

Research Article

Phytochemical Screening, Antioxidant and Alpha-Amylase Inhibitory Activities of *Clitoria ternatea* and *Melastoma malabathricum* Flower Extracts

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ABSTRACT

Diabetes mellitus is a chronic disease partly caused by the imbalance between reactive oxidative stress (ROS) and endogenous antioxidant activity in the body. This study focuses on two edible flowers commonly used in traditional medicine in Malaysia namely *Clitoria ternatea* (bunga telang) and *Melastoma malabathricum* (bunga senduduk). Although considerable studies have separately shown that these flowers have high nutritional value and beneficial bioactive compounds, direct comparisons on the phytochemical, antioxidant and alpha amylase inhibitory properties of these flowers remain limited. Thus, the present study aims to examine the in vitro phytochemical constituents, antioxidant and alpha amylase inhibitory properties of both flowers. The flowers were collected, air-dried, and grounded followed by extraction using 70% ethanol. Phytochemical studies conducted were total phenolic content (TPC), total flavonoid content (TFC) and total anthocyanin content (TAC). Additionally, DPPH radical scavenging assay and alpha-amylase inhibition assay were done to assess the antioxidant and in vitro antidiabetic properties, respectively. *Clitoria ternatea* had a markedly elevated TPC: 23.54 ± 3.26 mg GAE/g, TFC: 7.28 ± 0.39 mg QE/g, TAC: 53.39 ± 5.64 mg C3G/100 g, DPPH radical scavenging, IC_{50} : 770.99 ± 19.29 ug/ml and alpha-amylase inhibition, IC_{50} : 276.11 ± 63.81 ug/ml while *Melastoma malabathricum* with TPC: 67.05 ± 0.95 mg GAE/g, TFC: 14.48 ± 0.76 mg QE/g, TAC: 34.98 ± 1.39 mg C3G/100 g, DPPH radical scavenging, IC_{50} : 100.21 ± 8.29 ug/ml and alpha-amylase inhibition, IC_{50} : 590.68 ± 14.40 ug/ml. Statistically significant differences were indicated by independent t-test results ($p < 0.05$). Preliminary findings indicate that *C. ternatea* and *M. malabathricum* flowers are good candidates as natural sources of antioxidants and antidiabetic agents, which further supports towards understanding their therapeutic benefits.

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1. Introduction

Diabetes mellitus is a metabolic disorder characterised by chronic hyperglycemia, resulting from the interplay between insulin resistance (IR) and progressive pancreatic β -cell dysfunction (WHO, 2024). Globally, about 600 million adults had diabetes in 2024, which is projected to reach 850 million by 2050 (IDF, 2025). Diabetes symptoms include fatigue, excessive thirst, frequent urination, blurred vision, skin

infections, and slow wound healing. Lifestyle changes including smoking cessation, managing obesity, balanced diet, regular exercise, and moderate alcohol can reduce risks of diabetes. Oxidative stress from excess reactive oxygen species (ROS) damaging cells contributes to the disease progression of diabetes (Volpe et al., 2018). Antioxidant defects and inflammation worsen complications, highlighting the importance of managing oxidative stress in diabetes care.

The body controls ROS through endogenous antioxidants like superoxide dismutase and glutathione (Chandimali et al., 2025). Exogenous antioxidants from diet, such as vitamin C and phytochemicals also help reduce oxidative stress (Dilworth et al., 2024). In many underdeveloped nations, limited access to modern medicine and economic constraints lead people to rely on herbal remedies for managing diabetes, such as fenugreek, bitter melon, and neem, which are commonly used to control blood sugar levels (Matpady et al., 2022). These culturally relevant therapies are often perceived more affordable and accessible than conventional medical care, making them vital in communities with scarce health resources (Raja et al., 2024). Combining traditional herbal knowledge with modern medicine offers a promising approach to reduce the burden of diabetes (Raja et al., 2024).

The tropical flowers of *Clitoria ternatea* and *Melastoma malabathricum* are widely distributed in Malaysia and have unique potential as natural sources for antidiabetic therapy (Low et al., 2021). *C. ternatea* known as "Bunga Telang" in Malaysia are traditionally used in culinary as food colourings and medicinal applications (Jamil et al., 2018). It is also reported to exhibit blood glucose-lowering, antioxidant, anti-inflammatory, and antimicrobial effects (Weerasinghe et al., 2022). Similarly, *M. malabathricum*, locally known as "Senduduk," is widely used in traditional medicine across Asia to treat wounds, infections, and various ailments (Low et al., 2021).

