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## Antioxidant and Antibacterial Activities of Vegetables and Fruits Commonly Consumed in Thailand

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**Abstract:** The vegetables and fruits commonly consumed in Thailand have been suggested as rich sources of beneficial phytochemicals. In this study, vegetables and fruits native to the Northeast region of Thailand were evaluated for antioxidant and antibacterial activities. For vegetables, the extracts of *Limnophila aromatica* (Lamk.) Merr. (extracted by 80% ethanol) and *Sauropus androgynus* (Linn.) Merr. (extracted by distilled water) were found to have significant levels of antioxidant activities measured by DPPH scavenging ( $IC_{50}$  at  $4.92 \pm 0.01$  and  $4.71 \pm 0.01$  mg mL<sup>-1</sup>, respectively) and FRAP antioxidant assays ( $74.38 \pm 0.25$  and  $74.00 \pm 0.04$  mmol FeSO<sub>4</sub> g<sup>-1</sup> of dry weight of vegetable, respectively) and also total phenolic compounds ( $10.96 \pm 0.02$  and  $10.34 \pm 0.01$  mg gallic acid eq g<sup>-1</sup> of dry weight of vegetable). For fruits, the extracts derived from *Terminalia chebula* Retz. when using distilled water and 80% ethanol as solvents were shown to have significantly high levels of DPPH scavenging ( $IC_{50}$  at  $3.73 \pm 0.01$  and  $3.81 \pm 0.01$  mg mL<sup>-1</sup>, respectively), FRAP antioxidant activities ( $80.85 \pm 0.10$  and  $65.93 \pm 0.11$  mmol FeSO<sub>4</sub> g<sup>-1</sup> of dry weight of fruit, respectively) and total phenolic compounds ( $13.10 \pm 0.06$  and  $10.66 \pm 0.02$  mg gallic acid eq g<sup>-1</sup> of dry weight of fruit, respectively). The antibacterial assays showed that *Moringa oleifera* Lam., *Limnophila aromatica* (Lamk.) Merr., *Terminalia chebula* Retz. and *Phyllanthus emblica* Linn. that were extracted using 80% ethanol as solvent were found to have antibacterial activities against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus pyogenes* and *Propionibacterium acnes*. The results in this study may be useful for future application of edible plants that are native to Thailand to be used as cosmetic or therapeutic products.

**Key words:** Antioxidant activity, antibacterial activity, vegetable extract, fruit extract, Thailand

### INTRODUCTION

Plants are rich sources of several important bioactive compounds. Apart from medicinal herbs, some commonly consumed vegetables and fruits may also have important phytochemicals with pharmacological properties, for example, *Brassica* vegetables (Podsdek, 2007) and *Lycium barbarum* fruit (Goji) (Amagase and Farnsworth, 2011). Furthermore, some native vegetables, especially leafy green vegetables and fruits with dark colors have also been found to have bioactive compounds with antioxidant and antimicrobial activities (Andarwulan *et al.*, 2010; Tan *et al.*, 2011; Murillo *et al.*, 2012). The antioxidant activities and bioactive compounds in dietary plants can provide additional health benefits for prevention of cardiovascular disease, cancer, neurological decline and diabetes (Wootton-Beard and Ryan, 2011). In Thailand, a variety of native vegetables and fruits that are used as daily food and seasoning are proven to have high antioxidant activities in addition to their nutritional values, for instance, *Cassia siamea*, *Tagetes erecta*, *Antigonon leptopus*, *Gymnema inodorum*, *Piper sarmentosum*,

*Mentha arvensis*, *Diospyros decandra*, *Terminalia chebula* and *Phyllanthus emblica* (Chanwitheesuk *et al.*, 2005; Kaisoon *et al.*, 2011; Kubola *et al.*, 2011). There are a large number of Thai vegetables and fruits that are attractive due to their health-related functional properties as well as their possible future application for prevention and therapeutic purposes. However, there are many of them that remain unexplored. Therefore, this study aims to evaluate the antioxidant and antibacterial activities of the vegetables and fruits commonly consumed in the Northeast region of Thailand.

