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Antioxidant, antityrosinase and antibacterial activities of fruit peel extracts

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Abstract Total phenolic compounds, antioxidant, antityrosinase and antibacterial activities of ethanolic fruit peel extracts of six different fruits: cantaloupe, passion fruit, pineapple, dragon fruit, watermelon and raw mango were recorded. The results showed that the mango, *Mangifera indica* L. peel ethanolic extract (MIPE), contained high total phenolic compounds of 56.79 ± 1.86 mgGAE/g extract. MIPE possessed an ABTS radical scavenging activity and a ferric reducing activity of 594.21 ± 2.94 and 344.91 ± 17.15 mgTrolox/g extract, respectively. MIPE also inhibited radical scavenging activity with an IC_{50} value of 0.37 ± 0.01 mg/ml. All the six extracts had significantly less effective antityrosinase activitythan kojic acid. In addition, MIPE was able to inhibit *Staphylococcus epidermidis* with 6 strains and also inhibit *Streptococcus pyogenes* with 5 strains. The results suggested that mango could be promoted as a potential source of natural antioxidant and as an antimicrobial agent to apply in functional food, nutraceutical or cosmetic formulations.

Keywords: Free radical, *Mangifera indica* L., Fruit peel

Introduction

A number of epidemiological studies have shown diets high in phytochemicals and antioxidants to have nutritional and disease-preventive properties. These natural antioxidants can be useful in the battle against oxidative stress which is linked to cancer, heart disease, diabetes, Alzheimer's disease, and aging (Wong *et al*., 2006). Natural antioxidants such as vitamin C, vitamin E, carotenoids, lutein and lycopene are commonly found in fruits and vegetables (Cai *et al*., 2004). High consumption and industrial production of fruits produce a huge mass of by-product. The non-edible parts such as peels and other fruit residues are usually discarded as waste, leading to serious problems that may be detrimental to the environment. However, fruit wastes

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and by-products are high in antioxidant polyphenols and contain important chemical components that can be beneficial to human health (Kim *et al*., 2010). The utilization of biological wastes not only decreases the environmental impact but also increases the economic benefits.

Cantaloupe (*Cucumis melo* L.) belongs to Cucurbitaceae. Polyphenols, carotenoids, and biologically active compounds are abundant in cantaloupe peels (Ismail *et al*., 2010). The cantaloupe extract showed high antioxidant and anti-inflammatory activities (Vouldoukis *et al*., 2004). Passion fruit (*Passiflora edulis*) is a member of the Passifloraceae. The peel of passion fruit contains a high amount of anthocyanin and flavonoids, which inhibit *in vitro* properties of matrix metalloproteinase (MMP2 and MMP4) as well as potent anti-inflammatory properties *in vivo* (Zeraik *et al*., 2011). Passion fruit peel extracts also possess antidiabetic and antioxidant properties against streptozotocin-induced diabetes (Kandandapani1 *et al*., 2015). Pineapple (*Ananas comosus* L.) is a tropical plant and a member of the Bromeliaceae. *A. comosus* peel extracts possess phytochemicals, phenolic, and flavonoid compounds (Bamidele and Fasogbon, 2017). The peel extracts of *A. comosus* showed antioxidant and antibacterial activivity (Putri *et al*, 2018, Fidrianny *et al.*, 2018), antidiabetes activities (Kalpana *et al*., 2014), anti-imflammatory (Lawal, 2013), and antimicrobial activities (Dabesor *et al*., 2017). Dragon fruit (*Hylocereus undatus*), a white-fleshed red peeled fruit, is a member of the Cactaceae. Dragon fruit is a source of carbohydrates, flavonoids, thiamine, niacin, pyridoxine, glucose, polyphenol, beta-carotene, lycopene, and vitamin E. (Charoensiri *et al*., 2009). *H. undatus* peel extract has shown antioxidant and antibacterial activities (Som *et al*., 2019). Watermelon (*Citrullus lanatus*) belongs to the Cucurbitaceae which alkanes, saturated and unsaturated fatty acids and their esters, cyclic ketones, aldehydes, phenolic compounds and anthocyanin derivatives are found in peels. (Asghar *et al*., 2013). Watermelon extracts potentially exhibit analgesic activity (Kumari *et al*., 2013) as well as antibacterial and antifungal activities (Egbuonu Anthony Cemaluk, 2015). Mango (*Mangifera indica* L.), a member of the Anacardiaceae, is one of the most famous tropical fruits. Mango peels are reported to be a good source of phytochemicals including polyphenols, carotenoids, vitamin E, vitamin C, as well as antioxidant and antiproliferative properties (Kim *et al.*, 2010).

