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Evaluation of phytochemical profile, antioxidant, antidiabetic activities of indigenous Thai fruits

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Background. This research aims to explore the antioxidant and alternative therapy options for managing type 2 diabetes mellitus (T2DM) through the use of lesser-known Thai fruits. Including,*Antidesma puncticulatum, Dillenia indica, Diospyros decandra, Elaeagnus latifolia, Flacourtia indica, Garcinia dulcis, Lepisanthes fruticose, Mimusops elengi, Muntingia calabura, Phyllanthus reticulatus, Streblus asper, Syzygium cumini, Syzygium malaccense, Willughbeia edulis, Schleichera oleosa*by analyzing their phenolic and flavonoid content. These fruits have received limited scientific attention, prompting an investigation into their health benefits, particularly their relevance to diabetes management.

Methods. The study utilized methanolic crude extracts for measuring phenolic and flavonoid levels. Additionally, HPLC-DAD was utilized to quantify phenolics and assess antioxidant and antidiabetic abilities, including alpha-glucosidase and alpha-amylase inhibition.

Results and Conclusion. The study highlighted*S. cumini*as rich sources of phenolic (980.42 ± 8.89 mg GAE/g) and flavonoid compounds (3.55 ± 0.02 mg QE/g) with strong antioxidant activity ($IC_{50}$by DPPH; 3.00 ± 0.01 µg/ml, IC_{50} by ABTS; 40 ± 0.01 µg/ml, FRAP; 898.63 ± 25.02 mg TE/ml). Additionally,*S. cumini*exhibited promising antidiabetic effects by inhibiting alpha-glucosidase and alpha-amylase. (*S. cumini*IC_{50}; 0.13 ± 0.01 µg/ml for alpha-glucosidase inhibition, 3.91 ± 0.05 for alpha-amylase inhibition). Remarkably, compounds like catechins, gallic acid, kaempferol, and ellagic acid were identified in various quantities.This study suggests that these fruits, packed with phenolics, hold potential for consumption and even pharmaceutical and cosmetic applications due to their health-promoting properties.

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Abstract

Background. This research aims to explore the antioxidant and alternative therapy options for managing type 2 diabetes mellitus (T2DM) through the use of lesser-known Thai fruits. Including, *Antidesma puncticulatum, Dillenia indica, Diospyros decandra, Elaeagnus latifolia, Flacourtia indica, Garcinia dulcis, Lepisanthes fruticose, Mimusops elengi, Muntingia calabura, Phyll*[illegible]*us reticulatus, Streblus asper, Syzygium cumini, Syzygium malaccense, Willughbeia edulis, Schleichera oleosa* by analyz[illegible]heir phenolic and flavonoid content. These fruits have received limited scientific attention, p[illegible]mpting an investigation into their health benefits, particularly their relevance to diabetes management.
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Introduction

Diabetes Mellitus (DM) is a serious chronic non-communicable disease that has seen a dramatic increase in prevalence in the past three decades. According to the World Health Organization (WHO), around 422 million people worldwide have diabetes, with the majority living in low-middle income countries. Diabetes is characterized by high blood glucose levels, which can lead to damage to the heart, blood vessels, eyes, kidneys and nerves (Chassagne et al.). There are two types of diabetes, type 1, which is caused by β-cell destruction and absolute insulin deficiency since birth, and type 2, which is the most common form, and is associated with overweight and obesity, and characterized by various degrees of β-cell dysfunction and insulin resistance. Type 2 diabetes can be prevented through healthy lifestyle choices such as regular exercise, avoiding smoking and eating a healthy diet. Currently, there are various pharmacological approaches for preventing and treating DM, including antioxidant agents, eating a healthy diet and taking oral hypoglycaemic drugs, which inhibit carbohydrate digestion enzymes such as α-glucosidase and α-amylase. These drugs can be effective in delaying carbohydrate and glucose absorption, but they often have side effects. In addition, Thailand has a diverse range of fruits throughout every season, yet many of them remain underexplored in terms of their phytochemical and biological properties. Therefore, searching for new and safe natural potential source is a good choice. Fruits contain high levels of flavonoids and carotenoids, which play important roles in plant growth, defence mechanisms, and pigmentation. Flavonoids have been shown to have potential health benefits as antioxidants and have been used to treat DM. For example, flavonoids such as quercetin can stimulate glucose uptake, insulin receptors, and carbohydrate metabolism, while rutin can increase glucose storage, insulin sensitivity, and decrease lipid accumulation. Oxidative stress has been linked to the pathogenesis of both types of DM, promoting insulin resistance and the development of complications. Antioxidants play a crucial role in preventing the body against diabetes by decreasing radical-induced damage to β-cells, which, can lead to β-cell dysfunction and subsequently result in diabetes. Moreover, these agents contribute to maintaining oxidant levels within β-cells, thereby reducing oxidative stress. In light of this, the aim of this study is to compare the phytochemical, antioxidant and antidiabetic potential of selected local fruits in Thailand.

