

Preliminary GC-MS profiling of bioactive compounds in *Muntingia Calabura* from the rural area of Bukit Besi

Nur Syukriah Ab Rahman^{1*}, Muhammad Hazim Ahmad², Qistina Liyana
Othman³, Nur Hanisah Mohamad Nizam⁴, Nurizzati Mohd Daud⁵

^{1,2,3,4}Faculty of Chemical Engineering, Universiti Teknologi MARA Cawangan Terengganu, Kampus Bukit Besi, 23200 Dungun, Terengganu, Malaysia

⁵Department of Biomedical Engineering and Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

ARTICLE INFO

Article history:

Received 14 August 2025
Revised 23 September 2025
Accepted 22 October 2025
Online first
Published 31 October 2025

Keywords:

GC-MS
Muntingia calabura
Bioactive compounds
Rural area
Bukit Besi

DOI:

10.24191/mjcet.v8i2.8511

ABSTRACT

Muntingia calabura is a medicinal plant commonly found along roadsides in Malaysia and is traditionally believed to possess various therapeutic activities. Although it has been widely utilised in traditional medicine and several pharmacological properties have been reported, most studies have relied on crude extracts without detailed characterisation of the bioactive constituents. Therefore, the present study aimed to identify the bioactive compounds in the fruit, leaves, and stem bark using Gas Chromatography-Mass Spectroscopy (GC-MS). Each part of the plant was extracted using the Soxhlet technique and hexane and petroleum ether as a solvent. GC-MS analysis revealed seven (7) compounds using petroleum ether and ten (10) compounds in hexane extract in fruit parts; ten (10) compounds in petroleum ether and seventeen (17) compounds using hexane in leaf parts; and ten (10) compounds in petroleum ether and fifteen (15) compounds using hexane in stem bark parts. The prime compound found in fruit is 2-Methyl-Z, Z-3,13-octadecadienol (64.27%) using petroleum ether, while it is L-(+)-Ascorbic acid 2,6-dihexadecanoate (29.95%) when using hexane. For leaves, both solvents showed a similar most extracted compound, which is 9-Octadecenoic acid, 1,2,3-propanetriyl ester (42.29% with petroleum ether and 25.34% with hexane). In stem bark, the most extracted compound is 2-Methyl-Z, Z-3,13-octadecadienol (29.88%) (fatty alcohol) for petroleum ether, while for hexane extract, it is 2H-1-Benzopyran-6-ol,3,4-Dihydro-2,5,7,8-Tetramethyl-2-(4,8,12-Trimethyl Tridecyl) (31.88%). These findings indicate the diverse bioactive compound was found in different parts of *Muntingia calabura*, emphasising the need for further pharmacological and biological studies to validate its therapeutic claim.

^{1*}Corresponding author. E-mail address: nursyukriah@uitm.edu.my
<https://doi.org/10.24191/mjcet.v8i2.8511>

1. INTRODUCTION

Medicinal plants are an important source of several bioactive compounds, which are believed to treat various diseases in humans. Based on data from the World Health Organisation (WHO), it is estimated that 80% of developing countries rely on medicinal plants due to their easy accessibility and inexpensiveness. Therefore, the search for the potential of medicinal plants has led to the discovery of novel therapeutic drugs against various diseases (Vankudoth et al., 2022).

Gas chromatography is a valuable instrument used nowadays to identify novel bioactive compounds from medical plants with therapeutic properties with the aim of discovering a new lead potential drug. The identified compounds can be used in various applications, for example, pharmaceuticals, cosmeceuticals, forensic applications and the food industry. In addition, identifying the bioactive compounds from different parts leads to an additional investigation of biology and pharmacology because different potent bioactive compounds could treat different diseases (Uma et al., 2009; Vankudoth et al., 2022).

Muntingia calabura (*M. calabura*), widely known as Kerukup Siam in Malaysia, belongs to the family of Muntingiaceae and is an indigenous plant of Central America and commonly found in Indonesia, Malaysia, Philippines, China, India, and Brazil. In Malaysia, this plant can be found easily on the roadside and can be categorised as a neglected plant. It has been used since ancient times against several illnesses, for example, cough, flu and fever, and possesses high therapeutic activities like antioxidants, antiseptics, anti-inflammatories, antimicrobials, antihypertensives, antihyperglycemics, gastroprotectives, laxatives, and anti-gout properties (Krishnaveni et al., 2015; Rezeki et al., 2023; Taslim et al., 2023; Gunny et al., 2024; Widodo et al., 2024). However, the current research on the antioxidant and antidiabetic properties of *M. calabura* extract revealed that it could act as an amylase inhibitor, and the molecular docking results suggest that quercetin, which is one of the flavonoids, might be a potent inhibitor of α -amylase (Gunny et al., 2024). Meanwhile, the phytochemical profiling of *M. calabura* showed that the extract contains several bioactive compounds, for example, phlobatannins, flavonoids, tannins and alkaloids (Ariffin et al., 2022; Nghi et al., 2025). Other studies also revealed the presence of gallic acid, which is known for its strong antioxidant activities that lead to various therapeutic properties (Muniyappan et al., 2022). Other than that, the leaf extract of *M. calabura* possesses a protective effect on the pancreas by inhibiting the mechanism of β -cell necrosis in the islet of Langerhans and is found to have immunomodulatory activity by reducing the inflammation. Both these two (2) activities are important and beneficial in the management of diabetes mellitus (Hassan et al., 2024).

Based on the literature, there are three (3) parts of the plant that are widely used as a therapeutic agent, which are fruit, leaves and bark. The fruit part has been documented to possess antioxidant, anti-inflammatory and antibacterial properties; the leaves have been reported to have antinociceptive, cardioprotective, anti-platelet aggregation, antipyretic, antioxidant and anti-inflammatory properties, while the bark part has shown cytotoxic and antibacterial properties. Taken together, these parts represent the most traditionally utilised components and exhibit the most valuable pharmacological potential for further exploration (Mahmood et al., 2014).