Plant-derived secondary metabolites, particularly polyphenols, have significant therapeutic potential because of their bioactive properties, including antioxidant activity (Samtiya et al., 2021). Dietary polyphenols can protect pancreatic cells, neutralize free radicals and stimulate insulin production, making them valuable complementary treatments for type 2 diabetes (Naz et al., 2023). Furthermore, the growing interest in plant-based complementary therapy stems from their lower side effects and toxicity compared to synthetic drugs. Although both flowers are widely available in Sabah, Malaysia, detailed research on their antioxidant and antidiabetic activities remains limited. Also, as both of these flowers are purplish in color, the specific analysis of their anthocyanin content has not been conducted in parallel. Furthermore, specific comparisons between the phytochemical, antioxidant and alpha amylase inhibitory properties of these flowers still require further investigations. Thus, this study aims to evaluate and compare the phytochemical, antioxidant and alpha amylase inhibitory effects of these local edible flowers, which may potentially be used as functional foods or nutraceuticals to combat oxidative stress and hyperglycaemia owing to their unique bioactive compounds.



Figure 1. The flowers of (A) *M. malabathricum* and (B) *C. ternatea*

2. Materials and Methods

2.1 Sample Extractions

The *M. malabathricum* flowers were obtained from Bundu Tuhan, Kundasang, Sabah, Malaysia while The *C. ternatea* flowers were obtained from Keningau, Sabah, Malaysia. The flowers were identified by Mr. Johnny Gisil, a botanist from Institute of Tropical Biology and Conservation. The *C. ternatea* and *M. malabathricum* flowers were air-dried for seven days and grounded into small pieces. 5 mg/ml extract was prepared by dissolving 200mg of dried flower in 40 mL of 70% ethanol, the extract was macerated by agitation in a water bath for 2 hours. The extracts were then sonicated for 15 minutes, centrifuged at 3000 rpm for ten minutes, and filtered using Whatman paper no. 1. The filtered extracts were stored in a freezer for further phytochemical, antioxidant, and alpha-amylase inhibition assays. The extracts were diluted to the required concentrations for each assay. All laboratory work, including plant extraction and assays, took place in the laboratory facilities of the Faculty of Food Science and Nutrition and Faculty of Science and Technology, following established protocols.

2.2 Materials

The chemicals used for this study were ethanol (System, $\geq 95.0\%$), Gallic acid (Sigma Aldrich, $\geq 95.0\%$), Folin-ciocalteu (FC) reagent (Chemiz), distilled water, Sodium bicarbonate (Chemiz, $\geq 99.0\%$), Quercetin (Sigma Aldrich, $\geq 95.0\%$), Aluminium chloride (Chemiz, $\geq 98.0\%$), Potassium acetate (Chemiz, $\geq 99.0\%$), 2,2-diphenyl-1-picrylhydrazyl powder (DPPH) (Chemiz), Ascorbic acid (Chemiz, $\geq 99.0\%$), Sodium phosphate dibasic (Na_2HPO_4) (System, $\geq 99.0\%$), Sodium phosphate monobasic (NaH_2PO_4) (System, $\geq 99.0\%$), Sodium chloride (NaCl) (System, $\geq 99.0\%$), Potassium chloride (Chemiz, $\geq 99.0\%$) and sodium acetate (R&M, $\geq 99.0\%$), Alpha-amylase enzyme (Macklin, $\geq 95.0\%$), Potato starch (R&M, $\geq 95.0\%$), Sodium Carbonate (ChemAR, $\geq 99.0\%$), Potassium iodide (ChemAR, $\geq 99.0\%$), Iodine-resublimed (Chemiz, $\geq 99.0\%$).

