Research Article

การหาปริมาณแอลฟาแมงโกสทินในสารสกัดเปลือกมังคุดและสมรรถภาพการต้านออกซิแดนท์ในหลอดทดลองของสารสกัด

นิธิมา ตติยอภิรดี[1,2], เชิญพร นาวานุเคราะห์[3], วรัญญา จตุพรประเสริฐ[2,4], กนกวรรณ จารุกำจร[2,5]*

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บทคัดย่อ

การหาปริมาณแอลฟาแมงโกสทินในสารสกัดเปลือกมังคุดและสมรรถภาพการต้านออกซิแดนท์ในหลอดทดลองของสารสกัด

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ว. เภสัชศาสตร์อีสาน 2561; 14(2) : 83-93

รับบทความ : 20 พฤศจิกายน 2560 **ตอบรับ :** 30 เมษายน 2561

มังคุด (*Garcinia mangostan* Linn.) ที่รู้จักในนามราชินีแห่งผลไม้เนื่องด้วยมีรสชาติอร่อยและมีฤทธิ์ทางเภสัชวิทยาที่หลากหลาย เปลือกมังคุดอุดมไปด้วยสารทุติยภูมิกลุ่มแซนโธนและมีฤทธิ์ต้านการอักเสบ ฤทธิ์ต้านแบคทีเรีย และฤทธิ์ต้านออกซิแดนท์ **วัตถุประสงค์:** การศึกษานี้มีวัตถุประสงค์เพื่อหาปริมาณแอลฟาแมงโกสทินในสารสกัดเปลือกมังคุด และศึกษาสมรรถภาพการต้านออกซิแดนท์ในหลอดทดลองของสารสกัดเปลือกมังคุด **วิธีการศึกษา:** เปลือกมังคุดสกัดด้วยตัวทำละลาย ได้แก่ น้ำกลั่น เอธานอล และเมธานอลด้วยเทคนิคการสกัดแบบซอกห์เลต ปริมาณแอลฟาแมงโกสทินในสารสกัดวิเคราะห์ด้วยเทคนิคโครมาโทกราฟีของเหลวสมรรถนะสูง การศึกษาสมรรถภาพการต้านออกซิแดนท์ในหลอดทดลองต่อการทำลายอนุมูลอิสระเอบีทีเอส (2,2-azinobis-3-ethylbenzothiazoline-6-sulphonic acid, ABTS) ไฮดรอกซิล (hydroxyl) และซุปเปอร์ออกไซด์ (superoxide) และสมรรถภาพการจับโลหะ (metal chelating capacity) รวมถึงการวิเคราะห์ลิปิดเปอร์ออกซิเดชัน (lipid peroxidation) **ผลการศึกษา:** สารสกัดเปลือกมังคุดส่วนเอธานอล (17.93±0.08% น้ำหนักแห้ง) มีปริมาณแอลฟาแมงโกสทินสูงกว่าสารสกัดส่วนเมธานอล (11.38±1.86% น้ำหนักแห้ง) ในขณะที่สารสกัดเปลือกมังคุดส่วนน้ำตรวจไม่พบปริมาณแอลฟาแมงโกสทิน สารสกัดเปลือกมังคุดส่วนเอธานอลมีค่าความเข้มข้นที่ต่ำที่สุดในการยับยั้งได้ 50% (IC_{50}) ของอนุมูลอิสระเอบีทีเอสต่ำที่สุด (0.26±0.15 mg/mL) ในขณะที่สารสกัดเปลือกมังคุดส่วนน้ำแสดงค่า IC_{50} ต่ออนุมูลอิสระซุปเปอร์ออกไซด์ การจับโลหะ และลิปิดเปอร์ออกซิเดชันต่ำที่สุด (0.49±0.08, 1.84±0.31 และ 4.14±1.57 mg/mL ตามลำดับ) อย่างไรก็ตามสารสกัดทั้งสามส่วนและกรดแอสคอร์บิกมีสมรรถภาพในการต้านอนุมูลอิสระไฮดรอกซิลไม่แตกต่างกันอย่างมีนัยสำคัญ **สรุปผลการศึกษา:** ผลการศึกษานี้สนับสนุนสมรรถภาพการต้านออกซิแดนท์ของสารสกัดเปลือกมังคุดจากสารสำคัญที่ละลายน้ำ อาทิ สารกลุ่มฟีนอลิกและแทนนิน และแอลฟาแมงโกสทิน อย่างไรก็ตามจำเป็นต้องประเมินศักยภาพการต้านออกซิแดนท์ในกายต่อไปเพื่อยืนยันถึงศักยภาพของสารสกัดเปลือกมังคุด