Fruit peels may be considered a potential source of natural antioxidants for cosmetics and nutraceutical products. Therefore, the aim of this study was to investigate antioxidant, antityrosinase, and antibacterial activities of six fruit peel extracts (cantaloupe, passion fruit, pineapple, dragon fruit, watermelon, and mango).

Materials and methods

Chemicals

6-hydroxy-2, 5, 7, 8-tetramethylchroman-2-carboxylic acid (Trolox), 2, 4, 6-93 tripyridyl-s-triazine (TPTZ), 2, 2'-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and tyrosinase from mushroom were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Other chemicals and reagents were of analytical grade. All reference tested bacterial strains were obtained from the Culture Collection for Medical Microorganism, Department of Medical Sciences and Thailand (DMST) and Thailand Institute of Scientific and Technology Research (TISTR).

Sample collection and preparation

The fruit peels of cantaloupe (*Cucumis melo* L.), passion fruit (*Passiflora edulis*), pineapple (*Ananas comosus* L.), dragon fruit (*Hylocerecus undatus*), watermelon (*Citrullus lanatus*), and raw mango (*Mangifera indica* L.) were obtained from a fruit shop at the canteen of Rajamangala University of Technology Isan, Nakhon Ratchasima, Thailand (October, 2017). All of the sample peels were cleaned, subsequently cut into small pieces and placed in a hot air oven (Memmert, UF110, Germany) at 40 ℃ for 72 h. The dried sample peels were ground into fine powders and stored at -20 ℃ for use in experiments.

Sample extraction

The dried powders of each sample peel (50 g) were macerated in 500 ml of 70% ethanol (w/v) using an orbital shaker at 150 rpm at room temperature for 24 h. The extracts were filtered and concentrated in a rotary evaporator (Buchi, 9230 Flawil, Switzerland). The crude extracts were dried in a hot air oven at 60 ℃ overnight and kept at -20 ℃ until use. The abbreviations used for the crude extracts were as follows: *Cucumis melo* peel ethanolic extract (CMPE), *Passiflora edulis* peel ethanolic extract (PEPE), *Ananas comosus* peel ethanolic extract (ACPE), *Hylocercus undatus* peel ethanolic extract (HUPE), *Citrullus lanatus* peel ethanolic extract (CLPE), and *Mangifera indica* peel ethanolic extract (MIPE).

Determination of total phenolic compounds

The total phenolic compounds (TPC) of the different extracts were quantified by the colorimetric Folin-Ciocalteu method (Matthaus, 2002). One

hundred microliters of samples were mixed with 2 ml of 2% Na_2CO_3 and incubated at room temperature for 2 min. After the addition of 100 µl of folin-ciocalteu reagent (diluted with methanol, 1:1 v/v), the reaction was left to stand for another 30 minutes at room temperature. The absorbance was measured at 750 nm using a spectrophotometer (Thermo Fisher, Scientific Genesys 10 UV scanning, USA). The results were expressed as mg gallic acid equivalent (mgGAE) per g extracts.

ABTS radical scavenging activity assay

ABTS radical scavenging activity assay was performed according to Wiriyaphan *et al*. (2012). Radical $ABTS^{\bullet+}$ was prepared by mixing 7.4 mM ABTS solution and 2.6 mM potassium persulfate solution in 10 mM phosphate buffer (pH 7.4) and kept in the dark at room temperature for 16 h. The radical $ABTS^{\bullet+}$ was diluted with 10 mM phosphate buffer (pH 7.4) to attain absorbance of 0.7 ± 0.02 at 734 nm. Twenty microlitres of the different extracts were mixed with 1980 µl of $ABTS^{\bullet+}$ dilution and incubated in the dark for 5 min at room temperature. The absorbance decrease was measured at 734 nm. Results were expressed as mg Trolox equivalents per g extracts.