Materials & Methods

Chemicals and reagents

Analytical, HPLC grade chemicals were used in this study. HPLC grade of water containing 85% H_2PO_4 and methanol containing 85% H_2PO_4 were used for the HPLC analysis. Folin-Ciocalteu reagent, gallic acid, sodium carbonate, aluminium chloride, hydrated sodium acetate, quercetin, vanillin, sulfuric acid, L-ascorbic acid, iron(III) chloride hexahydrate (Fe[III] Cl3·6H2O), ABTS, potassium persulfate, potassium ferrocyanide (III), trichloroacetic acid (TCA), ferric chloride, sodium phosphate dibasic heptahydrate ($Na_2HPO_4·7H_2O$), sodium phosphate monobasic monohydrate ($Na_2HPO_4·H_2O$), hydrochloric acid (HCl), trisodium phosphate, iron (II) sulfate heptahydrate, ferrozine, ethylenediaminetetraacetic (EDTA), 3-hydroxybenzoic acid, 5,5′-dithiobis-2-nitrobenzoic acid (DTNB), acetylcholine (ATCl), tacrine,

rat intestinal powder, phosphate buffer saline (pH 7.4), acarbose and p-nitrophenyl-α-D-glucopyranoside (pNPG) were purchased from Sigma Aldrich. Sodium carbonate anhydrous and hydrogen peroxide (H_2O_2).

Samples collection and preparation

In this study, the indigenous Thai fruits were purchased and collected from local markets. The samples were t dried and finely ground. The samples were extracted in triplicate using the following method, 5 g of the samples were extracted with 80% methanol (50 ml) and sonicated for 30 minutes a om temperature. The extracts were filtered through Whatman No. 4 filter paper and the extraction was concentrated using a rotary evaporator at 45°C under vacuum. The concentrated extracts were then stored at -20°C for further HPLC and bioactivity analysis.

Phytochemical evaluation

The measurement of total phenolic content was analyzed in triplicate using the Folin-Ciocalteu (F-C) method. 0.25 ml of each extract were mixed 1.25 ml of Folin-Ciocalteu reagent (25%, v/v) in a 96-well plate and incubated for 5 minutes. Then, 1 ml of 10% sodium carbonate was added to the mixture. The mixture was incubated for 1 hour at ambient temperature in the dark and the absorbance was recorded at 765 nm. The results were given as milligrams of gallic acid equivale per gram of sample (mg GAE/g) (Blainski et al., 2013).

The flavonoid content wa alyzed in triplicate using the aluminum chloride method. Briefly, 0.8 ml of the extract was mixed with 0.8 ml of a 2% aluminum chlo solution in a 96-well plate. The mixture was incubated for 15 minutes at room temperature, a he absorbance was recorded at 440 nm. The results were presented as milligrams of quercetin equivalents per gram of sample (mg QE/g) (Molole et al., 2022).

Identification and quantitative analysis of phenolic compound

The method was modi from (Soto et al., 2022). Ultra - high pressure liquid chromatography (UHPLC) was performed on an Agilent 1290 Infinity II LC system, which includes a quaternary solvent pump, an automatic injector and column oven. A diode array detector (DAD) was used for analysis. The extracts were separated using a Raptor ARC-18 column (150 mm x 4.6 mm, 2.7 µm particle size; restek, USA). The injection volume was 10 µL and the column was maintained at 40 ºC. The mobile phase consisted of a gradient mixture of solvent A (water containing 85% H_2PO_4) and solvent B (methanol containing 85% H_2PO_4) with a flow rate of 0.5 ml/min. The gradient was started with 90% solvent A and 10% solvent B, and was adjusted to 82.8% A and 17.2% B at 3 min, 77% A and 23% B at 6.5 min, 68.7% A and 31.3% B at 8.5 min, 54% A and 46% B at 10 min, 45% A and 55% B at 11.5 min, 0% A and 100% B at 13 min, and 90% A and 10% B at 17 min. The DAD was used at 286 nm. Data acquisition and processing were carried out using the Agilent HPLC OpenLAB CDS 2.X software.