คำสำคัญ: มังคุด, อนุมูลอิสระเอบีทีเอส, อนุมูลอิสระซุปเปอร์ออกไซด์, อนุมูลอิสระไฮดรอกซิล, การจับโลหะ, ลิปิดเปอร์ออกซิเดชัน

Determination of α-mangostin in *Garcinia mangos*tana Linn. pericarp extract and its *in vitro* antioxidant capacity

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Abstract

Determination of α-mangostin in *Garcinia mangos*tana Linn. pericarp extract and its *in vitro* antioxidant capacity

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IJPS, 2018; 14(2) : 83-93

Received : 20 November 2017 **Accepted :** 30 April 2018

Garcinia mangostana Linn. or mangosteen is known as the queen of fruit due to its pleasant taste and various pharmacological properties. The pericarp of *G. mangostana* enriched with biological active secondary metabolites, xanthones, and showed anti-inflammatory, antibacterial, and antioxidant activities. **Objectives:** This study aimed to determine α-mangostin content in *G. mangostana* pericarp extract and investigate *in vitro* antioxidant capacity of the extract. **Methods:** The *G. mangostana* pericarp was extracted in distilled water (GM-DW), ethanol (GM-EtOH), and methanol (GM-MeOH) by soxhlet extraction. The content of α-mangostin in each extract was determined by high performance liquid chromatography (HPLC). *In vitro* antioxidant capacities, 2,2-azinobis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS), hydroxyl ($OH^{\bullet}$), and superoxide radical scavenging ($O_2^{\bullet-}$), including metal chelating capacities of the extracts were determined. Lipid peroxidation was also analyzed. **Results:** The GM-EtOH (17.93±0.08% dry weight) had higher α-mangostin content than the GM-MeOH (11.38±1.86% dry weight) whereas α-mangostin in the GM-DW was not detected. GM-EtOH exhibited the lowest 50% inhibitory concentration (IC_{50}) of ABTS activity (0.26±0.15 mg/mL) while GM-DW showed the lowest IC_{50} of scavenging activities against superoxide radicals, metal chelating, and lipid peroxidation (0.49±0.08, 1.84±0.31, and 4.14±1.57 mg/mL, respectively). However, there was no significant difference among three parts of the extracts and ascorbic acid in hydroxyl scavenging capacity. **Conclusion:** These findings revealed the *in vitro* antioxidant capacity of the *G. mangostana* pericarp extracts due to aqueous constituents, at least phenolics and tannins, and α-mangostin. However, further investigation on *in vivo* antioxidant activity is required to assure the antioxidant potential of the *G. mangostana* pericarp extracts.

Keywords: mangosteen, ABTS radical, superoxide radical, hydroxyl radical, metal chelating, lipid peroxidation

Introduction

An antioxidant plays a significant role in balancing of redox status by regulation oxidative stress (Qasim, 2012). Oxidative stress associates with pathological conditions of the body because it is a regularly on-going vital process for cell life and death. Imbalance of redox status leads to develop cellular oxidative stress due to the over-formation of reactive oxygen species (ROS) including hydrogen peroxide, superoxides, and hydroxyl ions (Shu, 1998). In addition, oxidative stress is occurred by reactive nitrogen species (RNS) including nitrate, nitrite, nitric oxide, and peroxynitrite (Qasim, 2012). Generally, the redox status is balanced by endogenous antioxidant system especially antioxidant enzymes including superoxide dismutase, catalase, glutathione peroxidase (Shu, 1998). However, if the endogenous antioxidants fail to overcome the reactive metabolite production, then exogenous antioxidants (i.e. vitamins, herbal extracts) would be helpful to balance the redox status.