Ferric reducing antioxidant power (FRAP)

The ability to reduce ferric ions was conducted following the method described by Benzie and Strain (1996). The FRAP reagent was freshly prepared by mixing 300 mM sodium acetate buffer solution (pH 3.6), 10 mM TPZT dissolved in 40 mM HCl and 20 mM $FeCl_3$ solution at a ratio of 10:1:1 (v/v/v). One hundred microliters of the different peel extracts were incubated with 1 ml of FRAP reagent at 37 ℃ for 15 min and measured at 593 nm. Results were expressed as as mg Trolox equivalents per g extracts.

DPPH radical scavenging activity

The antioxidant activity of the extracts against DPPH was estimated according to the method of Sanchez-Moreno *et al*. (1999) with some modification. The various concentrations of samples in 50 µl were mixed with 1.95 ml of 40 mg/l methanolic $DPPH^{\bullet}$ solution and incubated in the dark at room temperature for 45 min. The absorbance of the mixture was read at 515 nm. L-ascorbic acid was used as the positive control. The percentage inhibition was calculated using the following formula:

$$\% \ inhibition = \left(\frac{Acontrol \ - \ Asample}{Acontrol} \right) \times 100 \ (1)$$

Where Acontrol and Asample are the absorbance values of the control and test sample, respectively. The DPPH scavenging activity of the extracts was expressed as inhibition concentration 50% (IC_{50}).

Antityrosinase activity

Tyrosinase inhibitory activity was determined using the colorimetric method as described by Di Petrillo *et al*. (2016) with slight modification. L-3,4-dihydroxyphenylalanine (L-DOPA) was used as the substrate. Two hundred microliters of samples were mixed with 680 µl of 0.05 M phosphate buffer (pH 6.5). After the addition of 20 µl of mushroom tyrosinase (final concentration, 500 unit/ml in phosphate buffer, pH 6.5), the reaction was further incubated with 100 µl of 5 mM L-DOPA for 10 min at room temperature. The absorbance of dopachrome formation in the reaction mixture was measured at 492 nm. Kojic acid was used as the positive control. The percentage mushroom tyrosinase inhibitory activity was calculated following equation (1).

Antibacterial activity

The antibacterial activity of the peel extracts was assessed using the disc diffusion method as described by Chan *et al*. (2012). Two Gram-positive bacteria (*Staphylococcus epidermidis* and *Streptococcus pyogenes*) were grown in tryptic soy broth (TSB) at 37℃ for 24 h. The turbidity of bacterial suspensions was adjusted equivalent to a 0.5 McFarland standard. Inoculum suspensions of each strain (10^8 CFU/ml were swabbed on the top of the Muller Hilton Agar (MHA) set in 90 mm petridishes. The peel extracts were loaded onto sterile filter paper discs measuring 6 mm in diameter and firmly placed onto an inoculated agar ensuring even distribution to avoid overlapping of zones. All the plates were incubated at 37℃ for 24 h and the inhibition zone was measured at the end of incubation period. Kanamycin and chloramphenicol (0.1 mg/ml) were used as the positive controls, while ethanol (70%) was included as the negative control under the same condition.

Statistical analysis

All experiments were carried out in triplicates and the data were analyzed by ANOVA followed by the Duncan's Multiple Range Test to determine

significant differences between groups at a 95% confidence level using PASW Statistics 18 Release 18.0.0 software.

