
1096.88	C-O
1074.18	C-O
1049.89	C-O
1004.71	C-OH

FTIR peak value of *Garnicia Mangostana L.* extact of Ethyl Acetate

Peak (wavenumber cm¯1)	Assignments
3853.04	N-H
3838.51	N-H
3820.69	N-H
3801.36	N-H
3750.37	OH
3735.08	OH
3710.82	OH
3689.31	OH
3675.36	OH
3648.72	OH
3628.62	OH
3244.65	-OH
2962.16	CH_3
2915.12	CH_{2-}
2849.44	CH_3
2359.73	C=C
1771.93	C=O
1716.64	C=O
1638.95	C=C
1637.22	C=C
1607.62	C=C
1580.85	C=C
1449.35	CH_{2-}
1373.41	CH_{3-}
1275.43	C-O
1222.22	C-O
1181.71	C-O
1154.76	C-O
1094.29	C-O
1074.75	C-O
1049.61	C-O
1009.28	C-OH

FTIR peak value of *Garnicia Mangostana L.* extact of Methanol

Peak (wavenumber cm¯1)	Assignments
3266.19	NH
2914.54	CH_{2-}
2359.52	C=C
1607.73	C=O
1448.24	CH_{2-}
1373.16	-OH
1277.19	C-O

1151.93	C-O
1049.14	-C-O

FTIR peak value of *Garnicia Mangostana L.* extact of Distilled Water

Peak (wavenumber cm¯1)	**Assignment**
3265.06	N-H
2925.02	O-H
1601.40	C=O
1398.04	-C-H
1247.17	C-O
1050.00	C-O

3. Replicated antioxidant.

The percentage of scavenging of DPPH at various concentrations in hexane.

Concentration (mg/ml)	Experiment 1	Experiment 2	Experiment 3	Average	% DPPH Scavenging	Standard Deviation	IC_{50}
12.5	0.552	0.405	0.537	0.498	57.3630137	15.41794	At 25 mg/ml
25	0.527	0.557	0.584	0.556	52.39726027		
50	0.409	0.415	0.327	0.383667	67.15179795		
100	0.106	0.132	0.236	0.158	86.47260274		
200	0.119	0.247	0.186	0.184	84.24657534		

The percentage of scavenging of DPPH at various concentrations in ethyl acetate.

Concentration (mg/ml)	Experiment 1	Experiment 2	Experiment 3	Average	% DPPH Scavenging	Standard Deviation	IC_{50}
12.5	0.437	0.464	0.546	0.482333	58.70436644	16.88455	At 12.5 mg/ml
25	0.461	0.294	0.586	0.447	61.72945205		
50	0.073	0.101	0.166	0.113333	90.29683219		
100	0.077	0.098	0.133	0.102667	91.2101712		
200	0.074	0.09	0.137	0.100333	91.40984589		

The percentage of scavenging of DPPH at various concentrations in methanol.

Concentration (mg/ml)	Experiment 1	Experiment 2	Experiment 3	Average	% DPPH Scavenging	Standard Deviation	IC_{50}
12.5	0.646	0.458	0.648	0.584	50	20.33833	At 12.5 mg/ml
25	0.591	0.548	0.522	0.553667	52.59700342		
50	0.093	0.332	0.359	0.261333	77.62559932		
100	0.075	0.088	0.14	0.101	91.35273973		
200	0.073	0.083	0.133	0.096333	91.75231164		

The percentage of scavenging of DPPH at various concentrations in distilled water.

Concentration (mg/ml)	Experiment 1	Experiment 2	Experiment 3	Average	% DPPH Scavenging	Standard Deviation	IC_{50}
12.5	0.665	0.618	0.626	0.636333	45.51943493	7.772896	At 200 mg/ml
25	0.762	0.744	0.826	0.777333	33.44751712		
50	0.792	0.673	0.716	0.727	37.75684932		
100	0.794	0.541	0.607	0.647333	44.57765411		
200	0.29	0.845	0.488	0.541	53.68150685		