Recently, a demand on natural antioxidant is increasing due to consumer concerning about safety/toxicity of a synthetic antioxidant (Suttirak and Manurakchinakorn, 2014). *Garcinia mangostana* Linn. or mangosteen (family Guttiferae) is known as the queen of fruit due to its pleasant taste and medicinal properties. It has been used as a traditional Ayuravedic medicine for treatment of dysentery, skin infection, wound, and ulcers (Jung *et al*., 2006; Jindarat, 2014). *G. mangostana* pericarp extract has been reported to possess several pharmacological activities including antibacterial (Tatiya-aphradee *et al*., 2016), antiparasitic (Keiser *et al*., 2012), anticancer (Yu *et al*., 2009), anti-inflammatory (Tewtrakul *et al*., 2009), and antioxidant activities (Pedraza-Chaverri *et al*., 2008; Tewtrakul *et al*., 2009, Ngawhirunpat *et al*., 2010; Phyu and Tangpong, 2014; Tjahjani *et al*., 2014). *G. mangostana* pericarp is rich of various bioactive compounds including xanthones (α-, β-, and γ-mangostin), garcinone E, 8-deoxygartanin, gartanin (Ovalle-Magallanes *et al*., 2017), and phenolics and flavonoids including tannins and anthocyanins (Palapol *et al*., 2009; Pothitirat *et al*, 2009; Zadernowski *et al*., 2009; Zarena and Sankar, 2009). Though *in vitro* antioxidant capacities of *G. mangostana* pericarp extracts were reported, none contained simultaneously determination of active constituent and assessment of antioxidant capacity of aqueous (GM-DW), ethanol (GM-EtOH), and methanol (GM-MeOH) extracts of *G. mangostana* pericarp. Thus, the present study aimed to determine α-mangostin content and investigate antioxidant capacity of *G. mangostana* pericarp extracts by measuring ABTS, hydroxyl, and superoxide radical scavenging activities, including metal chelating activity, followed by lipid peroxidation.

Materials and Methods

Chemicals

α-Mangostin was supplied by Chengdu Biopurify Phytochemicals (Sichuan, China). Acetonitrile was a product from Merck (Damstadt, Germany). Ethanol and methanol were purchased from Ajax Finechem (Auckland, New Zealand). 2,2-azinobis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS), ascorbic acid, ferric chloride ($FeCl_3$), nitriloacetic acid (NTA), deoxyribose, thiobarbituric acid (TBA), β-nicotinamide adenide dinucleotide (NADH), phenazine methosulfate (PMS), nitroblue tetrazolium (NBT), and Tris HCl were obtained from Sigma-Aldrich (Missouri, USA). All other laboratory chemicals were purchased from commercial suppliers with the highest available purity and quality.

Preparation of *G. mangostana* pericarp extract

G. mangostana was purchased from the local market in Khon Kaen (April 2014). The specimen has been deposited at the Herbarium of Faculty of Pharmaceutical Sciences, Khon Kaen University and identified as PANPB-GM 2014-001 by Dr. Waraporn Putalun, Khon Kaen University. The pericarp was washed prior to dried in an oven at 50-60°C. The dried pericarp was grinded and

subjected to Soxhlet extraction with the solvents including distilled water (GM-DW) for 6 h, methanol (GM-MeOH), and ethanol (GM-EtOH) for 3 h. The extract was filtered through a filter paper (Whatman® No.1) and lyophilized to dryness. Each extract was weighed and calculated the percent yield prior to keep at -20°C for further study.

Determination of α-mangostin content in *G. mangostana* pericarp extracts

The reverse phase-high performance liquid chromatography (RP-HPLC) for determination of α-mangostin was validated according to the international Conference on Harmonization (ICH) guideline 2005, including specificity, linearity, accuracy, precision, and sensitivity, both limit of detection (LOD) and limit of quantification (LOQ). Specificity was determined by relative retention time of α-mangostin in the extract to the standard. Linearity was evaluated by correlation coefficient (R^2) of calibration curve of peak area and a series of α-mangostin (10-100 μg/mL) not less than 0.999. Accuracy was determined by %recovery from triplicates (n=3) of different α-mangostin concentrations. Precision was examined both within-day and between-day variations by subjecting 5 replicates (n=5) of α-mangostin (10, 30, 50, and 100 μg/mL) for one and 5 different days, and then relative standard deviation (%RSD) of the peak area was calculated to exhibit the within-day and between-day precision, respectively. LOD and LOQ were calculated from the standard deviation of the linear regression line (S_B) and y-intercept (Y_B) using the equations: $Y = 3S_B + Y_B$ for LOD and $Y = 10S_B + Y_B$ for LOQ. Then the value of Y was substituted in the linear regression equation to achieve LOD or LOQ, respectively.