Results

Total phenolic compounds and antioxidant activity of fruit peel extracts

The amounts of total phenolic compounds (TPC) and antioxidant activity of the six fruit peel extracts are shown in Figure 1. TPC of the extracts were from 37.38 ± 2.39 to 312.67 ± 43.25 mgGAE/g extract. The highest amount of TPC was significantly ($p<0.05$) observed in the MIPE and the lowest amount was found in the ACPE (Figure 1A). Free radical scavenging activity of the six fruit peel extracts are presented in Figure 1B. The decreasing order of the $ABTS^{\bullet+}$ scavenging activity of the extracts ranged from 48.55 ± 3.01 to 764.75 ± 55.26 mgTrolox/g extract. MIPE exhibited the highest $ABTS^{\bullet+}$ scavenging activity among other peel extracts. The ferric reducing ability of the six fruit peel extracts was from 21.26 ± 2.10 to 444.01 ± 22.07 mgTrolox/g extract. The results showed that MIPE possessed ($p<0.05$) the highest ferric reducing activity, whereas the capability of the other extracts showed a low antioxidant activity by reducing power (Figure 1C). In addition, the IC_{50} values of the six fruit peel extracts were measured by DPPH assays and are presented in Figure 1D. The IC_{50} values of the six fruit peel extracts through DPPH scavenging activity ranged from 0.29 ± 0.01 to 9.47 ± 0.37 mg/ml. A lower IC_{50} value indicates higher antioxidant activity. MIPE exhibited the highest scavenging activity on DPPH radicals while ACPE showed the lowest scavenging activities. Interestingly, the radical scavenging activity of MIPE on DPPH was not significantly different between the positive control and ascorbic acid with IC_{50} values of 0.29 ± 0.01 and 0.07 ± 0.00 mg/ml, respectively.

Tyrosinase inhibitory of fruit peel extracts

The antityrosinase activity of the six fruit peel extracts were determined and compared with the positive control, kojic acid, at the concentration of 0.5 mg/ml. Results of the extracts against tyrosinase enzyme are presented in Figure 2. All the peel extracts were able to inhibit tyrosinase enzyme activity, however, their inhibitory activities were lesser than those of the positive control, kojic acid. There were significant ($p<0.05$) differences between the extracts and kojic acid in tyrosinase inhibition activity. The most active peel extracts were PEPE and ACPE with the values of 60.31 ± 3.20% and 56.93 ± 5.46%, respectively, while the value for kojic acid was 72.72 ± 0.55%.

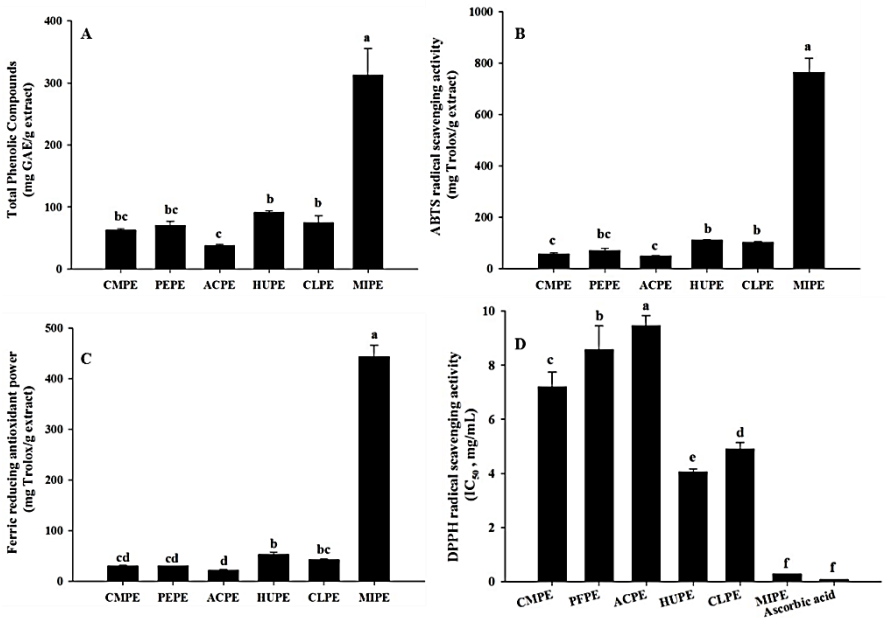

Figure 1. Total phenolic compounds: (A) and antioxidant activity was determined by ABTS radical scavenging activity (B), ferric reducing antioxidant power (C) and DPPH radical scavenging activity (D) of the six fruit peel extracts. Bars marked with different letters represent statistical difference ($p<0.05$). CMPE: *Cucumis melo* peel ethanolic extract, PEPE: *passiflora edulis* peel ethanolic extract, ACPE: *Ananas comosus* peel ethanolic extract, HUPE: *Hylocercus undatus* peel ethanolic extract, CLPE: *Citrullus lanatus* peel ethanolic extract, MIPE: *Mangifera indica* peel ethanolic extract