Even though there is widely documented research on the therapeutic activities of *M. calabura*, most studies have relied on crude extracts without detailed characterisation of the bioactive constituents. To the best of our knowledge, the present is the first report which analyses the phytochemical compositions of fruit, leaves and stem bark of *M. calabura* originating from Bukit Besi, Dungun. The phytochemical

composition of medicinal plants is known to be influenced by various environmental factors such as soil composition, climatic conditions, and altitude (Rawat et al., 2025). These factors may alter the biosynthesis and accumulation of bioactive metabolites, thereby affecting the therapeutic properties of the plant. Hence, the focusing on *M. calabura* samples collected from Bukit Besi is relevant, as the unique rural environment of this area may contribute to variations in the phytochemical profile and potential biological activities compared to plants grown elsewhere.

Therefore, this current study aimed to screen the potential bioactive compounds of the fruit, leaves and stem bark of the *M. calabura* originating from the rural area of Bukit Besi, Dungun, using GC-MS analysis. The conventional Soxhlet extraction method was chosen, while hexane and petroleum ether were used as solvents. This preliminary study will serve as a novel insight for further exploration of the therapeutic activity of this plant, which originated from Bukit Besi, Dungun, Terengganu.

2. MATERIAL AND METHOD

2.1 Collection of plant material

Fresh parts of *M. calabura* (fruits, leaves, and stem) were collected from Kampung Besul, Bukit Besi, Dungun, and Terengganu (GPS coordinate: 4.7500° N, 103.1967° E). The collected fresh parts samples were washed thoroughly with distilled water to remove dust, then proceeded to be ground using a grinder and kept in an airtight glass container for further processing.

2.2 Extraction process

Ten (10) grams of each part of *M. calabura* were placed into cylindrical thimbles. The sample-filled thimbles were kept in the cylindrical sample holder in the Soxhlet apparatus and filled with 250 mL of hexane. The crude extract was collected after the complete extraction process, and the remaining solvents were evaporated using a rotary evaporator. The crude extract was kept in a bottle sample at 4 °C, composed of extract/solvent (1:2), and subjected to further analysis. All steps were repeated using a different solvent, which is petroleum ether.

2.3 Gas chromatography-mass spectrometry (GC-MS) analysis

The phytochemical investigation of fruits, leaves, and stem bark of *M. calabura* was performed using Shimadzu QP2010 gas chromatography and mass spectrometry (GC-MS). Experimental conditions of the GC-MS system were as follows: the column used was Rtx-5MS (30 m, ID: 0.25 mm and film thickness of 0.25 µm). A sample size of one (1) µL of each extract was injected separately for analysis, and helium was used as a carrier gas at 1.2 mL/minute. The oven temperature was programmed from 70 to 280 °C (5 °C/minute), with an injector split ratio of 72.6 and a pressure of 14.0 kPa. The flow rate was 40 mL/minute, and the flow within the column was 0.50 mL/minute. A tentative identification of the compounds was performed based on the comparison of their relative retention time and mass spectra with those of the NIST11 reference library data of the GC-MS system.

3. RESULT AND DISCUSSION

The presence of bioactive compounds in the fruits, leaves, and stem bark of *M. calabura* was evaluated using gas chromatography-mass spectroscopy (GC-MS). Fig. 1 showed the spectrum from the extract of *M. calabura*'s fruits. The extraction process using different solvents yielded different extracted compounds.

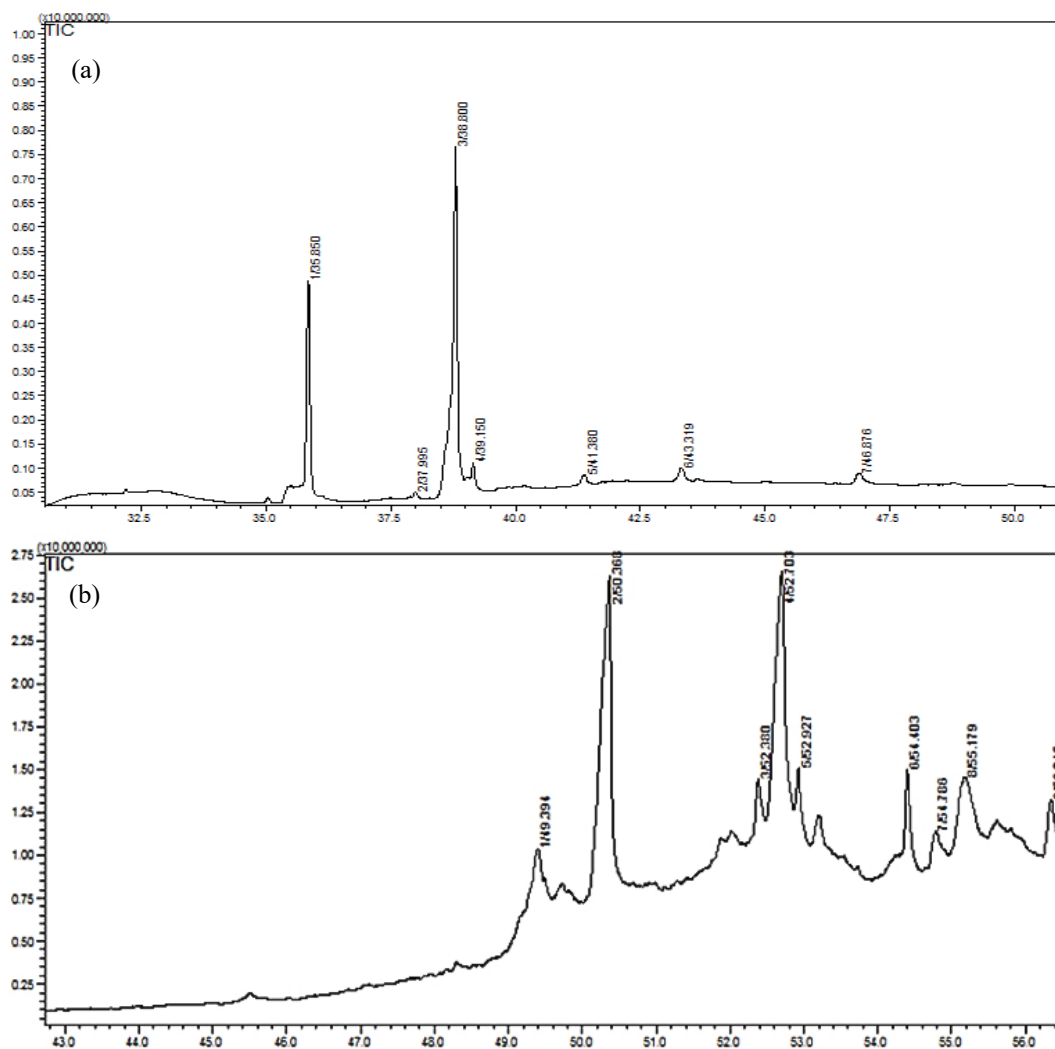


Fig. 1: GC-MS spectrum of fruits' part of *M. Calabura*; (a) Soxhlet extraction using petroleum ether (b) Soxhlet extraction using hexane

