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Enhanced antioxidant and antityrosinase activities of longan fruit pericarp by ultra-high-pressure-assisted extraction

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ABSTRACT

The health benefits of fruits acting against chronic diseases are ascribed to their antioxidant activities which are mainly responsible due to the presence of phenolic compounds. The use of ultra-high-pressure-assisted extraction (UHPE) has shown great advantages for the extraction of these phenolic compounds from longan fruit pericarp (LFP). Studies were carried out to investigate the effects of UHPE at pressures of 200, 300, 400 and 500 MPa on total phenolic contents, extraction yield, antioxidant and antityrosinase activities from LFP. The antioxidant activities of these extracts were analyzed, using various antioxidant models like 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity, total antioxidant capacity and superoxide anion radical scavenging activity. Extract from ultra-high-pressure-assisted extraction at 500 MPa (UHPE-500) showed the highest antioxidant activities of all the tested models. In addition, it also showed moderate tyrosinase inhibitory activity. Three phenolic acids, namely gallic acid, ellagic acid, and corilagin were identified and quantified by HPLC. Corilagin content was the highest compared to other phenolic acids identified. UHPE-500 obtained the higher phenolic acid contents compared to other high pressure processing and conventional extractions (CE). Compared with CE, UHPE-500 exhibited good extraction effectiveness in terms of higher extraction yields with high phenolic contents and also with higher antioxidant and antityrosinase activities.

1. Introduction

Antioxidants are chemical compounds that when added to lipids and lipid-containing foods, can prolong the shelf-life by retarding the process of lipid peroxidation, which is the major reason for the deterioration of food products during processing and storage. Synthetic antioxidants such as butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT) have received restricted use in foods, as these are suspected to be highly carcinogenic and for other safety concerns [1]. As a result the importance for exploiting natural antioxidants, especially those of plant origin has received increasing attention in recent years. Numerous isolated plant constituents and crude extracts from fruits and vegetables have been recognized to possess beneficial effects against free radicals in biological systems as natural antioxidants [2–4]. These useful effects of extracts from fruits and vegetables can be attributed to many phenolic compounds with high antioxidant activity [5].

Tyrosinase (EC 1.14.18.1) is an enzyme involved in melanin production. Alterations in melanin production might be responsible for a part of the histopathological features unique to malignant melanoma [6]. Therefore, tyrosinase inhibitors may be clinically useful for the treatment of skin cancer. Recently more attention is being paid to the use of natural plant extracts in the cosmetic industry as tyrosine inhibitors [7].

Longan (*Dimocarpus longan* Lour.) is a commercially attractive fruit and is widely distributed throughout the southern parts of China. Longan fruit pericarp (LFP) contains high amount of secondary metabolites like phenolic acids, flavonoids and polysaccharide. Phenolic acids and flavonoids display a broad range of pharmacological activities including, antioxidative, antityrosinase, antimutagenic, anti-inflammatory and anticancer effects and are considered to be one of the effective components in LFP [7,8]. It is of great interest to find a suitable method to extract these bioactive compounds from LFP with higher extraction yields. The growing interest in natural products for flavors and foodstuffs and in the use of green technologies for their extraction process has increased the interest in environmentally friendly routes to obtain these products. Thus, ultra-high-pressure-assisted extraction (UHPE) has received wide attention in recent decade [9].

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Ultra high pressures ranging from 100 to 800 MPa are widely used in the ceramics, casting industry, pharmaceutics, metallurgy, plastics making and civil engineering. Ahmed and Ramaswamy [10] reported that UHPE technique could shorten processing time and reach high extraction yields, yet have no adverse side effects on the activity and structure of the bioactive components. The application of high pressure to plant materials was initially reported by Zhang et al. for extraction of polyphenols from green tea [9]. Usage of UHPE increases mass transfer rates, which enhances cell permeability as well as secondary metabolite diffusion [11]. Since 2004, UHPE has been used for extraction of flavonoids from *Propolis* [12], anthocyanins from grapes [13], flavonoids from lychee [14] ginsenoside from *Panax quinquefolium* [15] and flavones and salidroside from *Rhodiola sachalinensis* [16].