### MATERIALS AND METHODS

**Preparation of plant extracts:** The vegetables and fruits that are commonly consumed in the Northeast region of Thailand were collected or purchased from Maha Sarakham provinces. The vegetables (their common and Thai names are written in the brackets, respectively) included *Neptunia oleracea* Lour. (water mimosa, Krashednam), *Limnophila aromatica* (Lamk.) Merr. (rice paddy herb, Kayang), *Coccinia grandis* (L.) J. Voigt (ivy gourd, Tamleung), *Basella alba* Linn. (Ceylon spinach,

Plungkhaw), *Sauropus androgynus* (Linn.) Merr. (sweet leaf bush, Wanban) and *Moringa oleifera* Lam. (drumstick tree, Maroom). The fruits included *Flacourtia indica* (Burm. f.) Merr. (governor's plum, Takhobpa), *Phyllanthus emblica* Linn. (Indian gooseberry, Makhampom), *Phyllanthus acidus* (L.) Skeels. (star gooseberry, Mayom), *Antidesma thwaitesianum* Müll. Arg. (Mao, Mamaoluang), *Ziziphus oenoplia* (L.) Mill. (jackal jujube, Lepmeaw) and *Terminalia chebula* Retz. (black myrobalan, Smore). These vegetables (leaves, stems and branches) and fruits (peels without seeds) were air dried to have less than 10% humidity, ground into fine powder and extracted using distilled water (DW) and 80% ethanol (E80) as solvents at the ratio 1:5 w/v. The extraction process was performed for 12 h with agitation at 150 rpm at room temperature (28-30°C). The resulting solutions were centrifuged at 4000 rpm for 10 min and the supernatants were concentrated using vacuum rotary evaporator at 45°C. The percentage of extraction yield was calculated as following:

$$\text{Yield (\%)} = \frac{\text{Weight of extract (g)}}{\text{Weight of dried vegetable (g)}} \times 100$$

#### Antioxidant activity determination by DPPH scavenging

**assay:** DPPH scavenging assay for evaluation of antioxidant activities was described previously (Butsat and Siriamornpun, 2010). Plant extract (100 µL) was mixed with freshly prepared 0.1 mM DPPH° solution (1.9 mL) and incubated at room temperature in the dark for 30 min and then measured for absorbance at 517 nm. BHA (butylated hydroxyanisole) was used as standard reagent. The levels of DPPH scavenging activities of the extracts were calculated and expressed as IC<sub>50</sub> (mg mL<sup>-1</sup>). The experiments were performed in three replicates.

#### Antioxidant activity determination by ferric reducing

**ability of plasma (FRAP) assay:** FRAP assay for determination of antioxidant activities was previously described by Butsat and Siriamornpun (2010). FRAP stock solution was prepared by mixing 300 mM acetate buffer (pH 3.6), 10 mM TPTZ solution (in 40 mM HCl) and 20 mM FeCl<sub>3</sub>.6H<sub>2</sub>O solution. FRAP solution (1.7 mL) must be prepared freshly and warmed at 37°C before adding to plant extract (300 µL). The mixture was incubated at room temperature for 1 h and then measured for absorbance at 593 nm. The standard curve was plotted using the result obtained from FeSO<sub>4</sub> standard reagent. The antioxidant activities of the extracts were calculated and expressed as mol FeSO<sub>4</sub> eq g<sup>-1</sup> of dry weight of vegetable or fruit. The experiments were carried out in three replicates.

**Total phenolic compound measurement:** The level of total phenolic compounds was measured by Folin-Ciocalteu method as previously described (Butsat and Siriamornpun, 2010). Plant extract (200 µL) was mixed with Folin-Ciocalteu reagent (diluted 1:10 with sterile distilled water) (1 mL), shaken for 1 min and added with 10% Na<sub>2</sub>CO<sub>3</sub> (800 µL). After that, the mixture was topped up with sterile distilled water to have total volume of 5 mL and incubated at room temperature in the dark for 2 h. Finally, the mixture was measured for absorbance at 760 nm. Gallic acid was used as standard reagent. The levels of total phenolic compounds of the extracts were calculated and expressed as mg gallic acid eq g<sup>-1</sup> of dry weight of vegetable or fruit. The experiments were performed in three replicates.

#### Antibacterial activity evaluation by agar well diffusion

**assay:** Agar well diffusion assay for determination of antibacterial activity was performed as described previously (Oke *et al.*, 2009) with some modifications. *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus pyogenes* and *Propionibacterium acnes* were grown overnight at 37°C and adjusted to approximately 1×10<sup>8</sup> CFU mL<sup>-1</sup>. The bacterial culture (100 µL) was then spread onto Mueller Hinton Agar (MHA) plate and let to dry for 10 min before being punctured by 0.6 cm sterile cork borer. Plant extract (30 µL) was added to each agar well and the plate was incubated at 37°C overnight. The antibacterial activities of the extracts were measured by the diameter size of inhibition zone around the agar well.