All of the *G. mangostana* pericarp extracts were analyzed for the α-mangostin content. The extract was diluted with the same solvent of extraction and filtered through a 0.22 μm-membrane filter before subjected to HPLC system consisted of a C_{18} column (Phenomenex® Luna 5u C18 100Å, ODS 5 μm, 4.6×250 mm, Waldbronn, Germany) and an isocratic mobile phase of 85% acetonitrile in distilled water. The flow rate was set at 1 mL/min and the wavelength of UV detector was 244 nm. The extract was calculated α-mangostin contents (% w/w) from the standard curve of α-mangostin (10-100 μg/mL).

Determination of 2,2-azinobis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS) radical scavenging activity

The extract was accurately weighed 50 mg and adjusted by distilled water to 1 mL. The extract was vortex mixed 15 min prior to centrifugation at 5,000 rpm at room temperature (25°C) for 15 min. A 10 μL-aliquot of supernatant was transferred to a 96-well plate. The mixture of 7 mM ABTS and 140 mM potassium persulfate ($K_2S_2O_8$) (200:3.55) was incubated in the dark at room temperature for 16 h. Then the reaction mixture was diluted with distilled water until the absorbance at 700 nm reached 0.700±0.02. A 200 μL-aliquot of the reaction mixture was added into the well containing the sample supernatant and incubated at room temperature for 6 min before measured absorbance at 700 nm (Re *et al*., 1999).

Determination of hydroxyl radical ($OH^{\bullet}$) scavenging activity

The extract (50 mg) was dissolved in 1 mL of distilled water and vortex mixed for 15 min before subjected to centrifugation at 5,000 rpm for 15 min. The supernatant (110 μL) was transferred to a 12 mL-test tube. The reaction mixture (100 μL of 25 mM ferric chloride, 100 μL of 100 mM nitriloacetic acid, 100 μL of 2.8 mM deoxyribose, and 190 μL of 2.8 mM hydrogen peroxide) was added into the 12 mL-test tube containing the sample supernatant and incubated at 37°C for 60 min. 1% Thiobarbituric acid (100 μL) and 2.8% trichloroacetic acid (100 μL) were added into the well and incubated at 100°C for 20 min. The absorbance was measured at 532 nm. Ascorbic acid was used as a positive control. The $OH^{\bullet}$ radical scavenging activity of the extract was calculated by comparing to % inhibition of standard ascorbic acid (200-1,600 μg/mL) (Arunoma and Halliwell, 1987).

Determination of superoxide radical ($O_2^{\cdot}$) scavenging activity

The extract (50 mg) was dissolved in 1 mL of distilled water and vortex mixed for 15 min prior to centrifugation at 5,000 rpm for 15 min. The supernatant (50 μL) was transferred to a 96-well plate. A 50 μL-aliquot of the reaction mixture of 624 μM NADPH, 120 μM phenazine methosulfate, and 2.52 mM nitroblue tetrazolium was added into the 96-well plate and incubated at room temperature for 14 min. The absorbance was measured at 560 nm. Ascorbic acid was used as a positive control. The $O_2^{\cdot}$ radical scavenging activity of the extract was calculated by comparing to %inhibition of standard ascorbic acid (0-10 μg/mL (Chidambaram and Venkatraman, 2010).

Determination of metal chelating activity

The extract (50 mg) was dissolved in 1 mL of distilled water and vortex mixed for 15 min prior to centrifugation at 5,000 rpm for 15 min. The supernatant (160 μL) was transferred to a 96-well plate. Then a 150 μL-aliquot of the mixture of 2 mM ferrous chloride and 5 mM ferrozine (1:2) was added into the well prior to incubate and shake at 25°C for 10 min. The absorbance was measured at 562 nm. Ascorbic acid was used as a positive control. The percent of metal chelating inhibition (%inhibition) of the extract was calculated comparing to standard ascorbic acid (0-50 μg/mL) (Oktay *et al*., 2003).