Source: Authors' own data

3.1 Determination of bioactive compounds from fruits part of *M. calabura*

In the extract of the fruit's part using petroleum ether, there are seven (7) compounds that have been identified, and the most extracted bioactive compound is 2-Methyl-Z, Z-3, 13-octadecadienol (64.27%)

<https://doi.org/10.24191/mjceet.v8i2.8511>

(Fig. 1a), while the extraction using hexane exhibited ten (10) different bioactive compounds, with L-(+)-Ascorbic acid 2,6-dihexadecanoate when using hexane (29.95%) (Fig. 1b) being the most extracted phytochemical compound. The data tabulated in Table 1 indicates that the extraction of *M. calabura*'s fruit yielded various types of bioactive compounds, and different types of solvents will result in the different extracted bioactive compounds even if both solvents are non-polar solvents. The major compounds extracted using petroleum ether are fatty acid esters and long-chain alcohols, while in hexane extract are fatty acid esters and vitamin derivatives. 2-Methyl-Z, Z-3, 13-octadecadienol is categorised as an alcoholic compound, whereas L-(+)-Ascorbic acid 2,6-dihexadecanoate (29.95%) is a derivative of ascorbic acid (vitamin C) and has been found to exhibit antibacterial properties against *Proteus mirabilis*, *Streptococcus pneumonia*, *Escherichia coli*, and *Staphylococcus aureus* (Karthikeyan et al., 2014). While 2-Methyl-Z, Z-3, 13-octadecadienol has been reported to show anti-cancer activities (Varnakulendran & Elango, 2019). Both solvents exhibited the ability to extract fatty acids, and their esters with hexane showed a potential to extract a greater abundance and diversity of these compounds.

Table 1: Phytochemical compounds detected in the extraction of fruit of *M. calabura* using petroleum ether and hexane

Peak #	Retention time	Name of the compound	Molecular formula	Peak area (%)
Petroleum ether				
1	35.85	Hexadecanoic acid 1-(hydroxymethyl)-1 2-ethanediyl ester	C ₃ H ₆₈ O ₅	22.98
2	37.99	Oleic acid, 3-hydroxypropyl ester	C ₂₁ H ₄₀ O ₃	0.5
3	38.80	2-Methyl-Z,Z-3, 13-octadecadienol	C ₁₉ H ₃₆ O	64.27
4	39.15	Glycidol stearate	C ₂₁ H ₄₀ O ₃	6.30
5	41.38	6-Ethyl-3-trimethylsilyloxydecane	C ₁₅ H ₃₂	1.61
6	43.32	Diethyl n-hexadecyl malonate	C ₂₃ H ₄₄ O ₄	2.30
7	46.88	9-Octadecenal	C ₁₈ H ₃₄ O	2.04
Hexane				
1	49.39	Cis-10-Heptadecanoic acid	C ₁₇ H ₃₂ O ₂	5.44
2	50.37	L-(+)-Ascorbic acid 2,6-dihexadecanoate (29.95%) when using hexane	C ₃₈ H ₆₈ O ₈	29.95
3	52.38	Glycidol stearate	C ₂₁ H ₄₀ O ₃	3.39
4	52.70	9-Octadecenoic acid, (E)-	C ₁₈ H ₃₄ O ₂	27.67
5	52.93	Octadecanoic acid	C ₁₈ H ₃₆ O ₂	3.78
6	54.40	Glycidol stearate	C ₂₁ H ₄₀ O ₃	4.15
7	54.79	9-Octadecenoic acid, 1,2,3 propanetriyl ester, (E,E,E)-	C ₅₇ H ₁₀₄ O	2.53
8	55.18	Hexadecenoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester	C ₁₉ H ₃₈ O ₄	9.27
9	56.35	9-Octadecenoic acid, 1,2,3 propanetriyl ester (E,E,E)-	C ₅₇ H ₁₀₄ O	3.25
10	56.60	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester	C ₁₉ H ₃₈ O ₄	10.57

Source: Authors' own data

3.2 Determination of bioactive compounds from leaves part of *M. calabura*

In the extraction of the leaves part, the extract using petroleum ether showed ten (10) compounds, while there are seventeen (17) compounds when using hexane. The most extracted bioactive compound using both solvent petroleum ether and hexane is 9-Octadecenoic acid, 1,2,3-propanetriyl ester (42.29% and 25.34%, respectively) (Fig. 2a). This compound was documented to possess an immune modulator with

spasmodic activity (Tsilo et al., 2020). The hexane extract demonstrated the presence of a notable bioactive molecule, hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester, which is extensively documented for its therapeutic properties; for example, it possesses hepatoprotective activity by improving liver function in rats and reducing inflammation and necrosis (Tripathi et al., 2023). The extract from both solvents showed different types of extracted bioactive compounds, with petroleum ether as the solvent exhibiting fatty acid esters, sterol derivatives and triglycerides, while the extract from hexane exhibited a hydrocarbon, phospholipid and long-chain ketones.