In vitro antioxidant assays of extracts

The antioxidant activity was quantified by the free radical scavenging effect on the DPPH radical using the method described by (Molyneux, 2003) in triplicate. Briefly, 90 µL of the extract was added to 90 µL of methanolic DPPH dye and 90 µL of methanol in 96-well plates. The mixtures were incubated for 30 min in the dark and the absorbance was measured at 520 nm.

The FRAP (Ferric reducing antioxidant power) assay was used to determine the antioxidant activity of the extracts. The samples were prepared by adding FRAP solution to the extracts and Trolox (used as a standard), and then incubated for 30 minutes in the dark at room temperature. The absorbance was measured at 593 nm. The results were expressed as trolox equivalents (mm TE). The samples were determined in triplicate (Fernandes et al., 2016).

The ABTS (2,2'-azinobis 3-ethylbenzothiazoline-6-sulfonic acid) assay was used to determine the antioxidant activity of the extracts. The samples were determined in triplicate. Briefly, 0.2 ml of sample and 1.8 ml of 7 mM $ABTS^{+}$ were added in a microplate. The mixtures were incubated for 15 minutes at room temperature and the absorbance was measured at 734 nm (Dong et al., 2015)

In vitro antidiabetic assay of extracts

The anti-diabetic activity was quantified using the α-Glucosidase inhibition assay as follows: 50 µL of potassium phosphate buffer and 10 µL of α-Glucosidase were added to 20 µL of extract, incubated for 15 minutes and then 20 µL of p-nitrophenyl-α-D-glucopyranoside (PNPG) was added and incubated for 20 minutes at 37 ºC. Then, 50 µL of 0.1 M sodium carbonate (Na2CO3) was added after incubation and the absorbance was measured at 450 nm. A mixture of all other reagents and the enzyme except the extract was used as a blank, while a mixture without the test extract and enzyme was taken as a control. Acarbose was used in the assay as a positive control. The α-glucosidase inhibitory activity was determined based on the percentage inhibition of the enzyme activity.

$$\text{Inhibition}(\%) = \left(\frac{\text{Absorbance}_{\text{Negative control}} - \text{Absorbance}_{\text{Sample}}}{\text{Absorbance}_{\text{Negative control}}}\right) \text{x } 100\%$$

The α-Amylase inhibition was determined by the following method: 0.1 mg/mL of procine pancreatic amylase was added to 30 mL of extract, incubated for 10 minutes at 37 ºC and then 50 µL of soluble starch solution (0.2%) was added. The enzyme reaction activity was stopped by adding 75 µL of HCl (1 M) and 50 µL of iodine reagent solution (5 mM iodine and 5 mM potassium iodide) was added to the mixture and the absorbance was measured at 620 nm. A mixture of all other reagents and the enzyme except the extract was used as a blank, while a mixture without the test extract and enzyme was taken as a control. Acarbose was used in the assay as a positive control. α-Amylase enzyme activity was determined as follows (Figueiredo-Gonzalez et al., 2016)

158 Relative enzyme activity (%) = $\left(\frac{\text{Enzyme activity}_{\text{sample}}}{\text{Enzyme activity}_{\text{Negative control}}}\right)$x 100%