2.3 Phytochemical, Antioxidant and Enzymatic Assays

2.3.1 Total Phenolic Content

The total phenolic content was determined using the Folin-Ciocalteu (FC) assay using a modified method from Velioglu et al. (Velioglu *et al.*, 1998). Briefly, 150 μL of sample (2 mg/mL) was mixed with 750 μL of Folin–Ciocalteu (FC) reagent (Diluted 1/10 with distilled water), and the mixture was incubated for 5 min. Next, 750 μL of Na_2CO_3 was added and incubated for another 2 hours. Subsequently, 200 μL of the reaction mixture were pipetted into the microplate and absorbance was measured. Standards were then set at concentrations of 0 to 500 mg/mL. Blanks were prepared by replacing the sample with an equivalent volume of solvent. The assay was repeated in triplicate. Sample concentrations were determined via extrapolation from the standard curve using the following formula; Total phenolic content, TPC (mg GAE/g dried powder) = $(C_1 \times v) / m$ where; C_1 = concentration of Gallic acid established from the calibration curve (mg/mL) v = volume of flower extracts (mL) m = weight of the dried flower powder (g).

2.3.2 Total Flavonoid Content

The total flavonoid content was determined using the aluminium chloride (AlCl_3) colorimetric assay using modified method from Chang *et al.*, 2002. Briefly, 150 μL of sample (2mg/mL) was mixed with 30 μL of 10% AlCl_3 and the mixture was incubated for 5 min. Following incubation, 450 μL of 100% methanol, 30 μL of potassium acetate, and 840 μL of distilled water were added to the sample mixture. The final mixture was incubated for 30 minutes at room temperature. 200 μL of the reaction mixture was pipetted into a microplate was read for absorbance at 415 nm. The standards were prepared at 0.20, 0.10, 0.08, 0.06,

0.04, and 0.02 mg/mL. A blank was prepared to act as a sample, but the sample volume was filled with solvent. The assay was repeated in triplicate. The sample concentration was then determined against the standard curve using the following formula: Total flavonoid content, TFC (mg QE/g) = $(C1 \times v) / m$ where; C1 = concentration of quercetin established from the calibration curve (mg/mL) v = volume of flower extracts (mL) m = weight of the dried flower powder (g).

2.3.3 Total Anthocyanin Content

Total monomeric anthocyanin content (TAC) was determined via the pH differential method as described by Giusti and Wrolstad (2001), with minor modifications. Briefly, a 200 μ L aliquot of the extract (50 mg/mL) was mixed with 1400 μ L of potassium chloride buffer (0.025 M, pH 1.0) and incubated for 15 min. Absorbance was recorded at 515 nm and 700 nm using distilled water as a blank. Simultaneously, 200 μ L of the extract was combined with 1400 μ L of sodium acetate buffer (0.4 M, pH 4.5) and incubated for 15 min under identical conditions. After incubation, absorbance was measured again at 515 nm and 700 nm. The final TAC was calculated according to the following equation: Total anthocyanin (mg/L) = $(A \times MW \times DF \times 1000) / (\epsilon \times L)$ Where, A, absorbance = $(A_{515} - A_{700})$ pH 1.0 – $(A_{515} - A_{700})$ pH 4.5, MW = molecular weight for cyanidin-3-glucoside = 449.2, DF is a dilution factor of the samples = 8, ϵ = is the molar absorptivity of cyanidin-3-glucoside = 26900, and L = pathlength (1 cm). The result was expressed as mg cyanidin-3-glucoside (C3G) equivalent per 100g dried samples.

2.3.4 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity was evaluated using a 96-well microplate method using methods by Baliyan et al with modifications. Briefly, 100 μ L of the plant extract (1 mg/mL) was added to the initial wells and serially diluted with 70% ethanol to achieve a range of concentrations. Subsequently, 100 μ L of DPPH (0.3 mM) solution was added to each well. The plate was wrapped in aluminium foil and incubated in the dark for 30 min at room temperature. Following incubation, the absorbance was recorded at 517 nm using a microplate reader. Ascorbic acid was employed as the positive control. The percentage of radical scavenging activity was determined according to the following equation: Percentage of inhibition = $[(A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}}] \times 100$ Where; A_c = Absorbance of ethanol with DPPH reagent A_s = Absorbance of sample with DPPH reagent.