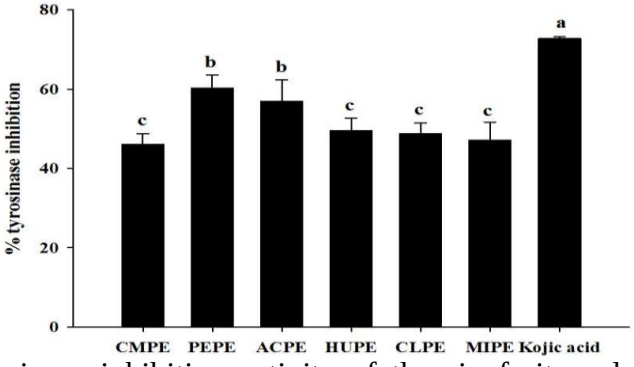

Figure 2. Tyrosinase inhibition activity of the six fruit peel extracts at the concentration of 0.5 mg/ml. Bars marked with different letters represent statistical difference ($p< 0.05$): CMPE: *Cucumis melo* peel ethanolic extract, PEPE: *passiflora edulis* peel ethanolic extract, ACPE: *Ananas comosus* peel ethanolic extract, HUPE: *Hylocercus undatus* peel ethanolic extract, CLPE: *Citrullus lanatus* peel ethanolic extract, MIPE: *Mangifera indica* peel ethanolic extract

Antibacterial activity

In the present study, two Gram-positive bacterial species, *Staphylococcus epidermidis* (DMST 15460, 5868, 15457, 15661, 15548 and TISTR 518) and *Streptococcus pyogenes* (DMST 30653, 4478, 17020, 4369 and 26758) were tested for their sensitivity to the six fruit peel extracts using the disc diffusion method. The antibacterial activity of the extracts against *S. epidermidis* is shown in Table 1. The diameters of the inhibition zones of the extracts ranged from 5.7 ± 0.6 to 14.7 ± 3.7 mm against *S. epidermidis.* MIPE and ACPE showed antibacterial activity against all the tested strains of *S. epidermidis*, whereas MIPE exhibited better antibacterial activity against *S. epidermidis* than ACPE. In addition, HUPE inhibited almost all of the bacteria strains tested except for *S. epidermidis* DMST 15457, while CMPE, PEPE and CLPE managed to inhibit the four tested bacteria strains. Kanamycin and chloramphenicol, the positive controls, showed an inhibition zone of more than 15 mm, however, the negative control which was 70% ethanol did not show any inhibition zone.

Table 1. The antibacterial activity of the fruit peel extracts against *S. epidermidis*

Extracts	Concentration (mg/ml)	Inhibition zone of *S. epidarmidis* (mm)*					
		DMST 15460	DMST 5868	TISTR 518	DMST 15457	DMST 15661	DMST 15548
CMPE	50	6.7±0.5	6.7±0.6	7.3±0.6	-	-	6.0±0.0
	25	-	6.3±0.5	-	-	-	6.7±0.5
	5	-	-	-	-	-	-
PEPE	50	7.3±1.2	6.3±0.6	-	-	6.3±0.6	6.0±0.0
	25	-	6.3±0.6	-	-	-	6.3±0.6
	5	-	-	-	-	-	6.7±1.2
ACPE	50	6.7±1.2	8.7±0.6	5.7±0.6	6.7±0.6	6.0±0.0	6.0±0.0
	25	-	8.3±0.2	-	-	-	6.3±0.1
	5	-	6.0±0.0	-	-	-	6.0±0.0
HUPE	50	6.0±0.0	6.3±0.5	6.0±0.0	-	6.3±0.6	6.7±0.6
	25	-	-	-	-	6.3±0.5	6.3±0.6
	5	-	-	-	-	-	6.3±0.6
CLPE	50	-	7.1±1.0	7.7±0.1	-	6.7±0.6	7.3±0.6
	25	-	6.7±0.6	6.0±0.0	-	-	6.3±0.6
	5	-	-	-	-	-	6.3±0.6
MIPE	50	10.7±0.2	14.7±3.7	9.7±0.6	11.0±2.0	9.0±1.0	13.3±0.5
	25	10.3±0.6	10.7±1.2	8.3±1.5	8.7±1.2	10.0±1.0	10.7±2.1
	5	6.7±0.6	8.3±1.5	-	-	6.3±0.6	7.0±1.0

CMPE: *Cucumis melo* peel ethanolic extract, PEPE: *passiflora edulis* peel ethanolic extract, ACPE: *Ananas comosus* peel ethanolic extract, HUPE: *Hylocercus undatus* peel ethanolic extract, CLPE: *Citrullus lanatus* peel ethanolic extract, MIPE: *Mangifera indica* peel ethanolic extract.