159 Enzyme inhibition (%) = 100% - Relative enzyme activity (%)

160

161 # Results

162 **Phytochemical evaluation**

163 Methanolic extracts were used for phytochemical evaluation in this study, as a previous
164 study found that methanol was the most efficient solvent for phenolic extraction (Javier et al.,
165 2017). The total phenolic content was reported as gallic acid equivalents per gram of methanolic
166 extract (mg GAE/g). As shown in Table 2, the highest amounts of total phenolic contents were
167 found in *S. cumini* (980.42 ± 8.89 mg GAE/g), *S. malaccense* (235.98 ± 12.41 mg GAE/g), and
168 *L. fruticose* (188.19 ± 16.95 mg GAE/g), respectively. Flavonoids are a large group of phenolic
169 compounds found in nature that have beneficial effects on human and animal health. This study
170 compared the quantity of flavonoids in 14 fruits. As shown in Table 2, the total flavon
171 content was reported as quercitin equivalents per gram of methanolic extract (mg QE/g). the
172 highest amounts of flavonoids were found in *S. cumini* (3.55 ± 0.02 mg QE/g), *E. latifolia* (1.06
173 ± 0.08 mg QE/g), *D. indica* (0.94 ± 0.14 mg QE/g) and *L. fruticosa* (0.77 ± 0.05 mg QE/g),
174 respectively. These findings indicate that *S. c i* could be a good source of phenolic and
175 flavonoid supplements compared to other fruits. The variation in TPC and TFC among samples
176 may be due to genetic factors and ecological conditions. The high phenolic and flavonoid content
177 in *S. cumini* is consistent with previous studies that have demonstrated its potential health
178 benefits, such as antioxidant, anti-inflammatory, and anti-diabetic properties.

179

180 **Identification and quantitative analysis of phenolic compound**

181 The methanolic crude extract was analyzed for phenolic compound identification through
182 ultra-high-performance liquid chromatography (UHPLC) at a wavelength of 286 nm due to its
183 significant antioxidant and antidiabetic properties. The stu dentifi x phenolic compounds
184 (catechin, epicatechin, epicatechin gallate, gallic acid, keamferol, ellagic acid). The results,
185 presented in Table 3, showed that catechin has the highest concentration in *S. cumini* (2048.83 ±
186 1.98 µg/mg), *S. oleosa* (728.26 ± 3.69 µg/mg), and *L. fruticose* (473.79 ± 3.58 µg/mg).
187 Epicatechin had the highest concentration in *S. cumini* (5397.40 ± 3.03 µg/mg) and *M. calabura*
188 (1101.8 ± 8.16 µg/mg). Epicatechin gallate was abundant in *S. cumini* (3843.07 ± 1.93 µg/mg).
189 Ellagic acid was found in high concen ons in *S. cumini* (172.45 ± 0.16 µg/mg) and *M.*
190 *calabura* (89.91 ± 0.63 µg/ml). Keamferol was detected in low concentrations in *G. dulcis* (24.45
191 ± 0.95 µg/ml), *F. indica* (16.75 ± 0.11 µg/mg), and *D. indica* (13.85 ± 0.99 µg/mg). Gallic acid
192 was found in most of the samples, with the highest concentration in *M. calabura* (2118.55 ± 6.44
193 µg/mg), *M.s elengi* (689.26 ± 0.49 µg/mg), and *G. dulcis* (552.51 ± 2.99 µg/mg)

194

195 **Antioxidant capacities of crude extracts**

The methanolic extract were determined for antioxidant activities using three assays: DPPH, FRAP, and ABTS. The DPPH assay is a colorimetric reaction that is widely used and easy to perform. The results, shown in Table 4, are expressed as IC_{50} value and indicate that *S. cumini* (IC_{50} value of 3.00 ± 0.01) had the highest antioxidant potential among the compounds tested, followed by *D. decandra* (IC_{50} value of 110 ± 0.04) and *G. dulcis* (IC_{50} value of 120 ± 0.01). The ABTS assay measures the ability of antioxidants to scavenge ABTS radicals generated in aqueous phase. The results are expressed as mg of Trolox, and show that *S. cumini* (IC_{50} value of 40 ± 0.01) had the highest antioxidant potential, followed by *S. malaccense* (IC_{50} value of 430 ± 0.02) and *L. fruticose* (IC_{50} value of 500 ± 0.06). The FRAP assay measures the antioxidant capacity by reducing ferric ions to ferrous ions, and the results are expressed as Fe^{2+} equivalents or FRAP values. The results, shown in Table 5, reveal that *S. cumini* (898.63 ± 25.02 mg TE/ml) had the highest antioxidant potential, followed by *S. malaccense* (484.75 ± 42.66 mg TE/ml) and *A. puncticulatum* (169.41 ± 12.69 mg TE/ml). Overall, the results indicate that *S. cumini* and *S. malaccense* are excellent sources of antioxidant compounds and their antioxidant activity is positively correlated with their total phenolic content.