2.3.5 Alpha-Amylase Inhibition Assay

This assay was done according to the modified method of Xiao *et al.*, (2006). 200 mL of 1 M HCl was made by combining 16.7 mL of concentrated HCl with 183.3 mL of distilled water. The iodine reagent (5 mM I₂ and 50 mM KI) was made by dissolving 1.66 g of potassium iodine and 0.254 g of iodine crystals in 200mL distilled water. Alpha-amylase reagent was made by adding alpha-amylase enzyme in sodium phosphate buffer (2 unit/mL). 1% starch solution was prepared by dissolving 1g of starch in 100mL of distilled water and boiled until a clear solution was formed. 500 μ L of plant extracts with various concentrations and 500 μ L of Alpha-amylase enzyme (2 unit/mL) solution in 0.02M phosphate buffer (pH 6.9) were mixed and pre-incubated at 37°C for 10 minutes. Subsequently, 500 μ L of 1% starch solution was added to initiate the reaction and incubated again at 37°C for another 15 minutes. The reaction was terminated with 20 μ L of 1 M HCl after incubation, and 100 μ L of iodine reagent was added to develop a blue coloured solution. The solution absorbance was read at 620 nm using a Spectrophotometer. Acarbose solution was used as positive control.

The reagent blank contained only 1000 μ L of buffer and 500 μ L of 1% starch solution. The extract blank contained 500 μ L of extracts with different concentrations but without alpha-amylase enzyme. The enzyme control contained 500 μ L of alpha-amylase enzyme and 500 μ L of buffer. All blanks and control were subjected to similar assay procedure. Extract concentrations for *C. ternatea* and *M. malabathricum* were 2000, 1000, 500, 250, and 100 μ g/ml, while acarbose concentrations were 100, 50, 25, 12.5, and

6.25 µg/ml. The percentage of alpha-amylase inhibition was calculated using the following formula with controls for enzyme activity and extract blanks applied in the experiment. IC₅₀ values were calculated based on the generated standard curves.

$$\text{Percentage of inhibition} = [(A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}}] \times 100,$$

where A_{control} = Absorbance of enzyme control – Absorbance of reagent blank, and A_{sample} = Absorbance of extract – Absorbance of extract blank.

2.4. Statistical Analysis

Results are reported as mean $\pm$ standard deviation. An independent samples t-test was employed to evaluate significant differences in phytochemical contents and bioactivities between the two species, to compare the IC₅₀ values between *C. ternatea*, *M. malabathricum* and Acarbose, One-Way ANOVA was employed. Data analysis was conducted via IBM SPSS Statistics v. 30.0, with the threshold for statistical significance set at $p < 0.05$.

3. Results and Discussion

3.1 Total Phenolic Content

As presented in **Table 1**, the flower extract of *M. malabathricum* has a significantly higher total phenolic content (TPC) (67.05 ± 0.95 mg GAE/g) compared to *C. ternatea* (23.54 ± 3.26 mg GAE/g) ($P < 0.05$). This represents an approximately 2.8-fold higher concentration of phenolic compounds in *M. malabathricum*, indicating substantial variation in secondary metabolite biosynthesis between the two floral matrices. For *M. malabathricum*, the TPC content reported in this study was higher than previously reported, 12.76 mg GAE/g, using ethanolic extract of the flowers (Kuspradini *et al.*, 2016), but lower than the methanolic extract (179.14 ± 3.09 mg GAE/g) as reported previously by Giri and Rajbhandari, (2018).

Table 1. Phytochemical content, antioxidant and alpha-amylase inhibitory activities of *C. ternatea* and *M. malabathricum*

Assays	<i>C. ternatea</i>	<i>M. malabathricum</i>	<i>P value</i>
Total Phenolic Content, (mg GAE/g dry weight)	23.54 ± 3.26	67.05 ± 0.95	<0.001
Total Flavonoid Content, (mg QE/g dry weight)	7.28 ± 0.39	14.48 ± 0.76	<0.001
Total Anthocyanin Content, (mg C3G/100 g dry weight)	53.39 ± 5.64	34.98 ± 1.39	<0.005
DPPH, IC ₅₀ (µg/ml)	770.99 ± 19.29	100.21 ± 8.29	<0.001
Alpha-amylase inhibition (µg/ml)	276.11 ± 63.81	590.68 ± 14.40	<0.001

values are means of triplicate determinations $\pm$ SD. P value less than 0.05 indicate significant differences.