Determination of lipid peroxidation

The extract (50 mg) was dissolved in 1 mL of distilled water and vortex mixed for 15 min prior to centrifugation at 5,000 rpm for 15 min. The supernatant (10 μL) was transferred to a 96-well plate containing 150 μL of 150 mM Tris HCl buffer, 10 μL of 4 mM $FeCl_2$, and 100 μL of the liver homogenate (protein 10 mg/mL). The plate was incubated at 37°C for 60 min while shaking at 100 rpm. The reaction mixture (120 μL) was transferred to a 12 mL-test tube and mixed with 0.6% TBA (400 μL) and distilled water (160 μL) before placed into a 100°C water bath for 30 min. n-Butanol (700 μL) was immediately added to stop the reaction. The reaction mixture (1 mL) was transferred to a 1.5 mL-microtube and centrifuged at 3,000×g for 10 min. Then supernatant (150 μL) was transferred to a 96-well plate to measure absorbance at 532 nm. The %inhibition of lipid peroxidation of the extract was calculated comparing to standard ascorbic acid (a positive control) (Bajpai *et al*., 2014).

Statistical analysis

The data was analyzed by one-way analysis of variance (ANOVA) followed by Tukey's *post hoc* test (SPSS ver17.0). p □ 0.05 was considered statistically significant.

Results

α-Mangostin content in the *G. mangostana* pericarp extracts

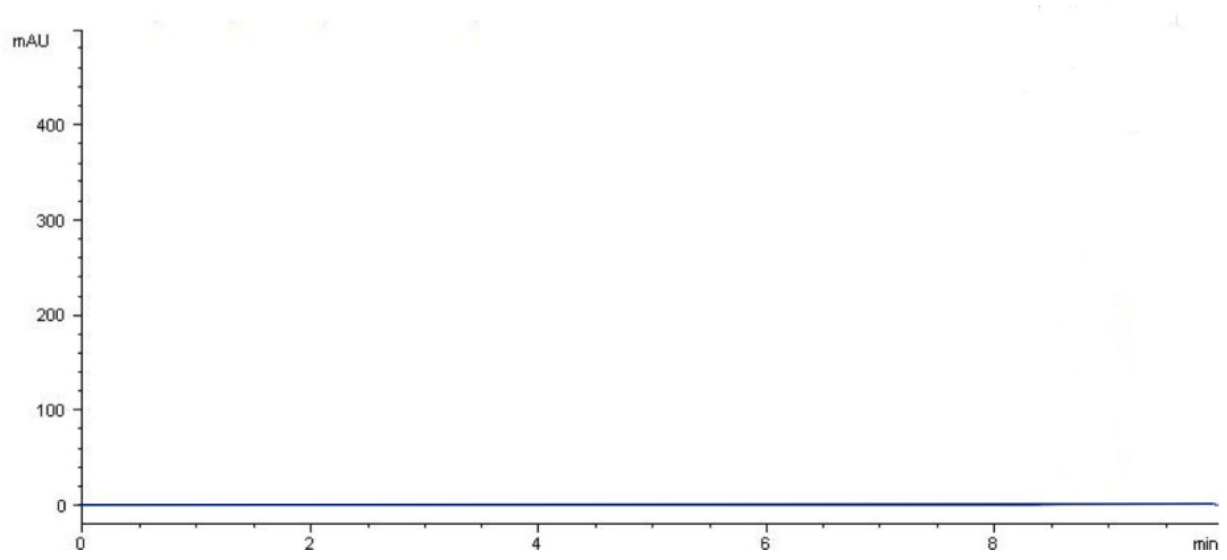
An optimization of RP-HPLC was demonstrated as a good specificity, linearity, accuracy, precision, and sensitivity for quantitative determination of α-mangostin. Validation of the method was assured high specificity of α-mangostin with a unique peak and no interference. The retention time of α-mangostin was 9.022 min (Figure 1). The linear regression of α-mangostin ranged from 10 to 100 μg/mL exhibited a good linearity (R^2= 0.99965) (Table 1). The accuracy of the method was good with %recovery of 97.20±7.24%. The precision was good presented by %relative standard deviation within the linearity range of 0.65-1.60% for within-day and 0.55-2.18% for between-day. The method showed a good sensitivity with the limit of detection (LOD) and limit of quantification (LOQ) of 1.44 and 4.80 μg/mL, respectively.

Table 1 Validation parameters for determination of α-mangostin using RP-HPLC.