Antidiabetic activities of crude extracts

The antidiabetic capacity of methanolic extracts were determined using two assays: α-glucosidase inhibition and α-amylase inhibition. The α-glucosidase inhibition assay is used to measure the potential of antidiabetic activity and the results are expressed as IC_{50}. The results, shown in Table 5, reveal that *S. cumini* (IC_{50} value of 0.13 ± 0.01) had the highest potential of α-glucosidase inhibition among the compounds tested, followed by *M. calabura* (IC_{50} value of 3.27 ± 0.82) and *D. decandra* (IC_{50} value of 3.96 ± 0.19). The α-amylase inhibition assay is also used to measure the potential of antidiabetic activity and the results are expressed as IC_{50} value. The results, shown in Table 6, show that *S. cumini* (IC_{50} value of 3.91 ± 0.05) had the highest ability of α-amylase inhibition, followed by *L. fruticosa* (IC_{50} value of 4.14 ± 0.04) and *W. edulis* (IC_{50} value of 4.88 ± 0.02). Overall, the results indicate that *S. cumini* has the highest potential of antidiabetic activity among the compounds tested.

Discussion

Antioxidants play a crucial role in safeguarding and sustaining the body against diabetes. They work by preventing radical-induced damage to β-cells, which, if unchecked, can lead to β-cell failure and subsequently result in diabetes. Moreover, these agents contribute to maintaining optimal oxidant levels within β-cells, thereby reducing oxidative stress. Simultaneously, the management of diabetes can involve inhibiting enzymes such as α -amylase and α -glucosidase. These enzymes play a key role in breaking down carbohydrates. By inhibiting them, the absorption of glucose can be slowed down, potentially aiding in the control of blood sugar levels. In this study, we used three different radical scavenging assays to analyze the antioxidant abilities of various fruit extracts. The assays included the DPPH assay, which measures the sample's ability to scavenge DPPH radicals. DPPH radicals is soluble in organic medium. Thus,

it is commonly employed for screening bioactive compounds such as phenols and flavonoids, The ABTS assay, which measures the sample's ability to scavenge ABTS radical cations. ABTS radical is soluble both organic and aqueous medium, allowing it to screen both lipophilic and hydrophilic samples. The FRAP assay, which measures the reducing power of the sample. We have chosen these three assays to ensure the reliability of our results. (Sadeer et al., 2020). We also analyzed antidiabetic activity by measuring the inhibition of two key enzyme activities: α-amylase, which breaks down complex carbohydrates into smaller polysaccharides, and α-glucosidase, which breaks down disaccharides and oligosaccharides into glucose that can be absorbed by the body.

All plants tested exhibited antioxidant activity in all three assays and antidiabetic activity in both assays. In particular, *S. cumini* showed prominent antioxidant and antidiabetic activities and had the highest total phenolic content and flavonoid content among all samples. An exceptional example that ranked second was *S. malaccense*, which also contained high phenolic and flavonoid content and overall high antioxidant and antidiabetic ability. Additionally, this research conducted a comparative analysis of various commercial fruits through an extensive review of the existing literature, which using the similar extraction method. The assessment of antioxidant properties, as measured by the DPPH assay, revealed that the samples examined in this study, which included *S. cumini, D. decandra, F. indica, S. malaccense,* and *P. reticulatus*, exhibited superior antioxidant properties when compared to well-known fruits such as *Punica granatum* (Pomegranate), *Malus domestica* (Apple), *Prunus armeniaca* (Apricot), *Citrus reticulata* (Mandarin), and *Prunus persica* (Peach) (Habiba et al., 2020). Furthermore, this research involved a comparative analysis of the antidiabetic capabilities of the studied fruits. Notably, *S. cumini* in this study demonstrated superior α-amylase and α-glucosidase inhibition compared to commercially known fruits, including *Mangifera indica* (mango) (Sekar et al., 2019), *Citrus macrocarpa* (wild orange) (Uddin et al., 2014), *Fragaria x ananassa* (strawberry) (Pinto et al., 2010). Apple (Utami et al., 2019), Apricot (Kaya et al., 2021), Peach (Nowicka et al., 2023).