For *C. ternatea*, the value obtained in this study was lower than the previous result (50.71 ± 0.85 mg GAE/g) (Abdullah *et al.*, 2025), but almost similar to the 90% ethanolic extract of the flower (26.66 mg

GAE/g) (Jaafar *et al.*, 2020). Furthermore, the TPC content obtained in this study may have varied from other previous studies due to differences in extraction conditions and the sample source itself. The pronounced disparity in TPC can be attributed to the specific polyphenolic profiles inherent to each species. *M. malabathricum* is known to synthesize high levels of hydrolysable tannins, gallic acid derivatives, proanthocyanidins, and simple phenolic acids (Vega *et al.*, 2026). In contrast, while *C. ternatea* flowers are rich in specialized polyacylated delphinidin glycosides (ternatins) and other phenolics, their overall phenolic mass proportion relative to structural polysaccharides, mucilage in the floral matrix could be lower (Maia *et al.*, 2025).

3.2 Total Flavonoid Content

The quantitative estimation of total flavonoid content (TFC) revealed significant variation ($P < 0.05$) between the two floral species evaluated using the aluminum chloride colorimetric assay. The flower of *M. malabathricum* exhibited significantly higher total flavonoid content (TFC) value (14.48 ± 0.76 mg QE/g) than *C. ternatea* (7.28 ± 0.39 mg QE/g) (**Table 1**). The value of TFC in *M. malabathricum* flower found in this study is less than previously reported (38.17 ± 5.36 mg QE/g), which may be attributed to differences in extraction methodology (Danladi *et al.*, 2015).

For *C. ternatea*, the measured TFC in this study was 7.28 mg QE/g dry sample, which is significantly lower than a previous report of 21.44 mg QE/g dry extract (Abdullah *et al.*, 2025) and 46.23 mg QE/g dry extract (Kurniawati *et al.*, 2024), both were extracted using 70% ethanol. However, the current extraction method without evaporation and reconstitution with solvent may have affected the results obtained in this study.

This marked difference in flavonoid accumulation can be attributed to the distinct phytochemical profiles inherent to each floral matrix. *M. malabathricum* flowers synthesise a diverse array of flavonols, which are predominantly quercetin, kaempferol, and myricetin glycosides alongside prominent anthocyanins concentrated in the petal tissues (Low *et al.*, 2021). In contrast, *C. ternatea* is widely recognised for its concentration of polyacylated anthocyanins (ternatins) responsible for its deep blue pigmentation (Handayani *et al.*, 2024), its overall pool of aglycones and non-acylated flavonoids reactive to the aluminium chloride complex may be lower under the present extraction conditions.

Some factors may affect this finding, including sample source, sample processing, extraction solvent efficiency, and extraction methodology. Flavonoids act as free radical scavengers and are linked to antioxidant abilities, indicating a potential reduction in oxidative stress-related diseases. Moreover, they may inhibit carbohydrate-digesting enzymes, suggesting a relationship between TFC and antidiabetic properties. Overall, while both *C. ternatea* and *M. malabathricum* contain beneficial flavonoids. The higher flavonoid content in *M. malabathricum* may have higher antioxidant activity, which may be attributed to its traditional medicinal applications such as wound healing, anti-inflammatory, and antioxidant effects (Low *et al.*, 2021).

3.3 Total anthocyanin content

For total anthocyanin content (TAC) analysis, *C. ternatea* demonstrated significantly higher anthocyanin concentration (53.39 ± 5.64 mg C3G/100g dry flower) compared to *M. malabathricum* (34.98 ± 1.39 mg C3G/100g dry flower) (**Table 1**). This represents approximately 1.5-fold higher accumulation of water-soluble anthocyanin pigments in the petals of *C. ternatea*, showing the distinct interspecific variation in the expression of flavonoid biosynthetic pathway. The flowers of *C. ternatea* generally consist of flavonols such as quercetin, myricetin, and kaempferol derivatives, and anthocyanins (ternatin A1-A3, B1-B4, C1-C4, and D1-D3). Among the anthocyanins in *C. ternatea* flowers, the six key anthocyanins are ternatin A1, A2, B1, B2, D1, and D2 which are delphinidin-based (Jeyaraj *et al.*, 2022). Compared to previous study, *C. ternatea* anthocyanin value is notably lower than previously reported (115.22 ± 4.20 mg C3G/100 g) by Shu *et al.*, (2022). Previously, *M. malabathricum* flower 96% ethanolic extract was reported to contain 30.42 mg CG/100 g fresh weight (Kuspradini *et al.*, 2016), which was around the value obtained in this study.