Several extraction techniques such as soxhlet, microwave [17] and ultrasound-assisted extraction [18] have been adopted to extract phenolics and polysaccharides from LFP, yet there are very few studies on the use of the UHPE. The objective of this study was to determine the effects of ultra-high-pressure-assisted extraction at 200 MPa (UHPE-200), 300 MPa (UHPE-300), 400 MPa (UHPE-400) and 500 MPa (UHPE-500) on the (a) extraction yields, (b) total phenolics contents, (c) antioxidant activities, (d) antityrosinase activity and (e) individual phenolic acid contents. The UHPE were compared to those of conventional extraction (CE) to confirm the advantages of ultra-high-pressure-assisted extraction.

2. Materials and methods

2.1. Chemicals and reagents

1,1-Diphenl-2-picryldydrazyl (DPPH), nitro blue tetrazolium (NBT), butylated hydroxy toluene, L-tyrosine, tyrosinase with a activity of 1000 units/mg, riboflavin, methionine and gallic acid were purchased from Sigma Chemical Co. (St. Louis, MO, USA). All other solvents and chemicals used in this study were of analytical grade and obtained from Tianjin Reagent Company (Tianjin, China).

2.2. Plant material

Fresh fruits of longan (*Dimocarpus longan* Lour.) at the commercially mature stage were picked from a commercial orchard in Guangzhou, China. Fruits were selected for uniformity of shape and color. The fruits were washed in clean water and the longan pericarp tissues were manually separated. It was then dried for 24 h using a hot air oven at 60 °C, and finally powdered with a blender.

2.3. Ultra-high-pressure-assisted extraction

Ultra-high-pressure-assisted extraction was conducted with a Batch High Hydrostatic Pressure Food Processor (Kefa Food Equipment Ltd., Baotou, China). The dried LFP powder (10 g) was mixed with 500 mL of 50% ethanol, and then pressurized for 30 min at pressures of 200, 300, 400 or 500 MPa, with the dioctyl sebacate acting as the pressure transmitting media. The pressure chamber was maintained at 30 °C with a water bath. Pressurization cycles, pressures and time were programmed by a computer to control the automatic locking of the safety box and the alarms. After depressurization, the extracted solutions were separately collected, then filtered and stored in −30 °C freezer pending further analysis.

2.4. Conventional extraction

Conventional extraction was performed as described by Corrales et al. [13] with some modifications. The dried LFP powder (10 g) was extracted for 30 min with 500 mL of 50% ethanol in a conical flask at 30 °C. After extraction, the solution was filtered and the filtrate was stored in −30 °C freezer pending further analysis.

2.5. Extraction yield

The extraction yield was determined as described by Zhang et al. [16] with some modifications. In brief, the filtrate obtained was evaporated with a rotary evaporator (RE-52A, Shanghai Woshi Co., Shanghai, China) and was then lyophilized in a freeze-dryer (Savant, Vapornet VN 100, Labequip Ltd., Canada) to obtain the freeze-dried extracts. The freeze-dried extracts were weighed and the extract yields were calculated as the weight (g) from 10 g raw material, and the yield were expressed in percentage on a dry basis.

2.6. Determination of total phenolic content

Total phenolic contents of the UHPE and CE extracts were determined by the method of Prasad et al. [3] with some modifications, and then expressed as gallic acid equivalents (GAE). In brief, a 100 μL aliquot of the extracts dissolved in 50% ethanol was added to 2 mL of 2% Na_2CO_3 solution. After 2 min, 100 μL of 500 mL/L Folin–Ciocalteu reagent was added and the mixture was allowed to stand for 30 min at 25 °C. The absorbance was measured at 750 nm using a spectrophotometer (UV-2802, Unico Co. Ltd., Shanghai, China). The blank consisted of all reagents and solvents except the tested samples. The total phenolic contents were determined using the standard gallic acid calibration curve.