We also investigated the total of bioactive content. encompassing both phenolic content and flavonoid content which is a large group of phenolics. Phenolic compounds have been reported to inhibit radicals through mechanisms such as hydrogen atom transfer, transfer of a single electron, sequential proton loss electron transfer, and chelation of transition metals. The hydroxyl group and benzene ring in their structure play crucial roles. The hydroxyl group functions in antioxidation by donating electrons to radicals, while the benzene ring stabilizes antioxidant molecules through reactions with free radicals (Zeb, 2020). Indicating that the quantity of phenolic compounds might be related to antioxidant ability. Similarly, the findings of this study align with previous research, particularly the work conducted by Vijaya Kumar Reddy, Sreeramulu, and Raghunath, which suggest that fruits with elevated total phenolic content tend to exhibit heightened antioxidant capabilities. (Vijaya et al., 2010). Furthermore, natural antioxidants rich in phenolic and flavonoid content from fruit have been reported to act as antidiabetics (Sun et al., 2021). In addition, there have been studies showing that the phenolic

compounds in methanolic extract of *S. cumini* fruit have strong antioxidant and antidiabetic activities (Gajera et al., 2017).

Based on the preceding results regarding total phenolic and flavonoid content, the next investigation focuses on identifying the specific phenolic compound present in the crude extract. The study identified and quantified phenolic compounds in crude extracts. Catechins (including catechin, epicatechin, and epicatechin gallate) were abundant in *S. cumini*, while epicatechin was abundant in *M. calabura*. Gallic acid was found in most samples and was particularly abundant in *M. calabura*. Kaempferol was present in small amounts in most samples, and ellagic acid was found in low amounts in some of the plants analyzed. Due to the results, we expected that catechins might be one of the powerful active compounds for antioxidant and antidiabetic activities. Likewise, there have been studies showing that catechins have a powerful antioxidant activity by scavenging of free radicals. (Musial et al., 2020). Potential antidiabetic inhibition can be achieved through reducing reactive oxygen species by suppressing NADPH oxidase activity (Mrabti et al., 2018). Improving mitochondrial function causes the release of insulin, increasing the inhibition of blood glucose. Furthermore, an improvement of intestinal function and high anti-inflammatory activity can be noticed (Wen et al., 2022). In addition, Gallic acid was reported as a powerful antioxidant and antidiabetic agent (Salih, 2010). The increasing of blood glucose cause[ ]dative stress in β-cell and is leading to dysfunction, apoptosis and necrosis of β-cell. This effects the insulin secretion and function which leads to diabetes. Therefore, an increase in free radical scavenging agents can lower the risk of diabetes and alleviate its symptoms (Sun et al., 2021).

Conclusions

This research focused on both the antioxidant and antidiabetic activities, along with the phytochemical evaluation of various samples. For the phytochemical evaluation, methanolic extracts were used and the highest total phenolic contents were found in *S. cumini*, *S. malaccense*, and *L. fruticose*, respectively. The highest amounts of flavonoids were found in *S. cumini, E. latifolia*, *D. indica*, and *L. fruticosa*, respectively. It was found that *S. cumini* could be considered a good source for phenolic and flavonoid supplements, compared to other fruits in this research. For antioxidant capacities of crude extracts, three assays were used: DPPH, FRAP, and ABTS. The results revealed that *S. cumini* has the highest antioxidant potential among the compounds tested. The antioxidant activities of *S. cumini* and *S. malaccense* are positively correlated to their total phenolic content. For antidiabetic activities of crude extracts, two assays were used: α-glucosidase inhibition and α-amylase inhibition. The results showed that *S. cumini* has the highest potential of α-glucosidase inhibition and α-amylase inhibition among the compounds tested, indicating that it has the highest potential of antidiabetic activity. This study involves a preliminary assessment of antioxidant and antidiabetic activities in crude extracts. We propose further fractionation and purification of the extract to enhance bioactivities, pinpointing

the active compound responsible for these effects. Moreover, we recommend conducting in vivo and clinical tests for future research to validate these findings.

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Table 1(on next page)