The results of antibacterial activity of the six fruit peel extracts against *S. pyogenes* are presented in Table 2. The extracts exhibited inhibition zones of about 6.0 ± 0.0 to 12.0 ± 2.0 mm. The negative control, 70% ethanol, did not show any inhibition zone, whereas kanamycin and chloramphenicol showed inhibition zones of more than 15 mm. MIPE exhibited strong activity against *S. pyogenes*, which were DMST 30653, 4478, 17020, 4369, and 26758. HUPE and CLPE inhibited three out of five tested bacteria, whereas ACPE and PFPE exhibited very poor activity even at higher extract concentrations. However, CMPE showed no antibacterial activity against *S. pyogenes*. The results revealed that the antibacterial properties of MIPE exhibited better antibacterial activity against *S. pyogenes.*

Table 2. The antibacterial activity of the fruit peel extracts against *S. pyogenes*

Extracts	**concentration**	**Inhibition zone of *S. pyogenes* (mm)***				
	(mg/ml)	DMST 30653	DMST 4478	DMST 17020	DMST 4369	DMST 26758
CMPE	50	-	-	-	-	-
	25	-	-	-	-	-
	5	-	-	-	-	-
PEPE	50	7.3±0.6	-	-	-	-
	25	-	-	-	-	-
	5	-	-	-	-	-
ACPE	50	-	7.3±1.2	7.0±1.0	-	-
	25	-	-	-	-	-
	5	-	-	-	-	-
HUPE	50	6.0±0.0	7.0±1.00	6.3±0.6	-	-
	25	6.0±0.0	-	-	-	-
	5	-	-	-	-	-
CLPE	50	6.7±0.6	6.3±0.6	6.0±0.00	-	-
	25	6.3±0.6	-	-	-	-
	5	-	-	-	-	-
MIPE	50	10.7±3.2	11.0±2.6	9.3±1.2	11.3±1.2	12.0±2.0
	25	9.7±2.5	8.0±2.0	9.3±1.2	10.0±0.0	11.7±2.1
	5	8.3±1.5	7.0±0.0	8.0±1.0	9.3±1.2	10.6±1.2

CMPE: *Cucumis melo* peel ethanolic extract, PEPE: *passiflora edulis* peel ethanolic extract, ACPE: *Ananas comosus* peel ethanolic extract, HUPE: *Hylocercus undatus* peel ethanolic extract, CLPE: *Citrullus lanatus* peel ethanolic extract, MIPE: *Mangifera indica* peel ethanolic extract.

Discussion

Almost all phytochemicals have antioxidant activity that protect the cells from ROS and therefore reduce the risk of developing degenerative diseases (Aruoma, 2003). The results showed that MIPE had the highest amount of total phenolic compounds with the value of 312.67 ± 43.25 mgGAE/g extract. Polyphenols from plants are the primary antioxidant agents in natural products. They are potent free radical terminators which donate hydrogen to free radicals thus interrupting the initiation stage of lipid oxidation reaction (Gulcin *et al*., 2003). A study by Ajila *et al*. (2010) reported that 80% acetone extract of raw and ripe mango peels had total polyphenolic content ranging from 90 to 110 mg/g and 55 to 100 mg/g, respectively. In addition, 80% ethanol extract of unripe mango peel had a total polyphenolic content of 92.62 mg GAE/g (Kim *et al*., 2010), both exhibiting lower amounts of total phenolic content than MIPE.