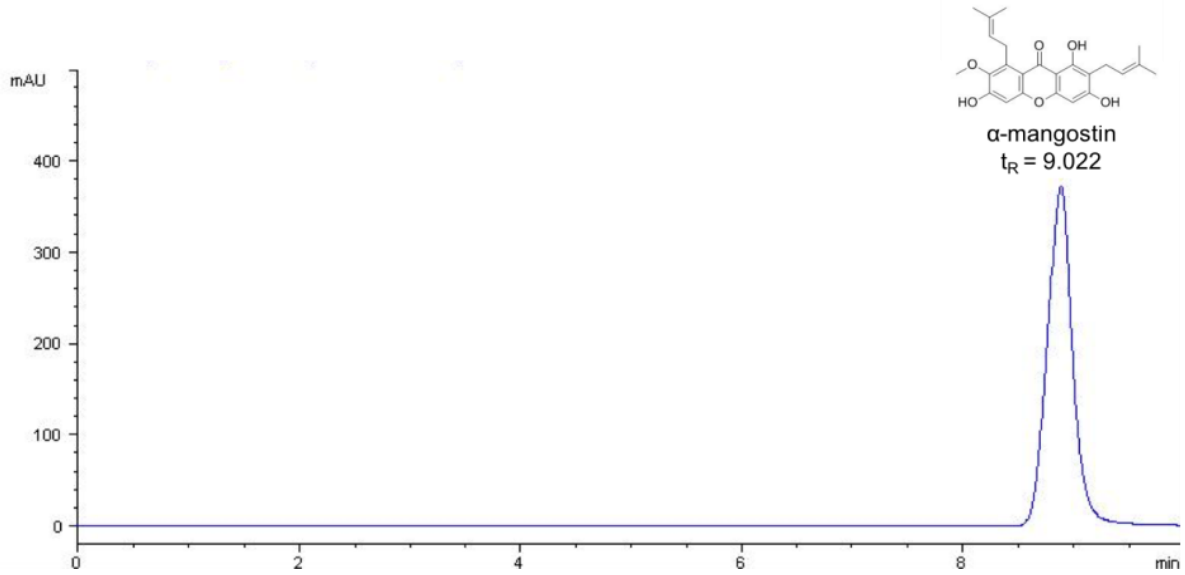
Linearity (concentration ranged 10-100 μg/mL)	
• Linear regression equation	Y = 58.285x-77.691
• R^2	0.99965
Accuracy	
• % Recovery	97.20±7.24
Precision (%RSD, concentration ranged 10-100 μg/mL)	
• Within-day	0.65-1.60
• Between-day	0.55-2.18
Specificity	
• Wavelength 244 nm	No peak interference
• Retention time (min)	9.022
Sensitivity	
• LOD (μg/mL)	1.44
• LOQ (μg/mL)	4.80

The chromatograms of α-mangostin standard and each extract were shown in Figure 1. The α-mangostin content of the extract was shown in Table 2. The GM-EtOH extract (17.93±0.08% dry weight) had higher α-mangostin content than the GM-MeOH (11.38±1.86% dry weight). On the other hand, the α-mangostin in the GM-DW was not detected.