Phenolic, Flavonoid contents in fruits

Table1 Phenolic, Flavonoid contents in fruits

No.	Samples	TPC (mg GAE/g)	TFC (mg QE /g)
1	*A. puncticulatum*	81.21 ± 6.62 ^{efg}	0.03 ± 0.02^{fg}
2	*D. indica*	80.44 ± 5.2 ^{efg}	0.94 ± 0.14^{bc}
3	*D. decandra*	61.03 ± 5.59 ^{fgh}	0.37 ± 0.5^{f}
4	*E. latifolia*	48.25 ± 8.59 ^{h}	0.12 ± 0.01^{ce}
5	*F. indica*	103.53 ± 10.14 ^{e}	0.37 ± 0.04^{d}
6	*G. dulcis*	52.13 ± 4.38 ^{gh}	1.06 ± 0.08^{b}
7	*L. fruticosa*	188.19 ± 16.95 ^{c}	0.77 ± 0.05^{c}
8	*M.s elengi*	48.47 ± 4.22 ^{h}	0.13 ± 0.01^{ef}
9	*M. calabura*	148.63 ± 7.91 ^{d}	0.33 ± 0.01^{d}
10	*P. reticulatus*	69.63 ± 1.04 ^{fgh}	0.01 ± 0.02^{fg}
11	*S. asper*	75.62 ± 0.37 ^{efgh}	0.29 ± 0.01^{de}
12	*S. cumini*	980.42 ± 8.89 ^{a}	3.55 ± 0.02^{a}
13	*S. malaccense*	235.98 ± 12.41 ^{b}	0.36 ± 0.11^{d}
14	*S. oleosa*	59.67 ± 2.44 ^{fgh}	0.38 ± 0.03^{g}
15	*W. edulis*	84.76 ± 1.55 ^{ef}	0.07 ± 0.04^{f}

TPC; total phenolic content, TFC; total flavonoid content, GAE; gallic acid equivalent, QE; quercetin equivalent. Values are mean ± standard deviation in triplicate (n = 3)aa. Values in each column with superscript letters (a-d) are significantly different from each other ($p < 0.05$) from Tukey Honest Significant Difference test.

Table 2(on next page)

Identification and Quantitation of Phenolic compounds

Table2 Identification and Quantitation of Phenolic compounds

No.	Sample	catechin (µg/mg)	ellagic acid (µg/mg)	epicatechin (µg/mg)	epicatechin gallate (µg/mg)	gallic acid (µg/mg)	kaemferol (µg/mg)
1	*A. puncticulatum*	ND	ND	ND	ND	134.57 ± 0.04^{h}	ND
2	*D. indica*	ND	20.44 ± 0.12^{d}	ND	ND	ND	13.85 ± 0.99^{b}
3	*D. decandra*	171.54 ± 0.76^{d}	ND	ND	ND	ND	9.45 ± 0.19^{c}
4	*E. latifolia*	ND	6.02 ± 0.04^{e}	180.28 ± 2.49^{c}	ND	60.86 ± 0.45^{i}	6.89 ± 0.49^{cd}
5	*F. indica*	ND	ND	ND	ND	46.29 ± 0.07^{j}	16.75 ± 0.11^{b}
6	*G. dulcis*	ND	ND	ND	ND	552.51 ± 2.99^{c}	24.45 ± 0.95^{a}
7	*L. fruticosa*	473.79 ± 3.58^{c}	ND	ND	ND	196.16 ± 0.66^{g}	ND
8	*M.s elengi*	ND	6.91 ± 0.36^{e}	ND	58.14 ± 0.85^{b}	689.26 ± 0.49^{b}	ND
9	*M. calabura*	93.12 ± 0.49^{e}	89.91 ± 0.63^{b}	1101.8 ± 8.16^{b}	ND	2118.55 ± 6.44^{a}	1.13 ± 0.32^{ef}
10	*P. reticulatus*	ND	47.65 ± 0.34^{c}	ND	ND	384.87 ± 1.06^{f}	4.69 ± 0.43^{de}
11	*S. asper*	ND	ND	ND	ND	ND	3.28 ± 0.07^{def}
12	*S. cumini*	2048.83 ± 1.98^{a}	172.45 ± 0.16^{a}	5397.40 ± 3.03^{a}	3843.07 ± 1.93^{a}	436.44 ± 0.23^{e}	1.40 ± 0.13^{ef}
13	*S. malaccense*	73.73 ± 0.60^{f}	7.82 ± 0.11^{e}	ND	ND	457.74 ± 0.59^{d}	ND
14	*S. oleosa*	728.26 ± 3.69^{b}	ND	ND	ND	ND	ND
15	*W. edulis*	ND	ND	ND	ND	64.61 ± 0.13^{i}	2.59 ± 0.34^{ef}

Values are mean ± standard deviation in triplicate (n = 3). Values in each column with superscript letters (a-d) are significantly different from each other ($p < 0.05$) from Tukey Honest Significant Difference test. ND, not detected.