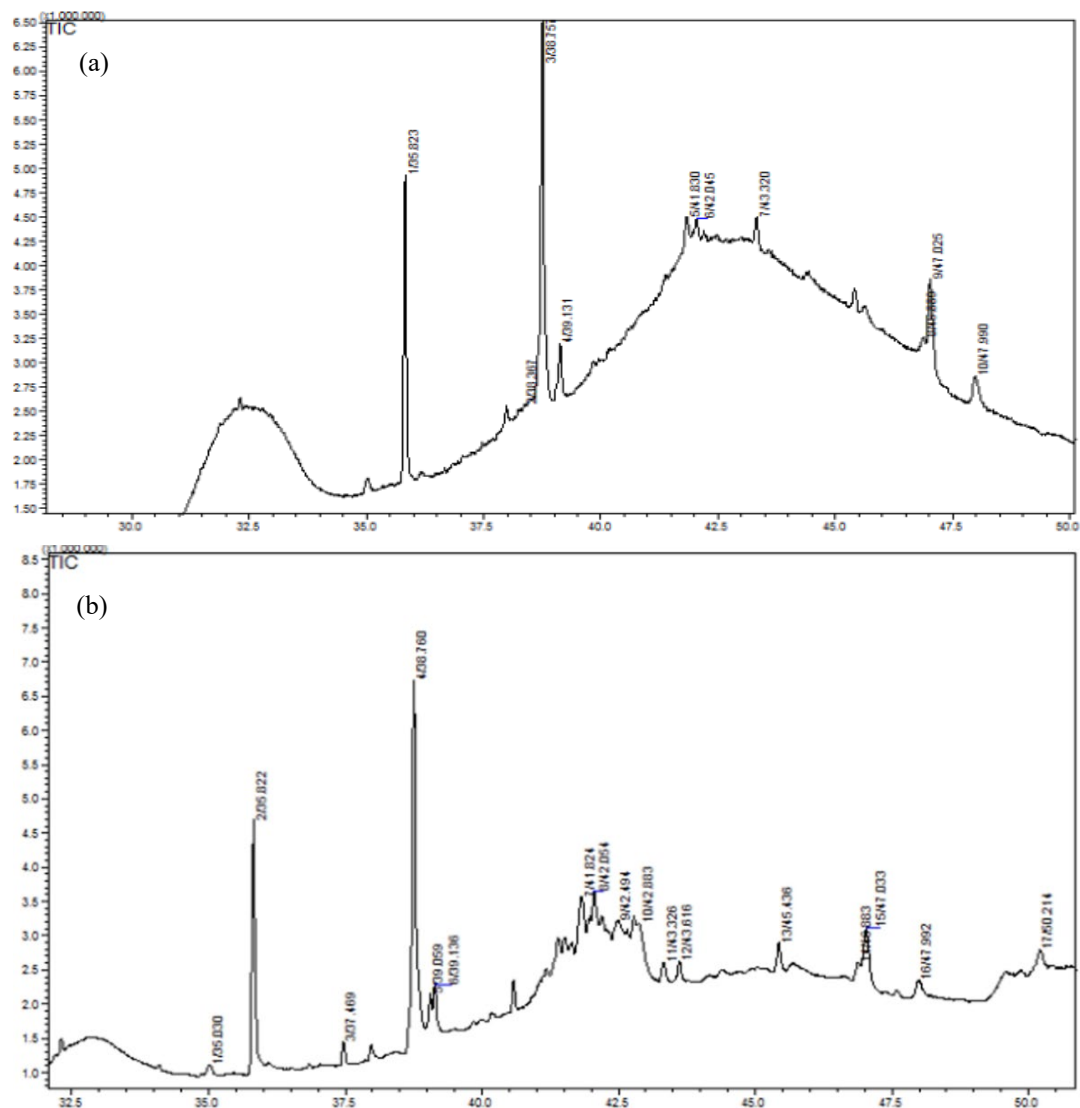


Fig. 2: GC-MS spectrum of leaves' part of *M. calabura*; (a) Soxhlet extraction using petroleum ether and (b) Soxhlet extraction using hexane

Source: Authors' own data

Table 2: Phytochemical compounds detected in the extraction of leaves of *M. calabura* using petroleum ether and hexane

Peak #	Retention time	Name of the compound	Molecular formula	Peak area (%)
Petroleum ether				
1	35.823	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	C ₃₅ H ₆₈ O ₅	20.66
2	38.367	3.alpha-(Trimethylsiloxy)cholest-5-ene (C ₃₀ H ₅₄ OSi)	C ₃₀ H ₅₄ OSi	2.50
3	38.757	9-Octadecanoic acid, 1,2,3-propanetriyl ester, (E,E,E)-	C ₅₇ H ₁₀₄ O ₆	42.29
4	39.131	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	C ₃₅ H ₆₈ O ₅	4.25
5	41.830	4-Dimethyl (pentafluorophenyl) silyloxypentadecane	C ₂₃ H ₃₇ F ₅₀ Si	6.68
6	42.045	Eicosane	C ₂₀ H ₄₂	4.03
7	43.420	Decyl sulfide	C ₂₄ H ₅₀ S	2.70
8	46.889	3-n-Pentylthiolane, S, S-dioxide		2.23
9	47.025	2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl)-, [2R-[2R*(4R, 8R)]]-	C ₂₇ H ₄₆ O ₂	11.54
10	47.990	1,5,9-Decatriene, 2,3,5,8-tetramethyl	C ₁₄ H ₂₄	3.12
Hexane				
1	35.030	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	C ₁₉ H ₃₈ O ₄	0.70
2	35.823	Hexadecanoic acid, 1-[[[(2-aminoethoxy)hydroxyphosphinyl]oxy]methyl]-1,2-ethanediyl ester	C ₃₇ H ₇₄ NO ₈ P	13.01
3	37.470	Tetratetracontane	C ₄₄ H ₉₀	0.97
4	38.760	9-Octadecenoic acid, 1, 2, 3-propanetriyl ester, (E,E,E)-	C ₅₇ H ₁₀₄ O ₆	25.34
5	39.059	Tetratetracontane	C ₄₄ H ₉₀	2.63
6	39.136	Glycidol stearate	C ₂₁ H ₄₀ O ₃	2.84
7	41.824	16-Hentriacontanone	C ₃₁ H ₆₂ O	12.42
8	42.054	Heneicosane	C ₂₁ H ₄₄	10.68
9	42.494	16-Hentriacontanone	C ₃₁ H ₆₂ O	7.91
10	42.883	16-Hentriacontanone	C ₃₁ H ₆₂ O	1.61
11	43.326	Decyl sulphide	C ₂₁ H ₄₄	1.03
12	43.616	Tetratetracontane	C ₄₄ H ₉₀	1.81
13	45.436	Tetratetracontane	C ₄₄ H ₉₀	1.45
14	46.883	3-n-Pentylthiolane, S,S-dioxide	C ₉ H ₁₈ O ₂ S	1.45
15	47.033	2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl) -, [2R- [2R*(4R, 8R)]]-	C ₂₇ H ₄₄ O ₂	5.38
16	47.992	2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl) -, [2R- [2R*(4R, 8R)]]-	C ₂₇ H ₄₄ O ₂	1.55
17	50.214	Tetra tetracontane	C ₄₄ H ₉₀	1.57