2.7. DPPH radical scavenging activity

The DPPH radical scavenging activities of extracts from UHPE of longan were analyzed by the method of Moon and Terao [19] with some modifications. Initially, 0.2 mL of the sample (dissolved in 50% ethanol) was mixed with 0.8 mL Tris–HCl buffer (pH 7.4), and then 1 mL of 500 μM DPPH in ethanol was added to it. The reaction mixture was incubated at 28 °C in a dark room for 30 min. The control contained all reagents except the extract sample while ethanol was used as blank. The scavenging activity against DPPH radicals was determined by measuring the absorbance at 517 nm with a spectrophotometer. The inhibition of DPPH• radicals by the test samples was calculated as scavenging activity (%) = (1 − absorbance of sample/absorbance of control) × 100. The DPPH radical scavenging activities of CE and BHT samples were also assayed for comparison.

2.8. Total antioxidant capacity

Total antioxidant capacities of extracts from UHPE of longan were investigated according to the method of Pan et al. [17]. The extract sample solutions from UHPE (0.1 mL) at 50 and 100 μg/mL were mixed with 0.3 mL of reagent solution containing 0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate. The tubes were capped and the reaction mixture was incubated in a water bath at 95 °C for 90 min. After the mixture had cooled to room temperature, the absorbance of each mixture solution was measured at 695 nm against a blank. The blank solution contained all the reagents excepting the test sample. The antioxidant activity was expressed as the absorbance of the sample. The higher absorbance value indicates the greater antioxidant activity. The antioxidant activities of CE and BHT samples were also assayed for a comparative analysis.

2.9. Superoxide anion radical scavenging activity

Superoxide anion radical scavenging activity was assayed as described by Duan et al. [20] with some modifications. All solutions

were prepared in 0.2 M phosphate buffer (pH 7.4). The photo-induced reactions were performed in an aluminum foil-lined box with two 30 W fluorescent lamps. The UHPE and CE extracts at 50 and 100 μg/mL were mixed with 3 mL of reaction buffer solution containing 1.3 μM riboflavin, 0.02 M methionine and 5.1 μM nitro blue tetrazolium, at pH 7.4. The reaction solution was illuminated for 20 min at 25 °C and the absorbance was then measured at 560 nm. BHT was used as the positive control while the reaction mixture without any tested sample was used as control. The superoxide anion radical scavenging activity was calculated as scavenging activity (%) = (1 − absorbance of sample/absorbance of control) × 100.

2.10. Antityrosinase activity

Inhibition of tyrosinase activity was tested according to the method of Yang et al. [21] with some modifications. L-Tyrosine solution (4 mL) at 0.5 mg/ml, dissolved in 20 mM phosphate buffer (pH 6.8), was added to 1 mL of UHPE or CE samples. After 20 min of incubation, 1 mL of mushroom tyrosinase (50 units/mL, dissolved in 20 mM phosphate buffer, pH 6.8) was added to the mixture solution. The absorbance (OD) was recorded after 3.0 min at 475 nm. A 50% ethanol solution was used as a blank, while 1 mL of distilled water was used as the control. Percent antityrosinase activity was calculated using the following formula: (OD of control − OD of sample/OD of control) × 100.

2.11. Polyphenol compound analysis by high performance liquid chromatography (HPLC)

The freeze-dried extract from the samples were re-dissolved in a small volume of 50% ethanol and filtered through a 13 mm, 0.45 μm PVD membrane (Shanghai ANPEL Scientific Instruments Co. Ltd., Shanghai, China) and the polyphenolic compounds were identified using HPLC by the method of Rangkadilok et al. [7]. The chromatographic conditions used were as follows. A Vydac C_{18} column (218 TP, 250 mm × 4.6 mm, 5 μm particle size, Sigma–Aldrich, St. Louis, MO, USA) was equipped with a Shimadzu LC-20 AT (Shimadzu Corporation, Japan) separation module. The samples were eluted with a gradient system consisting of solvent A (0.4% formic acid) and solvent B (methanol) used as the mobile phase, with a flow rate of 1 mL/min. The temperature of the column was maintained at 25 °C with the UV detection at 270 nm. The injection volume was 10 μL. The gradient system started from 0 min (100% A) to 2 min (95% A), 5 min (70% A), 8 min (66% A), 11 min (45% A), 14 min (45% A), 17 min (100% A) and maintained at this ratio for 20 min.

2.12. Statistical analysis

Data were expressed as means ± standard deviations (SD) of three replicate determinations and they were then analyzed by SPSS V.13 (SPSS Inc., Chicago, USA). Duncan's new multiple-range test was used to determine the differences of means. Differences between the means at the ($P < 0.05$) level were considered to be significant.