Table 3(on next page)

Antioxidant activities of indigenous Thai fruits

Table 3 Antioxidant activities of indigenous Thai fruits

No.	Samples	DPPH (IC_{50} µg/ml)	ABTS (IC_{50} µg/ml)	FRAP (mg TE/ml)
1	*A. puncticulatum*	1160 ± 0.01^{b}	2200 ± 0.08^{c}	169.41 ± 12.69^{c}
2	*D. indica*	690 ± 0.01^{de}	2240 ± 0.08^{e}	4.99 ± 1.45^{e}
3	*D. decandra*	110 ± 0.04^{g}	1870 ± 0.01^{c}	6.79 ± 1.09^{e}
4	*E. latifolia*	1060 ± 0.16^{bc}	4750 ± 0.07^{b}	6.96 ± 6.08^{e}
5	*F. indica*	140 ± 0.01^{g}	650 ± 0.01^{c}	17.23 ± 4.23^{e}
6	*G. dulcis*	120 ± 0.01^{g}	2130 ± 0.40^{c}	2.68 ± 1.06^{e}
7	*fruticosa*	740 ± 0.02^{de}	500 ± 0.06^{e}	19.45 ± 0.81^{e}
8	*M.s elengi*	620 ± 0.27^{de}	1170 ± 0.06^{d}	0.91 ± 1.61^{e}
9	*M. calabura*	550 ± 0.01^{def}	610 ± 0.02^{e}	27.41 ± 3.23^{e}
10	*P. reticulatus*	330 ± 0.04^{fg}	1420 ± 0.27^{d}	6.1 ± 4.06^{e}
11	*S. asper*	630 ± 0.25^{de}	2260 ± 0.18^{c}	9.23 ± 6.42^{e}
12	*S. cumini*	3.00 ± 0.01^{a}	40 ± 0.01^{a}	898.63 ± 25.02^{a}
13	*S. malaccense*	210 ± 0.02^{g}	430 ± 0.02^{e}	484.75 ± 42.66^{b}
14	*S. oleosa*	820 ± 0.14^{cd}	2150 ± 0.02^{c}	11.29 ± 4.06^{e}
15	*W. edulis*	520 ± 0.01^{ef}	2110 ± 0.10^{c}	124.93 ± 5.77^{d}

Values are mean ± standard deviation in triplicate (n = 3). Values in each column with superscript letters (a-d) are significantly different from each other ($p < 0.05$) from Tukey Honest Significant Difference test.

Table 4(on next page)

Antidiabetic activities of indigenous Thai fruits

Table 3 Antidiabetic activities of indigenous Thai fruits

No.	Samples	α-Glucosidase inhibition IC_{50} (mg/ml)	α-amylase inhibition IC_{50} (mg/ml)
1	*A. puncticulatum*	42.76 ± 1.08^{c}	5.51 ± 0.03^{e}
2	*D. indica*	62.65 ± 1.86^{b}	17.90 ± 0.07^{c}
3	*D. decandra*	3.96 ± 0.19^{f}	28.84 ± 0.05^{b}
4	*E. latifolia*	95.52 ± 9.53^{a}	46.6 ± 0.22^{a}
5	*F. indica*	26.23 ± 0.08^{f}	11.38 ± 0.14^{d}
6	*G. dulcis*	12.54 ± 0.28^{f}	15.71 ± 0.36^{d}
7	*L. fruticosa*	5.70 ± 0.20^{f}	4.14 ± 0.04^{e}
8	*M.s elengi*	13.01 ± 0.64^{f}	7.18 ± 0.02^{e}
9	*M. calabura*	3.27 ± 0.82^{f}	13.89 ± 0.14^{d}
10	*P. reticulatus*	30.21 ± 3.29^{de}	5.18 ± 0.01^{e}
11	*S. asper*	60.40 ± 1.23^{b}	24.72 ± 0.09^{b}
12	*S. cumini*	0.13 ± 0.01^{e}	3.91 ± 0.05^{e}
13	*S. malaccense*	54.43 ± 2.06^{b}	5.82 ± 0.04^{e}
14	*S. oleosa*	13.42 ± 0.34^{f}	5.25 ± 0.04^{e}
15	*W. edulis*	39.39 ± 1.36^{cd}	4.88 ± 0.02^{e}

The values provided in the tables are the mean values obtained from triplicate measurements, with the standard deviation also provided. The values in each column with superscript letters (a-d) are statistically significant from one another, as determined by the Tukey Honest Significant Difference test ($p < 0.05$).