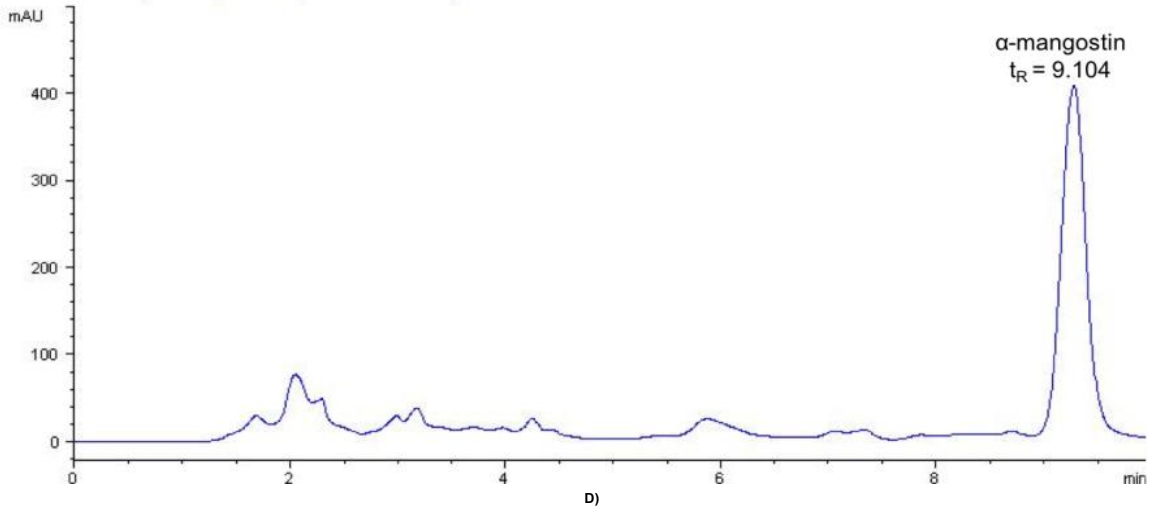
A) Blank-ethanol



B) Standard α-mangostin (100 μg/mL)



C) GM-EtOH



D)

E) GM-MeOH

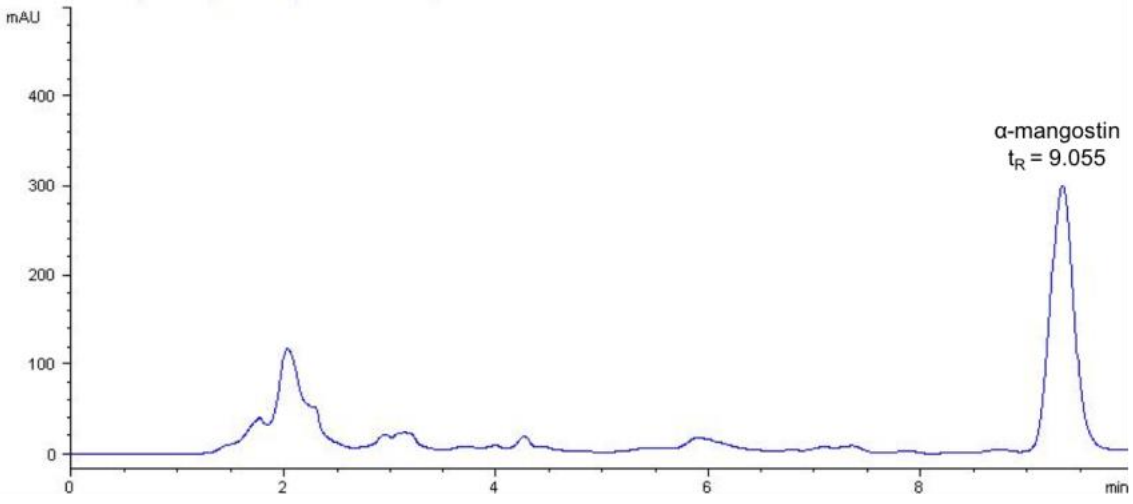


Figure 1 Chromatogram of A) blank ethanol, B) standard α-mangostin (100 μg/mL), C) GM-EtOH (20 mg/mL), and D) GM-MeOH (20 mg/mL)

Table 2 α-Mangostin content in the *G. mangostana* pericarp extracts.

Extract	α-mangostin content (% dry weight)	Retention time (min)
GM-DW	Not detected	Not detected
GM-EtOH	17.93±0.08	9.104
GM-MeOH	11.38±1.86	9.052

Antioxidant capacities of *G. mangostana* pericarp extracts

Antioxidant capacities, namely ABTS, $OH^{\bullet}$, $O_2^{\bullet}$, metal chelating activities, and lipid peroxidation of the *G. mangostana* pericarp extracts were shown as the lowest 50% inhibitory concentration (IC_{50}) values (Table 3). GM-EtOH had the lowest IC_{50} value of ABTS activity (0.26±0.15 mg/mL) while GM-DW showed the lowest IC_{50} values in scavenging activities of superoxide radical (0.49±0.08 mg/mL), metal chelating (1.84±0.31 mg/mL), and lipid peroxidation (4.14±1.57 mg/mL). Interestingly, all *G. mangostana* pericarp extracts showed similar hydroxyl scavenging activity as ascorbic acid.