The substantial anthocyanin presence in *C. ternatea* supports its role as a natural food colourant and functional ingredient, and the antioxidant properties linked to these compounds are emphasised as significant because they serve as efficient free radical scavengers and metal chelators (Maia *et al.*, 2025,

Vidana Gamage *et al.*, 2021, Weerasinghe *et al.*, 2022). In this study, *M. malabathricum*, exhibit a lower anthocyanin content despite having a variety of other phenolic compounds such as tannins and flavonols. This difference indicates *C. ternatea* 's position as a superior source of anthocyanins compared to *M. malabathricum*. Overall, both plants represent potential nutritional sources of anthocyanins, contributing to metabolic health, enhancing dietary variety, and mitigating oxidative stress-related diseases. The inclusion of these plant extracts in diets can therefore provide both bioactive benefits and a natural source of color for food products.

3.4 DPPH Radical Scavenging Assay

For the DPPH antioxidant assay, *C. ternatea* exhibited an IC₅₀ mean value of 770.99 ± 19.29 µg/mL, whereas *M. malabathricum* displayed a significantly lower IC₅₀ of 100.21 ± 8.29 µg/mL, indicating a superior free radical scavenging ability for *M. malabathricum*. The positive control, ascorbic acid, yielded an IC₅₀ of 47.56 ± 1.67 µg/mL (**Table 1**). Despite the lower DPPH value obtained for *M. malabathricum* in this study, it was still higher than the DPPH value of *M. malabathricum* flower methanolic extract, reported previously, IC₅₀ = 17.23 µg/mL (Giri and Rajbhandari, 2018) and reported by Danladi *et al.*, 2015, at 48 µg/mL.

The DPPH assay, utilized to assess antioxidant activity, suggested that *M. malabathricum* reduced IC₅₀ implies better antioxidant capacity, capable of neutralizing DPPH radicals more effectively than *C. ternatea* flower extract. Our value is significantly higher than reported in methanolic *C. ternatea* flower extract in prior research (IC₅₀=156 µg/mL) reported by Islam *et al.*, 2023, which may be attributed to variations in harvesting conditions, and potential degradation of active compounds during processing.

The elevated antioxidant activity in *M. malabathricum* can be attributed to its high levels of phenolic and flavonoid compounds, which are known to donate hydrogen or electrons to neutralize free radicals. This study corroborates previous findings that link greater phenolic content to improved DPPH scavenging activity. In contrast, the higher IC₅₀ value for *C. ternatea* suggests less effective free-radical scavenging despite its richness in anthocyanins and other antioxidants, potentially influenced by factors such as extraction methods, concentration, and the specific antioxidant assays used. Both *C. ternatea* and *M. malabathricum* are noted for their natural antioxidants, which could play a role in mitigating free radical damage, essential for reducing the risks of chronic diseases like heart disease, diabetes, and cancer.

3.5 Alpha-amylase Inhibition Assay

C. ternatea and *M. malabathricum* flower extracts exhibit inhibitory effects on α-amylase, a key enzyme in carbohydrate metabolism. In this study, *C. ternatea* extract IC₅₀ was significantly lower at 276.11 ± 63.81 µg/mL compared to *M. malabathricum* at 590.68 ± 14.40 µg/mL (**Table 1**). A lower IC₅₀ suggests stronger inhibitory activity, which means *C. ternatea* has more potent alpha-amylase inhibitory properties compared to *M. malabathricum* flower extracts. Previous studies have reported the IC₅₀ value of 910 µg/mL for reconstituted aqueous extract of *C. ternatea* flower (Chu *et al.*, 2017) and IC₅₀ value of 227.45 µg/mL for reconstituted *C. ternatea* flower ethanolic extract (Ranganathan *et al.*, 2026) which is closer to our value. For *M. Malabathricum* extracts, previous research has reported that the IC₅₀ value of 52.38 ± 1.32 µg/mL, for a methanolic leaves extract, which was much lower than reported in our study (Idris *et al.*, 2022), showing that the distribution of phytochemical varies according to plant parts. As far as we are concerned, this is the first report showing the alpha-amylase inhibitory activity of *M. malabathricum* ethanolic flower extract.