Source: Authors' own data

The consistent detection of 9-Octadecenoic acid, 1,2,3-propanetriyl ester in extracts in both solvents, hexane and petroleum ether (Table 2), might be contributed by its chemical characteristics and abundance in *M. calabura*. This current finding was in accordance with previous literature where they found that 9-Octadecenoic acid, 1,2,3-propanetriyl ester, was detected in both n-hexane and petroleum ether in the extraction of *Trigonella foenum-graecum* (EL-Kamali & Osman, 2024). The 9-octadecenoic acid, 1,2,3-propanetriyl ester, is a long-chain fatty acid ester that was found in abundance in plant extracts and can be extracted by using non-polar solvents (Ridhwan et al., 2022). Fatty acid esters with long hydrophobic chains are highly lipophilic and thus readily soluble in non-polar solvents, regardless of minor differences in

polarity or boiling range. This suggests that the dominance of such compounds is not merely solvent-dependent but also reflects their natural abundance in the plant matrix.

3.3 Determination of bioactive compounds from stem bark part of *M. calabura*

Other than that, the extraction of stem bark also exhibited different types of bioactive compounds (Fig. 3), with petroleum extracts showing ten (10) compounds, while hexane extract exhibited fifteen (15) different types of compounds. The highest extracted compound (Table 3) in petroleum ether is 2-Methyl-Z, Z-3,13-octadecadienol (29.88%) (fatty alcohol), while for hexane extract it is 2H-1-Benzopyran-6-ol, 3,4-Dihydro-2,5,7,8-Tetramethyl-2-(4,8,12-Trimethyl Tridecyl) (31.88%), widely known as d- δ -tocopherol. Even though the therapeutic activity of d- δ -tocopherol was rarely documented, the therapeutic activity of 2-Methyl-Z, Z-3,13-octadecadienol (terpenoid) has been widely reported for its antiprotozoal effect (Farag et al., 2021). The bioactive compound from both solvents reveals a significant compositional difference, indicating selectivity in isolating specific chemical compounds. However, there are also similar compounds found in both solvents, which are Eicosane, 7-hexyl- and Tetracosane, 11-decyl-, which might be due to the similar nature of non-polar solvents.

The current study found that various parts of the plants exhibit various types of bioactive compounds, and even similar parts can show different bioactive compounds depending on the solvents used. In this study, Soxhlet extraction was employed as the extraction method for all plant parts (stem bark, fruit, and leaves of *M. calabura*). Two (2) solvents, namely hexane and petroleum ether, were used to evaluate the effect of solvent polarity on the recovery of bioactive compounds. These solvents represent non-polar systems, and their use was aimed at extracting non-polar constituents such as fatty acids, terpenoids, hydrocarbons, and lipophilic compounds.

Current findings demonstrated that the major compound of fruit extract using petroleum ether yielded fatty acid esters and long-chain alcohols, while when using hexane, it yielded fatty acid esters and vitamin derivatives. In leaves extract, using petroleum ether as a solvent yielded fatty acid esters, sterol derivatives, and triglycerides; however, using hexane as a solvent resulted in the extraction of hydrocarbons, phospholipids, and long-chain ketones. Then, the major compounds extracted by petroleum ether in stem bark are fatty acid derivatives and long-chain carbon, while when using hexane, more diverse compounds are detected, such as long-chain alkane and vitamin E.

Fatty acid esters and derivatives, which were consistently detected across fruit, leaf, and stem bark, are known for their antimicrobial and anti-inflammatory effects (Mat Radzi, 2025). Sterol derivatives in the leaves have been linked to cholesterol-lowering (He et al., 2018) and anticancer properties (Shahzad et al., 2017), while vitamin derivatives such as vitamin C and E, found in fruit and stem bark extracts, are potent antioxidants (Sato et al., 2024; Ungurianu et al., 2021). These associations suggest that *M. calabura* from the rural area of Bukit Besi represents a valuable source of bioactive compounds, supporting its traditional medicinal use and warranting further biological evaluation. However, the plant part of *M. calabura* should be chosen depending on the specific therapeutic purpose or biological activity being studied, as each part contains different bioactive chemicals that contribute to varied pharmacological effects.

Additionally, the selection of solvent is a critical factor that substantially affects the extraction profile and, as a result, the types of bioactive compounds that are detected, even when the same plant part is used. These findings were supported by previous literature when they found different types of solvents showed different responses towards the antioxidant and antibacterial activities. The choice of solvent plays a crucial role in influencing the extraction efficiency and the types of bioactive compounds detected, as solvent polarity directly determines solubility and recovery of specific phytochemical components, for example, gallic acid, phenolic compounds, phenolic acid, flavonoids, vitamins and terpenoids, which in turn affects measured antioxidant and antimicrobial activities (Nur Syukriah et al., 2014; Ab. Rahman et al., 2015; Lee

et al., 2024). As a result, this study highlighted the importance of selecting the right solvent to optimise the extraction of targeted bioactive chemicals for the specific therapeutic activities assessed.