3. Results

3.1. Extraction yield and total phenolic content

In our previous study, an ethanol concentration of 50% and a time of 30 min of UHPE-500 were chosen, which established the optimal extraction condition [22]. A comparative analysis of extraction yield and total phenolic content of longan pericarp using conventional and ultra-high-pressure-assisted extraction is presented in Table 1.

Table 1
Comparative analysis of extraction yields and total phenolic content of longan pericarp using conventional (CE) and different ultra-high-pressure-assisted extraction (UHPE-200, UHPE-300, UHPE-400 and UHPE-500 MPa).

Extraction method	Extraction yield (%)	Total phenolic content (mg/g DW)
CE	7.2 ± 0.5 c	11.9 ± 1.2 c
UHPE-200	15.5 ± 0.4 b	16.5 ± 0.6 b
UHPE-300	15.8 ± 0.9 b	17.2 ± 0.5 b
UHPE-400	16.3 ± 0.5 b	18 ± 0.4 b
UHPE-500	17.6 ± 0.4 a	20.8 ± 1.9 a

Different letters in column indicate significant differences among means of treatments ($P < 0.05$).

UHPE-500 gave the highest extraction yield of 17.6 ± 0.4% compared to other ultra high pressure extraction, significantly ($P > 0.05$) higher than CE. This showed that the UHPE-500 was more effective in extracting bioactive compounds from LFP compared to other high pressure processing tested.

The highest total phenolic content of the extract was obtained from UHPE-500 having 20.8 ± 1.9 mg/g while the lowest content was from of CE having 11.9 ± 1.2 mg/g dry weight, expressed as gallic acid equivalents ($P < 0.05$). The UHPE increased phenolic compound recovery of the extract approximately two times than CE.

3.2. Scavenging activity on DPPH radical

In DPPH radical scavenging assay, antioxidants react with DPPH, producing yellow α,α-diphenyl-β-picryl hydrazine. The degree of discoloration indicates the radical scavenging activity of the antioxidant which could be studied by measuring the decrease in the absorbance at 517 nm [23]. Fig. 1 illustrates that extract from UHPE possessed significant high scavenging activities on the DPPH radical and it was concentration dependent. The scavenging effect of extract from UHPE at 50 μg/mL was higher than CE at the same concentration, indicating that the scavenging effect of the extract from UHPE on DPPH radical was superior to CE and equal to BHT. The scavenging activity of the extract from UHPE at 500 MPa was the highest (73.53 ± 0.20%) while that of CE or BHT was 50.6 ± 1.1 and 73.4 ± 0.5%. Therefore, DPPH radical scavenging activity was in decreasing order, UHPE-500 > BHT > UHPE-400 > UHPE-300 > UHPE-200 > CE.

3.3. Total antioxidant capacity

Total antioxidant capacity of extracts from UHPE and CE processes were analyzed by the formation of phosphomolybdenum complex. This analysis is based on the reduction of Mo (VI) to

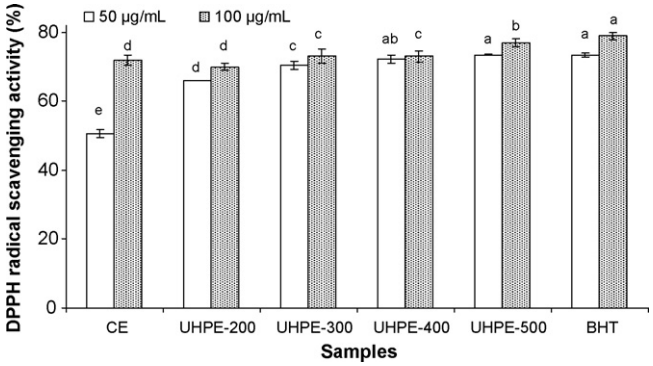

Fig. 1. Comparison of DPPH radical scavenging activity from longan fruit pericarp after application of conventional extraction (CE) and different ultra-high-pressure-assisted extraction conditions (UHPE-200, UHPE-300, UHPE-400 and UHPE-500 MPa). Different letters above the bars for the same concentration indicates significant differences among means of treatments ($P < 0.05$).