Table 3 Antioxidant capacities of the *G. mangostana* pericarp extracts

	IC_{50} (mg/mL)				
Samples	**ABTS[1]**	**$OH^{\bullet}$[2]**	**$O_2^{\bullet}$[3]**	**Metal Chelating**	**Lipid peroxidation**
Ascorbic acid	0.06±0.01	0.49±0.03	0.002±0.001	39.13±10.92	0.011±0.002
GM-DW	0.34±0.02*	0.51+0.39	**0.49±0.08***	**1.84±0.31***	**4.14±1.57***
GM-EtOH	**0.26±0.15*#**	0.33±0.07	0.82±0.06*#	69.57±6.46*#	21.08±9.18#
GM-MeOH	0.56±0.33*#	0.50±0.18	1.57±0.38*#	31.88±2.49#	21.08±9.18#

Note. The results are expressed as mean±SD from 3 independent experiments. [1]scavenging activity of 2,2-azinobis-3-ethylbenzothaiazoline-6-sulphonic acid (ABTS) radicals; [2]scavenging activity of hydroxyl ($OH^{\bullet}$) radicals; [3]scavenging activity of superoxide ($O_2^{\bullet}$) radicals. *p<0.05 vs ascorbic acid, #p<0.05 vs GM-DW

Discussion and conclusion

Nowadays, *G. mangostana* extract is a popular botanical dietary supplement in the market due to its antioxidant potential. The pericarp is enriched in biological active secondary metabolites, xanthones. α-Mangostin, a xanthone form *G. Mangostana* pericarp is a bioactive compound, in which its antioxidant activity has been extensively reported (Williams et al., 1995; Kondo *et al*., 2009; Ngawhirunpat *et al*., 2010). The present study found that the GM-EtOH had higher α-mangostin content than the GM-MeOH while the GM-DW was not detected, similar to the study of Ngawhirunpat *et al*. (2010), due to α-mangostin is a water-insoluble compound (Budavari, 1989).

In this study, antioxidant capacities of the *G. mangostana* pericarp extracts were demonstrated via scavenging of several types of free radicals including ABTS, $OH^{\bullet}$, $O_2^{\bullet}$ (Re *et al*., 1999), and metal chelating mechanism, followed by lipid peroxidation (Oktay *et al*., 2003). Correspondingly, *G. mangostana* ethanolic and methanolic extracts showed antioxidant activity against 2,2-diphenyl-1-picrylhydrazyl (DPPH) and ABTS radicals (Yoshikawa *et al*.

1994; Chomnawang *et al*., 2007). Interestingly, the current observations found that the aqueous extract of *G. mangostana* pericarp (GM-DW) had the lowest IC_{50} of superoxide scavenging and metal chelating capacities, including lipid peroxidation with the comparable capacity against hydroxyl radicals to ascorbic acid. Superoxide is a precursor of hydroxyl radicals and singlet oxygen (Gao *et al*., 2000) which diminish hydrogen atoms in lipid membrane, resulting in lipid peroxidation. Corresponding to the study of Ngawhirunpat *et al*. (2010), an aqueous extract of *G. mangostana* perciarp showed higher inhibitory activity on lipid peroxidation than its methanol extract. However, though the GM-DW contained no α-mangostin, it provided good antioxidant capacity. This phenomenon might partly due to an effect of phenolic compounds in the extract, at least tannins (Ngawhirunpat *et al*., 2010). Various phenolic compounds possess biological activities, especially antioxidant activity (Ishige *et al*., 2001).

There was no significant difference among three parts of the extracts in hydroxyl scavenging capacity similar to the study of Ngawhirunpat *et al*. (2010) which showed no difference of hydroxyl scavenging capacity between aqueous- and methanolic extracts of *G. mangostana* pericarp. Hydroxyl radicals act as potent oxidants reacting with most of biomolecules. In the model of deoxyribose assay, $OH^{\bullet}$ degraded deoxyribose and resulted in a series of reactions. Corresponding with the present findings, *G. mangostana* pericarp extracts possessed inhibitory action on hydroxyl radical-induced deoxyribose degradation (Ngawhirunpat *et al*., 2010).

Therefore, the *G. mangotana* pericarp extract is an ultimate antioxidant candidate which is superior to α-mangostin. The use of *G. mangostana* pericarp extract as a botanical dietary supplement is of benefit. However, further investigation of its *in vivo* antioxidant activity is required to assure the potential of *G. mangostana* pericarp extract and to unravel its regulatory mechanism.

Acknowledgements

Authors are grateful to the Research group of Pharmaceutical Activities of Natural Products using Pharmaceutical Biotechnology (PANPB), Faculty of Pharmaceutical Sciences, Khon Kaen University, Khon Kaen, Thailand, for research grant and facilities.

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