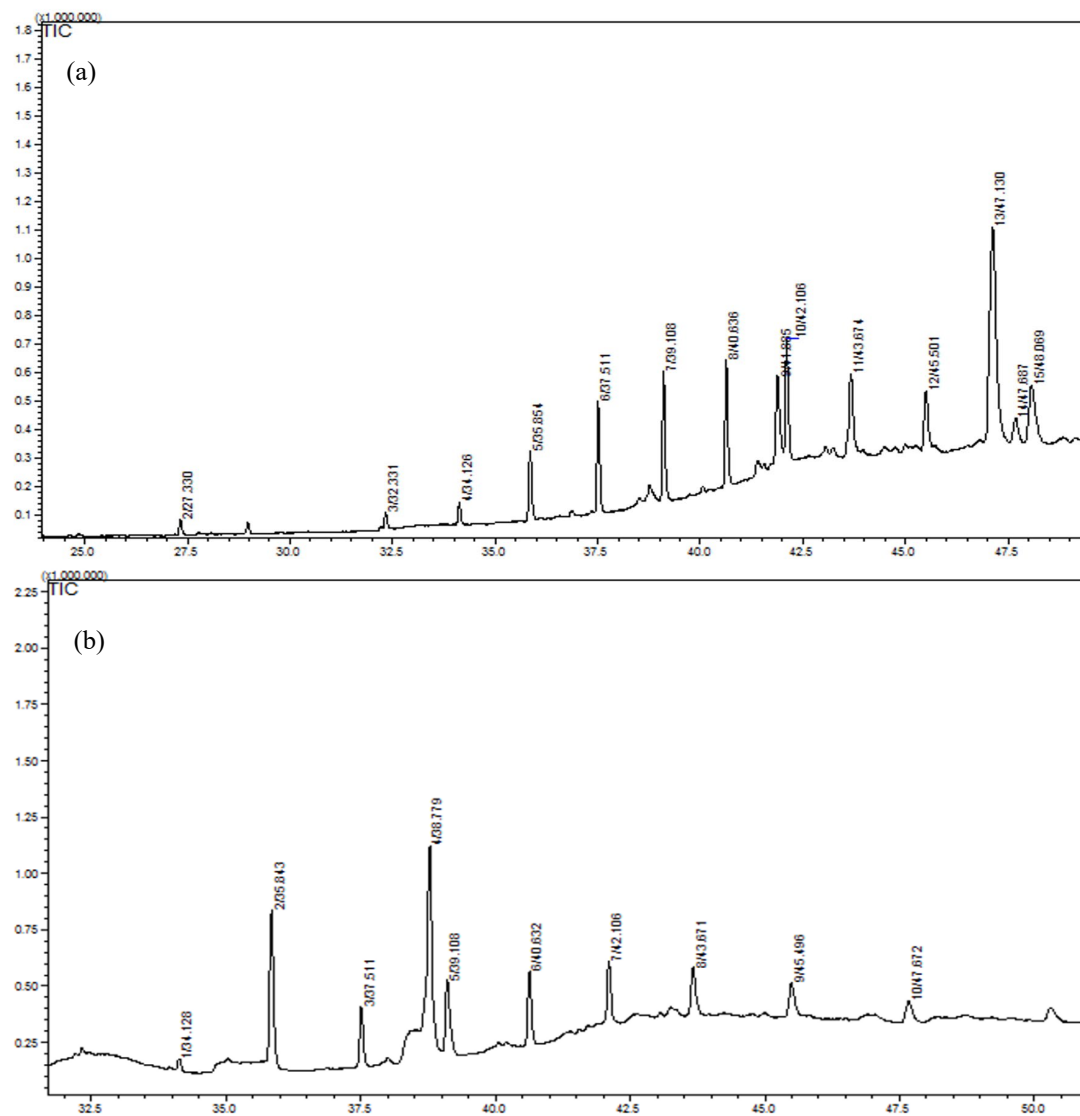


Fig. 3: GC-MS spectrum of stem bark' part of *M. calabura*; (a) Soxhlet extraction using petroleum ether (b) Soxhlet extraction using hexane.

Source: Authors' own data

Table 3: Phytochemical compounds detected in the extraction of stem of *M. calabura* using petroleum ether and hexane

Peak #	Retention time	Name of the compound	Molecular formula	Peak area (%)
Petroleum ether				
1	34.13	Heptadecane, 2, 6,10,15-tetramethyl-	C ₂₁ H ₄₄	1.03
2	35.84	Hexadecanoic acid, 1-[[[(2-aminoethoxy) hydroxyphosphinyl]oxy]methyl]-1,2-ethanediyl ester	C ₃₇ H ₇₄ NO ₈ P	19.80
3	37.51	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	6.74
4	38.78	2- Methyl-Z, Z-3, 13-octadecadienol	C ₁₉ H ₃₆ O	29.88
5	39.11	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	10.48
6	40.63	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	8.93
7	42.11	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	7.30
8	43.67	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	6.90
9	45.49	Tetracosane, 11-decyl-	C ₃₄ H ₇₀	5.65
10	47.67	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	3.29
Hexane				
1	3.29	1,3,5-Cycloheptatriene	C ₇ H ₈	0.66
2	27.33	2-Pentadecanone, 6,10,14-trimethyl-	C ₁₈ H ₃₆ O	0.66
3	32.33	10-Octadecenoic acid, methyl ester	C ₁₉ H ₃₆ O ₂	0.87
4	34.13	Eicosane, 10- methyl-	C ₂₁ H ₄₄	1.04
5	35.85	Tritetracontane	C ₄₃ H ₈₈	4.31
6	37.51	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	6.68
7	39.11	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	7.94
8	40.64	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	7.86
9	41.89	Coumaran-7-ol-3-one,2-[4-methoxybenzylidene]-6-methoxy-	C ₁₇ H ₁₄ O ₅	7.91
10	42.11	Eicosane, 7-hexyl-	C ₂₆ H ₅₄	8.00
11	43.67	Tetracosane,11-decyl	C ₃₄ H ₇₀	7.34
12	45.50	Tritetracontane	C ₄₃ H ₈₈	4.92
13	47.13	2H-1-Benzopyran-6-ol, 3,4-dihydro-2,8-dimethyl-2-(4,8,12-trimethyltridecyl) -, [2R- [2R*(4R, 8R)]]-	C ₂₉ H ₅₆ O ₂	31.88
14	47.69	Tritetracontane	C ₄₃ H ₈₈	1.83
15	48.07	1,5,9-Decatriene, 2,3,5,8-tetramethyl-	C ₁₄ H ₂₄	8.10

Source: Authors' own data

By applying the same extraction method across all plant parts while varying the solvent system, the study design allowed for the assessment of how solvent type influences the phytochemical profile detected by GC-MS. This preliminary investigation provides a foundation for future comparative work involving solvents of broader polarity ranges and different extraction methods. The present preliminary GC-MS profiling of *M. calabura* collected from the rural area of Bukit Besi revealed that the type of solvent significantly influences the class of compounds extracted from different plant parts.