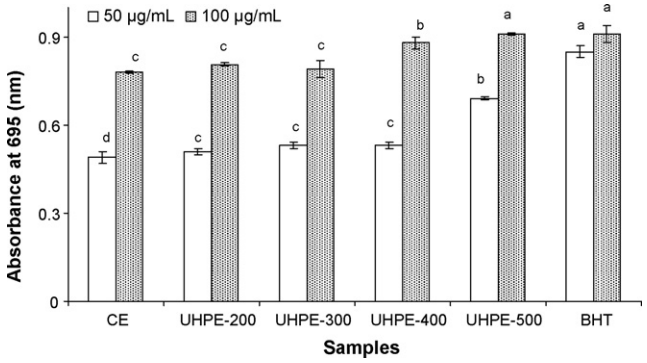

Fig. 2. Comparison of total antioxidant activity from longan fruit pericarp after application of conventional extraction (CE) and different ultra-high-pressure-assisted extraction (UHPE-200, UHPE-300, UHPE-400 and UHPE-500 MPa). Different letters above the bars for the same concentration indicates significant differences among means of treatments ($P < 0.05$).

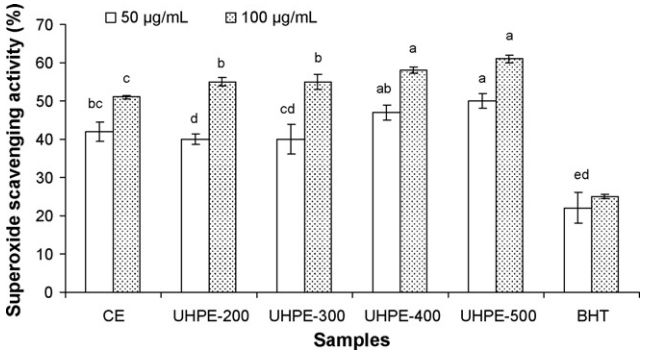

Fig. 3. Comparison of superoxide anion radical scavenging activity from longan fruit pericarp after application of conventional extraction (CE) and different ultra-high-pressure-assisted extraction (UHPE-200, UHPE-300, UHPE-400 and UHPE-500 MPa). Different letters above the bars for the same concentration indicates significant differences among means of treatments ($P < 0.05$).

Mo (V) by antioxidant compounds and consequent formation of a green phosphate—Mo (V) complex at acidic pH which has maximum absorption at 695 nm. A high absorbance value indicates that the sample possesses high antioxidant activity [17]. In this study, the total antioxidant activities of extracts from UHPE and CE were measured and compared with BHT (Fig. 2). UHPE-200 and UHPE-300 extracts at 100 μg/mL showed the same antioxidant activity as CE extract. However, UHPE-400 and UHPE-500 extracts showed significant ($P > 0.05$) higher antioxidant activities than BHT. The total antioxidant activities of the extract from CE, UHPE-200, UHPE-300, UHPE-400, UHPE-500 and BHT at a concentration of 100 μg/mL were 0.78 ± 0.003, 0.80 ± 0.005, 0.79 ± 0.03, 0.88 ± 0.02, 0.91 ± 0.005 and 0.91 ± 0.03, respectively. The total antioxidant activity of the extract from UHPE-500 was superior to that of the other UHPE extracts and CE.

3.4. Superoxide anion scavenging activity

Superoxide anion is produced by various cellular processes like electron transport system including numerous enzyme systems such as lipoxygenase, NADPH oxidase and xanthine oxidase. Even though the superoxide anion is a somewhat of a weak oxidant, it may combine with other reactive species to yield a more reactive species [20,24]. The relative scavenging effects of extracts from UHPE, CE, and the BHT sample towards superoxide anion radicals are shown in Fig. 3. The extracts from UHPE and CE exhibited excellent superoxide anion scavenging activity compared with BHT sample. At 50 μg/mL, the superoxide scavenging activity of extract from HPE-500 and CE were 50 ± 2 and $42 \pm 2.5\%$, respectively, while that of BHT was only $22 \pm 1.5\%$.