The enhanced activity in *C. ternatea* extract is most likely attributed to its rich content of bioactive compounds, specifically phenolic compounds, flavonoids, and anthocyanins, which inhibit alpha amylase by binding to or altering its active site and thus reduce the enzyme's ability to catalyse starch conversion to glucose (Oliveira *et al.*, 2020). Despite *M. malabathricum* showing comparatively higher phenolic and flavonoid contents in other assays, its higher IC₅₀ in the alpha-amylase enzyme inhibition assay indicates

differences in the specific phytochemical composition and bioavailability of its active compounds, affecting enzyme inhibition efficiency.

The selection of 70% ethanol as an extraction solvent for polar bioactive compounds may also influence results, as the efficacy of different solvents, combined with the specific characteristics of the plant species, can affect the bioactive compounds' recovery and their interaction with α -amylase (Jaafar *et al.*, 2020). Factors such as flavonoid structural properties and variation in hydroxylation and glycosylation can significantly impact enzyme inhibition (Stocierz *et al.*, 2026). The IC₅₀ value of *C. ternatea* reported in this current study ($276.11 \pm 63.81 \mu\text{g/mL}$) is almost similar to the previous findings of $227.45 \mu\text{g/mL}$ for the same extract (Ranganathan *et al.*, 2026), implying the reproducibility of our analysis.

The ethanolic flower extract of *C. ternatea* shows a promising natural agent for blood glucose regulation (Widowati *et al.*, 2024). Their ability to reduce glucose absorption through inhibition of glucose-metabolising enzyme, potentially through the presence of phenolic compounds, flavonoids and anthocyanins, suggests they could be beneficial additions to dietary regimens for individuals at risk of diabetes (Stocierz *et al.*, 2026). Because published literature regarding the antidiabetic activity of *M. malabathricum* predominantly evaluates leaf-derived extracts, direct quantitative comparisons with the floral extract investigated in the present study are constrained. Nonetheless, based on the present results, both flower extracts showed potential as hypoglycemic agents.

Overall, our study showed that *M. malabathricum* exhibited markedly higher total phenolic and flavonoid contents compared to *C. ternatea*, suggesting a richer source of antioxidant compounds. However, *C. ternatea* demonstrated greater total anthocyanin content, indicating its potential as a natural pigment with functional properties. In terms of antioxidant activity, *M. malabathricum* showed stronger DPPH radical scavenging ability, related to its higher phenolic concentration. Conversely, *C. ternatea* exhibited more effective α -amylase inhibition, implying better potential in controlling postprandial glucose levels. These findings highlight the distinct phytochemical profiles and functional properties of both extracts, showing their individual strengths as potential constituents in nutraceutical and functional food development.

3.6 Limitations and Recommendations

This study acknowledges several limitations, including the lack of analysis of certain phytochemical compounds such as tannins and saponins as well as certain functional or enzyme-inhibitory assays. All assays were conducted in vitro and may not reflect in vivo physiological effects. The research did not assess the bioavailability, metabolism, or long-term safety of the extracts. Future research using in vivo models, cell-based assays, and advanced techniques such as liquid chromatography mass spectrometry (LCMS) is suggested for compound validation. The biological molecular mechanisms behind the observed antioxidant and antidiabetic activities were not explored, indicating the need for improved studies on *C. ternatea* and *M. malabathricum* flowers to better elucidate their nutritional and therapeutic potential.

4. Conclusion

This study analysed the antioxidant and antidiabetic properties of *C. ternatea* and *M. malabathricum* flower extracts from Sabah. The species differed significantly in phytochemical composition and biological activity. *M. malabathricum* showed higher total phenolic content (TPC) and total flavonoid content (TFC), along with better antioxidant capabilities, evidenced by a lower DPPH IC₅₀ value. Conversely, *C. ternatea* had higher total anthocyanin content and a stronger ability to inhibit α -amylase, suggesting that anthocyanin

compounds may have greater potential against carbohydrate digestion. These findings indicate that both flowers showed unique characteristics, where *M. malabathricum* is more effective as an antioxidant, whereas *C. ternatea* shows promise as an antidiabetic agent. The study contributes valuable comparisons of these local plant species in Sabah, highlighting their potential as sources of functional food ingredients.

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