One limitation of the present study is the absence of extraction yield data. Although the crude extracts were successfully obtained and analysed, the lack of extraction yield restricts direct comparison with other studies. Future investigations should include extraction yield measurements to enhance reproducibility and provide a more comprehensive evaluation of the extraction process.

4. CONCLUSION

M. calabura was discovered to contain various types of bioactive compounds. Based on these current findings, it can be concluded that different parts of *M. calabura* will extract different types of bioactive compounds. Other than that, different types of solvents also reveal different varieties of bioactive compounds, even though they are for similar parts of compounds. The major compounds extracted from fruit using petroleum are fatty acid esters and long-chain alcohols, while in hexane extract are fatty acid esters and vitamin derivatives; while in leaves when using petroleum ether as a solvent, fatty acid esters, sterol derivatives and triglycerides are shown, while the extract from hexane exhibits a hydrocarbon, phospholipid and long-chain ketones; the major compounds found in stem bark using petroleum ether as a solvent are fatty acid derivatives and long-chain carbon, while in hexane are more diversified, including ketone, long-chain alkane, vitamin E and sesquiterpene. This indicates that the selection of the solvent is one of the crucial factors in the early stage of lead discovery for novel therapeutic development. Most of the extracted compounds from the fruit, leaves, and stem bark of *M. calabura* are potential bioactive constituents that are believed to contribute to its therapeutic activities. Among the plant parts studied, the fruit appears to be the most valuable, as it contains L-(+)-Ascorbic acid 2,6-dihexadecanoate (29.95%), which has previously been reported to exhibit strong antioxidant and antibacterial properties. Therefore, it is recommended that future studies validate these therapeutic claims by evaluating antioxidant potential using the DPPH radical scavenging assay and antibacterial activity using the disc diffusion method.

ACKNOWLEDGEMENT

The authors would like to acknowledge the support of Universiti Teknologi Mara (UiTM), Cawangan Terengganu, Kampus Bukit Besi and Faculty of Chemical Engineering, Universiti Teknologi MARA, Malaysia for providing the facilities and financial support on this research.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Nur Syukriah Ab Rahman: Supervision, writing review and editing; **Muhammad Hazim Ahmad:** Conceptualisation, methodology, and formal analysis; **Qistina Liyana Othman:** Conceptualisation, methodology and formal analysis; **Nur Hanisah Mohamad:** Conceptualisation, methodology and formal analysis; **Nurizzati Mohd Daud:** Supervision, writing- review and validation.

REFERENCES

Ab. Rahman, N. S., Md. Salleh, L., Abd. Majid, F. A., & Harisun, Y. (2015). Quantification of gallic acid and tannic acid from *Quercus infectoria* (Manjakani) and their effects on antioxidant and antibacterial activities. *Pertanika Journal of Science and Technology*, 23(2), 351–362.

- Ariffin, S., Zulkefli, J., & Saleh, A. M. (2022). Phytochemical analysis of *Muntingia calabura* Linn. and its antibacterial properties via in vitro evaluation. *Malaysian Journal of Analytical Sciences*, 26(4), 766–773.
- EL-Kamali, H. H., & Osman, G. A. (2024). GC/MS Analysis of Chemical Compounds Soluble in n-Hexane and Petroleum Ether From *Trigonella foenum-graecum* Seeds. *Asian Journal of Biological Sciences*, 17(4), 640–648. <https://doi.org/10.3923/ajbs.2024.640.648>
- Farag, S. M., Essa, E. E., Alharbi, S. A., Alfarraj, S., & Abu El-Hassan, G. M. M. (2021). Agro-waste derived compounds (flax and black seed peels): Toxicological effect against the West Nile virus vector, *Culex pipiens* L. with special reference to GC–MS analysis. *Saudi Journal of Biological Sciences*, 28(9), 5261–5267. <https://doi.org/10.1016/j.sjbs.2021.05.038>
- Gunny, A. A. N., Prammakumar, N. K., Ahmad, A. A., C.B., S., Gopinath, Bakar, A. R. A., Musa, H., & Mat, M. H. C. (2024). Results in chemistry exploring antioxidant and antidiabetic potential of *Muntingia calabura* (Kerukup Siam) leaf extract: In vitro analysis and molecular docking study. *Results in Chemistry*, 7, 101305. <https://doi.org/10.1016/j.rechem.2024.101305>
- Hassan, F. E., Yunus, R., & Magdalena. (2024). Immunomodulatory activity of kersen leaf extract (*Muntingia calabura*) on diabetic rats: analysis of immune response. *Indonesian Journal of Medical Laboratory Science & Technology*, 6(1), 9–17. <https://doi.org/10.33086/ijmlst.v6i2.5746>
- He, W. Sen, Zhu, H., & Chen, Z. Y. (2018). Plant Sterols: Chemical and enzymatic structural modifications and effects on their cholesterol-lowering activity. *Journal of Agricultural and Food Chemistry*, 66(12), 3047–3062. <https://doi.org/10.1021/acs.jafc.8b00059>
- Karthikeyan, S. C., Velmurugan, S., Donio, M. B. S., Michaelbabu, M., & Citarasu, T. (2014). Studies on the antimicrobial potential and structural characterization of fatty acids extracted from Sydney rock oyster *Saccostrea glomerata*. *Annals of Clinical Microbiology and Antimicrobials*, 13(1), 1–11. <https://doi.org/10.1186/s12941-014-0057-x>
- Krishnaveni, M., Banu, C. R., Kumari, G. K., & Kalaivani, M. (2015). GCMS/MS analysis of *Muntingia calabura* stem and its antimicrobial effect. *World Journal of Pharmacy and Pharmaceutical Sciences*, August. <https://www.cabdirect.org/cabdirect/abstract/20153281200>
- Lee, J., Jayakody, J. T. M., Kim, J., Jeong, J., Choi, K., Kim, T., Seo, C., Azimi, I., Hyun, J., & Ryu, B. (2024). The influence of solvent choice on the extraction of bioactive compounds from asteraceae: A comparative review. *Foods*, 13(19), 3151. <https://doi.org/10.3390/foods13193151>
- Mahmood, N. D., Nasir, N. L. M., Rofiee, M. S., Tohid, S. F. M., Ching, S. M., Teh, L. K., Salleh, M. Z., & Zakaria, Z. A. (2014). *Muntingia calabura*: A review of its traditional uses, chemical properties, and pharmacological observations. *Pharmaceutical Biology*, 52(12), 1598–1623. <https://doi.org/10.3109/13880209.2014.908397>
- Mat Radzi, S. (2025). Antibacterial and physicochemical properties of palm and olive-based wax esters. *Journal of Academia*, 13(1), 57–70. <https://doi.org/10.24191/joa.v13i1.4601>
- Muniyappan, G., Adenam, N. M., Muhamad Yuzaini Azrai, M. Y., Nurul Hijanah, M. H., Kernain, D., & Adli, H. K. (2022). Phytochemical screening of *Muntingia calabura* fruit for antioxidant and cytotoxic activities. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 28(1), 116–125. <https://doi.org/10.37934/araset.28.1.116125>