3.5. Inhibition of tyrosinase activity

The extract from UHPE and CE processes showed tyrosinase inhibitory activity in a concentration dependent manner (Fig. 4). As the concentration increases, the activity increases. The extract from UHPE-500 showed the highest percentage of antityrosinase activity of 23.6 ± 1.2 at a concentration of 100 μg/mL, when compared to CE (19.5 ± 0.6). The tyrosinase inhibitory activity of extract from UHPE-500 was higher, compared to that of the other UHPE levels tested and also higher than CE. This showed that samples obtained by UHPE possessed greater antityrosinase activities than those obtained by CE. However, kojic acid, a reference inhibitor showed a strong tyrosinase inhibitory activity with the IC_{50} value of 8.9 μg/mL according to Rangkadilok et al. [7].

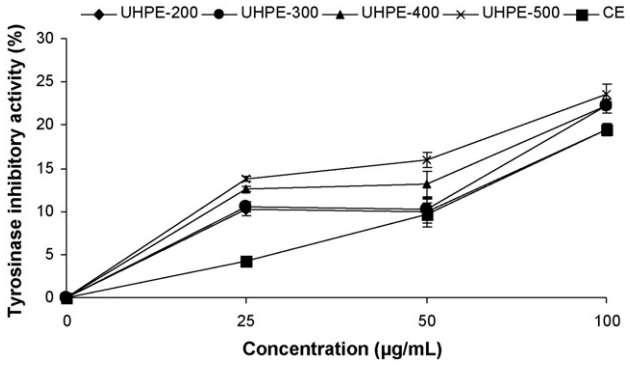

Fig. 4. Comparison of tyrosinase inhibitory activity from longan fruit pericarp after application of conventional extraction (CE) and different ultra-high-pressure-assisted extraction (UHPE-200, UHPE-300, UHPE-400 and UHPE-500 MPa).

3.6. Identification and quantification of polyphenolic compounds

Phenolic compounds of the extracts from longan fruit pericarp were identified by matching their retention times with those of known standards. Calibration curves of the standards were linear with concentration range, as given in Table 2. The HPLC profile of polyphenolic compounds extracted from longan fruit pericarp tissues are shown in Fig. 5. Three polyphenolic compounds namely gallic acid, ellagic acid, and corilagin have been identified as the major phenolic acids. Corilagin content was the highest when compared to other phenolic acids obtained (Table 3). UHPE-500 samples contained the highest amount of total phenolic acid contents (10.5 ± 0.4 mg/g DW) when compared to those for other high

Table 2
Linearity of standard curves and quantitation limits for the phenolic acids determined.

Phenolic acids	Concentration range (mg/mL)	Calibration equation (regression equation)	Correlation coefficient (R^2)
Gallic acid	0.02–0.1	$y = 2E+07x + 238,974$	0.9175
Corilagin	0.02–0.1	$y = 1E+07x - 171,846$	0.9024
Ellagic acid	0.02–0.1	$y = 1E+08x - 575,484$	0.9994

x is the concentration of phenolic acid standards while y is the peak area.