In regards to the antioxidant activity of the six fruit peel extracts, MIPE exhibited the highest $ABTS^{\bullet+}$ scavenging activity among the other peel extracts. In a previous study, Huang *et al.* (2018) found a positive and significant correlation between the polyphenol contents of peel extracts and ABTS radical scavenging activities. Another report showed that mango (*Mangifera indica* L.) peel extract had good antioxidant activity using the ABTS method (Ali *et al*., 2012, Kim *et al*., 2010). The ability of the extracts to reduce ferric ions was determined using the FRAP assay. MIPE showed the highest ferric reducing activity. El-Faham *et al*. (2016) reported that mango peels extract exhibited the highest reducing of ferric to ferrous iron with the value of 57.06 mmol Fe_2SO_4/100g. Likewise, Torunn *et al.* (2009) found that mango peels had higher FRAP activity than lemon and papaya peels. The higher ferric reducing activity of mango peel extract may be due to its rich total phenolic contents. DPPH radical has been widely used to assess the scavenging activities of various natural compounds. The results showed that MIPE exhibited the highest scavenging activity of DPPH radicals scavenging activities. There have been many researchers who found that fruit peel extracts are a good source of antioxidant activity (Putri *et al*., 2018, Fidrianny *et al*., 2018). Ali *et al.* (2012) revealed that 80% acetone mango peel extracts showed DPPH radical scavenging activity. A high level of radical scavenging activity is normally associated with a high phenolic content (Luo *et al*., 2014). As a result, the high antioxidant activity exhibited by mango peel extracts is most likely due to the presence of polyphenols which have the ability to scavenge free radicals by acting as hydrogen donors. Therefore, MIPE can be suggested as natural antioxidant that might be used for protective health or therapeutic agents.

The antityrosinase assay is based on the inhibition of the mushroom tyrosinase enzyme. Tyrosinase is an enzyme involved in the process of

melanogenesis that contributes to skin pigmentation and darker skin colour (Haliloglu *et al*., 2017). The antityrosinase activity for the six fruit peel extracts were determined and compared with the positive control, kojic acid, at the concentration of 0.5 mg/ml. However, the most active peel extracts were PEPE and ACPE with the values of 60.31 ± 3.20% and 56.93 ± 5.46%, respectively, whereas the other peel extracts had lower inhibitory activities than kojic acid. Phytochemical screening of the *P. edulis* peel revealed the presence of triterpenoids, saponin, and phenol (Sihombing *et al*., 2015). In addition, *A. comosus* peel showed the presence of oxalate, alkaloids, phytate, tannins, and glycoside (Dabesor *et al*., 2017). It could be suggested that phytochemical composition of fruit peels could inhibit tyrosinase enzymatic activity. Considering the *in vitro* antioxidant and antityrosinase activities of MIPE and PFPE, the extracts' effect on antimelanogenesis in mouse melanoma cells such as, B16F10 should be further evaluated.

In addition, MIPE also exhibited strong activity against *S. epidermidis* and *S. pyogenes* indicating that mango peel (*Mangifera indica* L.) contains high phenolic compounds, which exhibit antioxidant properties. The major phenolic compounds of mango peel extract are syringic acid, quercetin, mangiferin pentoside and ellagic acid (Ajila *et al*., 2010). Masud Parvez *et al*. (2016) reported that mango peel extracts showed antibacterial activity against two gram positive (*Bacillus cereus, Staphylococcus aureus*) and four gram negative pathogenic bacteria (*Escherichia coli, Shigella dysenteriae, Agrobacterium species* and *Shigella sonnei*). In addition, mango peel extract also exhibited antibacterial activity against *E. coli, Salmonella typhi, Shigella* spp. and *Enterobacter* spp. (Thambi *et al*., 2016). According to these results, MIPE possesses remarkable antibacterial activity against the human skin pathogens *Staphylococcus epidermidis* and *Streptococcus pyogenes*. These findings suggest that MIPE could be suitable for application in cosmetic products for preventing or treating skin disorders.

In conclusion, this study revealed that among the tested extracts, raw mango (*Mangifera indica* L.) peel extract (MIPE) contained the highest amount of total phenolic compounds and showed the greatest antioxidant activity as estimated by DPPH, ABTS and FRAP assays. In addition, MIPE was able to inhibit *Staphylococcus epidermidis* and *Streptococcus pyogene*. These findings suggest that mango peels could be used as a natural source of antioxidants and antibacterial agents in health care, therapeutic agents, and cosmetic products.

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