- Nghi T. M. P., Thanh T. N., Dung K. N., Ngoc M. V., Minh T. T. N., Loc H. T. N., Linh C. T. (2025). Optimization of the extraction protocol to uptake the flavonoid content from jamaican cherry (*Muntingia calabura L.*) leaves extract as a source for an antifungal bioproduct development. *Biocatalysis and Agricultural Biotechnology*, 64, 103520, <https://doi.org/10.1016/j.bcab.2025.103520>.
- Nur Syukriah, A. R., Liza, M. S., Harisun, Y., & Fadzillah, A. A. M. (2014). Effect of solvent extraction on antioxidant and antibacterial activities from *Quercus infectoria* (Manjakani). *International Food Research Journal*, 21(3), 1067–1073.
- Rawat, P., Dasila, K., Singh, M., & Kuniyal, J. C. (2025). Influence of environmental factors on phytochemical compositions and antioxidant activity of *Juniperus communis L.* *Discover Environment*, 3(1), 11. <https://doi.org/10.1007/s44274-025-00189-8>
- Rezeki, N. F., Bellatasie, R., & Ifora, I. (2023). Phytochemistry and anti-inflammatory properties of *Muntingia calabura L.* as a medicinal plant: A review. *International Journal of Pharmaceutical Sciences and Medicine*, 8(11), 8–18. <https://doi.org/10.47760/ijpsm.2023.v08i11.002>
- Ridhwan, N. M., Hamat, H., & Akanda, M. J.H. (2022). Fatty-acid profiles, triacylglycerol compositions, and crystalline structures of bambangan-seed fat extracted using different solvents. *Applied Sciences*, 12(16), 8180. <https://doi.org/10.3390/app12168180>
- Sato, A., Kondo, Y., & Ishigami, A. (2024). The evidence to date: implications of l-ascorbic acid in the pathophysiology of aging. *Journal of Physiological Sciences*, 74(1), 4–9. <https://doi.org/10.1186/s12576-024-00922-7>
- Shahzad, N., Khan, W., MD, S., Ali, A., Saluja, S. S., Sharma, S., Al-Allaf, F. A., Abduljaleel, Z., Ibrahim, I. A. A., Abdel-Wahab, A. F., Afify, M. A., & Al-Ghamdi, S. S. (2017). Phytosterols as a natural anticancer agent: Current status and future perspective. *Biomedicine and Pharmacotherapy*, 88, 786–794. <https://doi.org/10.1016/j.biopha.2017.01.068>
- Taslim, N. A., Sutisna, N., Nurkolis, F., Qhabibi, F. R., Kurniawan, R., & Mayulu, N. (2023). Dietary supplementation of *Muntingia calabura* leaves ameliorates reactive oxygen species and malondialdehyde levels: clinical study on alloxan-induced hyperglycemic rats. *Clinical Nutrition Open Science*, 48, 87–96. <https://doi.org/10.1016/j.nutos.2023.03.004>
- Tripathi, R., Gupta, V., & Tyagi, S. (2023). Hydroxymethyl ester derivative of hexadecanoic acid a possible hepatoprotectant from pulp of Cucurbita pepo. *Indian Journal of Physiology and Allied Sciences*, 75(4), 59–60. <https://doi.org/10.55184/ijpas.v75i04.208>
- Tsilo, P. H., Maliehe, S. T., Shandu, J. S., & Khan, R. (2020). Chemical composition and some biological activities of the methanolic encephalartos ferox fruit extract. *Pharmacognosy Journal*, 12(5), 1190–1197. <https://doi.org/10.5530/PJ.2020.12.167>
- Uma, B., Prabhakar, K., Rajendran, S., & Lakshmi Sarayu, Y. (2009). Studies on GC/MS spectroscopic analysis of some bioactive antimicrobial compounds from *Cinnamomum zeylanicum*. *Journal of Medicinal Plants*, 8(31), 125–131.
- Ungurianu, A., Zănfirescu, A., Nițulescu, G., & Margină, D. (2021). Vitamin e beyond its antioxidant label. *Antioxidants*, 10(5), 1–37. <https://doi.org/10.3390/antiox10050634>
- Vankudoth, S., Chirumamilla, P., Veera, S., & Taduri, S. (2022). Gas Chromatographic analysis of potentially bioactive compounds in leaf and root extracts of *Muntingia calabura* and their expected antibacterial activities. *Natural Resources for Human Health*, 2(4), 485–494. <https://doi.org/10.53365/nrfhh/145564>

Varnakulendran, N., & Elango, V. (2019). Detection of bioactive compound of Ayabirungaraja karpam GC-MS analysis. *The Pharma Innovation Journal*, 8(3), 449–457.

Widodo, A., Sulastri, E., Ihwan, I., Cahyadi, M. H., Maulana, S., & Zubair, M. S. (2024). Antidiabetic Activity, phytochemical analysis, and acute oral toxicity test of combined ethanolic extract of *Syzygium polyanthum* and *Muntingia calabura* leaves. *The Scientific World Journal*, 1, 3607396. <https://doi.org/10.1155/2024/3607396>



© 2025 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).