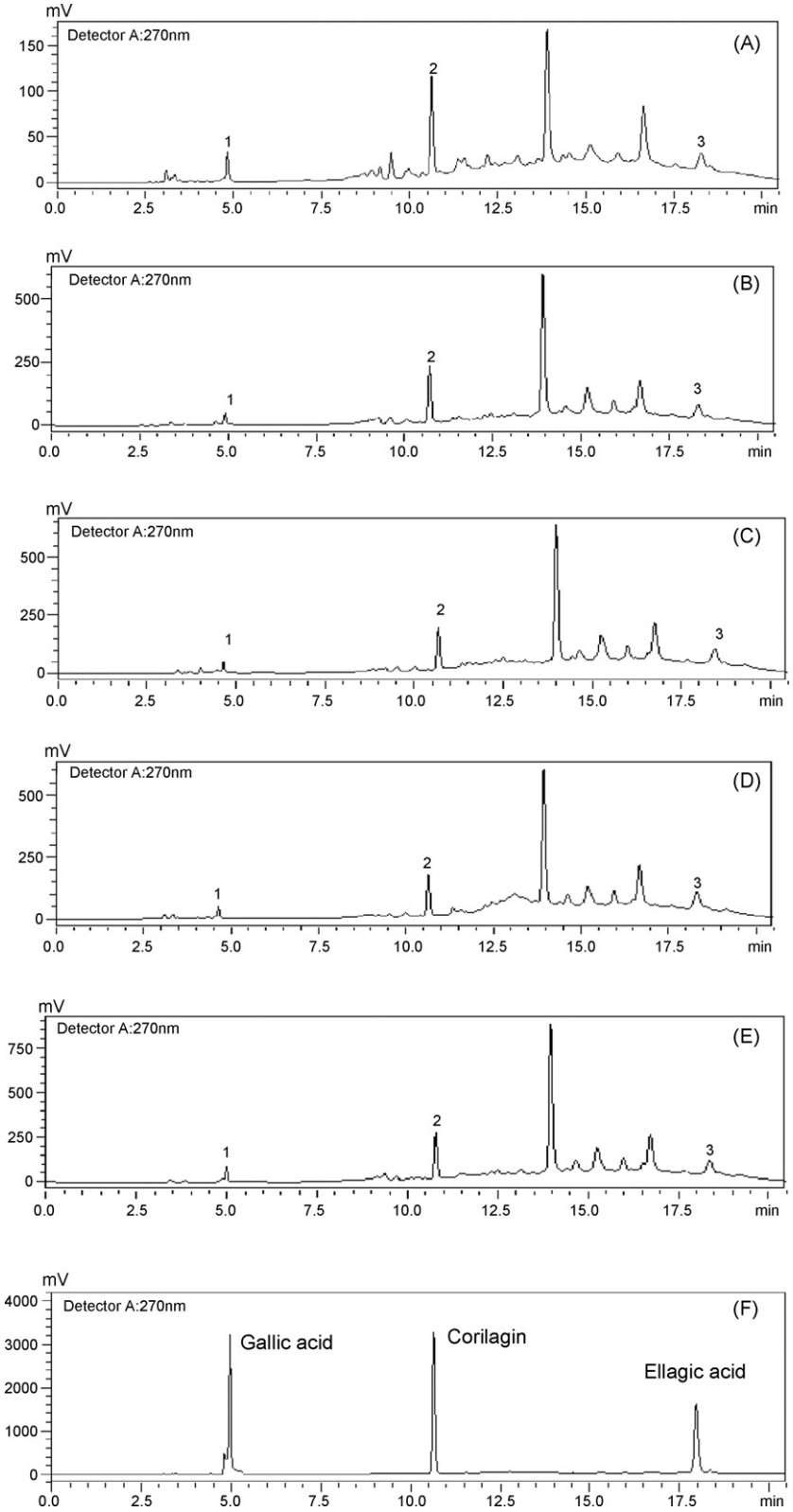

Fig. 5. HPLC profile of phenolic compounds (1, gallic acid; 2, corilagin and 3, ellagic acid) from longan fruit pericarp using conventional extraction (A), different ultra-high-pressure-assisted extraction [UHPE-200 (B), UHPE-300 (C), UHPE-400 (D) and UHPE-500 MPa (E), respectively], and phenolic acid standards (F).

pressure extractions and CE. This present study is in agreement with those of Rangkadilok et al. [7] and Yang et al. [8] where gallic acid, ellagic acid and corilagin were identified as the major phenolic compounds from longan fruit. Further work concerning identification of other peaks in the HPLC profile of LFP is underway.

4. Discussion

The extraction processing for bioactive compounds can be described as a mass transport phenomenon where solids contained in the plant matrix transfer into the solvent up to their equilib-

Table 3
Comparative analysis of phenolic acid contents of longan pericarp using conventional extraction (CE) and different ultra-high-pressure-assisted extractions (UHPE-200, UHPE-300, UHPE-400 and UHPE-500 MPa).

Phenolic acids (mg/g DW)[a]	Extraction methods				
	CE	UHPE-200	UHPE-300	UHPE-400	UHPE-500
Gallic acid	2.2 ± 0.02 a	0.1 ± 0.1 c	0.7 ± 0.03 b	0.08 ± 0.02 c	0.01 ± 0.01 c
Corilagin	2.3 ± 0.01 d	5.9 ± 0.4 c	7.2 ± 0.6 b	8.2 ± 0.1 b	9.6 ± 0.45 a
Ellagic acid	0.9 ± 0.02 a	0.8 ± 0.2 b	0.9 ± 0.5 a	0.9 ± 0.3 a	0.9 ± 0.03 a
Total content	5.4 ± 0.05 d	6.8 ± 0.7 c	8.8 ± 1.1 b	9.1 ± 0.4 b	10.5 ± 0.4 a

Different letters in row indicate significant differences among means of treatments ($P < 0.05$).
[a] Values are ± standard deviations of three replicate analyses.

rium concentration. Mass transport phenomena can be improved by changes in concentration gradients, heating and with the influence of new technologies such as high pressure, ultrasonics and pulsed electric fields. Increased extraction yield caused by high pressure was presumably due to its ability to deprotonate charged groups and to disrupt the salt bridges and hydrophobic interaction in cellular membranes which may have lead to higher permeability's [11]. Based on phase behavior theory, the pressurized cells exhibit increased permeability as pressure increases, which might account for increased extraction yields by UHPE [15,16].

The antioxidant activities of UHPE and CE samples corresponded with the amounts of phenolics present in the extracts. The extract from UHPE contained higher corilagin content as compared to CE. However, gallic acid content in CE sample was higher than UHPE samples because corilagin can be hydrolysed to gallic acid during storage [7], but this needs to be investigated further since storage can effect equally the CE and UHPE processes. It is the extent of phenolics present in this extract that is responsible for its marked antioxidant activity as demonstrated by various *in vitro* models. Several reports have convincingly shown a close relationship between antioxidant activity and total phenolic content [3,13,20]. The phenolic compounds exhibit extensive free radical scavenging activities through their reactivity's as hydrogen or electron-donating agents, as well as by metal ion chelating properties [25]. Therefore, there should be a close relationship between the phenolic compound contents and antioxidant activities [26]. The inhibition of tyrosinase activity might be dependent on the hydroxyl group of the phenolic compounds of LFP that could form a hydrogen bond to a site of the enzyme leading to a lower enzymatic activity. Song et al. [27] reported that some tyrosinase inhibitors act through hydroxyl groups that bind with the active site on tyrosinase resulting in steric hindrance or changed conformation.

Longan fruit pericarp contains large amount of polar compounds like phenolic acids, flavonoids and polysaccharides which have high antioxidant properties. Using high pressure, higher extraction of these compounds are probably due to increase in solvent power, solvent density, and solubility of polar compounds. A decrease in the dielectric constant of water caused by HPE could lead to decrease in the polarity of the media which may in turn contribute to the higher phenolic content yields and higher antioxidant activities. Moreover, high pressure provides the possibility of inactivating degrading enzymes which may explain the higher yields and also higher antioxidant activities compared to other methods. High pressure also has the ability to reduce the pH of the solvent during extraction not only because of the higher release of phenolics into the solvent but also because of the deprotonation of molecules present in the extracts. This reduction in the pH might also enhance the extraction of bioactive compounds since most of the compounds are more stable at pH under four [13,28].

Our results are in agreement with other authors who have reported parallel results. Corrales et al. [13] reported higher yields and higher antioxidant activities of anthocyanins from grape byproducts by HPE. Zhang et al. [15] obtained higher yields of ginsenoside extracted by ultra high pressure from *P. quinquefolium*, compared to conventional extraction, while del Valle et al. [28] obtained higher yield and with high antioxidant activity of *Peumus boldus* leaves using high pressure. HPE increased the flavonoid extraction yield up to 10 times as compared with conventional extraction reported by Prasad et al. [14] in litchi pericarp.

5. Conclusions

In the current study, the possibility of using ultra-high-pressure-assisted extraction to recover antioxidant and antityrosinase compounds from longan fruit pericarp was investigated. These results indicated that UHPE-500 sample possessed higher phenolic contents and exhibited stronger antioxidant activities than CE sample. This study also gave a strong impact for expanding the investigations of antioxidants extracted with ultra high pressure from longan pericarp and making the use of the extract from UHPE-500 as a substitute antioxidant in the food and cosmetic industry. Therefore, the use of high pressure for extraction of antioxidant compounds could be an alternative means to the conventional extraction methods. Further work is necessary to identify other peaks in the HPLC profile of LFP.

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