## RESULTS

#### Levels of antioxidant activities and total phenolic

**compounds:** The vegetables extracts were shown to have antioxidant activities measured by DPPH scavenging and FRAP assays (Table 1). The extracts of *N. oleracea* (extracted by DW and E80), *L. aromatica* (DW and E80), *C. grandis* (DW) and *S. androgynus* (DW) had significantly high antioxidant activities measured by DPPH scavenging assay. However, only the extracts of *L. aromatica* (E80) and *S. androgynus* (DW) that were also found to have significant levels of antioxidant activities measured by FRAP assays (74.38±0.25 and 74.00±0.04 mmol FeSO<sub>4</sub> eq g<sup>-1</sup> of dry weight of vegetable, respectively) and total phenolic compounds (10.96±0.02 and 10.34±0.01 mg gallic acid eq g<sup>-1</sup> of dry weight of vegetable, respectively). Interestingly, *B. alba* extract (DW) that had the highest FRAP antioxidant activities (80.59±0.09 mmol FeSO<sub>4</sub> eq g<sup>-1</sup> of dry weight of vegetable) was found to have rather

Table 1: Antioxidant activities and total phenolic compounds of vegetable extracts

| Vegetable                                 | Solvent | DPPH IC <sub>50</sub><br>(mg mL <sup>-1</sup> ) | FRAP antioxidant activity<br>(mmol FeSO <sub>4</sub> eq g <sup>-1</sup> dried vegetable) | Total phenolic compounds<br>(mg gallic acid eq g <sup>-1</sup> dried vegetable) |
|-------------------------------------------|---------|-------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| <i>Neptunia oleracea</i> Lour.            | DW      | 4.34±0.28 <sup>ab</sup>                         | 27.62±0.05 <sup>e</sup>                                                                  | 4.16±0.04 <sup>f</sup>                                                          |
|                                           | E80     | 4.68±0.03 <sup>ab</sup>                         | 29.31±0.07 <sup>f</sup>                                                                  | 4.84±0.00 <sup>ef</sup>                                                         |
| <i>Limnophila aromatica</i> (Lamk.) Merr. | DW      | 4.23±0.01 <sup>a</sup>                          | 34.71±0.04 <sup>e</sup>                                                                  | 5.61±0.01 <sup>de</sup>                                                         |
|                                           | E80     | 4.92±0.01 <sup>ab</sup>                         | 74.38±0.25 <sup>b</sup>                                                                  | 10.96±0.02 <sup>a</sup>                                                         |
| <i>Coccinia grandis</i> (L.) J. Voigt     | DW      | 4.39±0.01 <sup>ab</sup>                         | 68.06±0.08 <sup>e</sup>                                                                  | 9.96±0.01 <sup>b</sup>                                                          |
|                                           | E80     | 5.22±0.03 <sup>b</sup>                          | 25.38±0.59 <sup>b</sup>                                                                  | 3.15±0.01 <sup>e</sup>                                                          |
| <i>Basella alba</i> Liun.                 | DW      | 6.71±0.04 <sup>c</sup>                          | 80.59±0.09 <sup>a</sup>                                                                  | 8.18±0.03 <sup>c</sup>                                                          |
|                                           | E80     | 11.05±0.13 <sup>d</sup>                         | 24.52±0.04 <sup>f</sup>                                                                  | 3.21±0.01 <sup>e</sup>                                                          |
| <i>Sauropus androgynus</i> (Liun.) Merr.  | DW      | 4.71±0.01 <sup>ab</sup>                         | 74.00±0.04 <sup>b</sup>                                                                  | 10.34±0.01 <sup>ab</sup>                                                        |
|                                           | E80     | 6.30±0.04 <sup>c</sup>                          | 37.51±0.05 <sup>d</sup>                                                                  | 5.99±0.91 <sup>d</sup>                                                          |
| <i>Moringa oleifera</i> Lam.              | DW      | nd                                              | 8.35±0.55 <sup>j</sup>                                                                   | 0.36±0.01 <sup>h</sup>                                                          |
|                                           | E80     | 77.97±0.92 <sup>e</sup>                         | 5.77±0.01 <sup>k</sup>                                                                   | 0.22±0.02 <sup>h</sup>                                                          |

Values (Mean±SD) in the same column with the same lower-case letter(s) are not significant different as determined by Duncan's test at p<0.05, DW: Distilled water, E80: 80% ethanol, nd: Not detected

Table 2: Antioxidant activities and total phenolic compounds of fruit extracts

| Fruit                                     | Solvent | DPPH IC <sub>50</sub><br>(mg mL <sup>-1</sup> ) | FRAP antioxidant activity<br>(mmol FeSO <sub>4</sub> eq g <sup>-1</sup> dried fruit) | Total phenolic compounds<br>(mg gallic acid eq g <sup>-1</sup> dried fruit) |
|-------------------------------------------|---------|-------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| <i>Flacourtia indica</i> (Burn. f.) Merr. | DW      | 4.38±0.12 <sup>b</sup>                          | 65.14±0.07 <sup>e</sup>                                                              | 5.12±0.02 <sup>e</sup>                                                      |
|                                           | E80     | 7.34±0.30 <sup>d</sup>                          | 60.67±0.09 <sup>d</sup>                                                              | 4.55±0.03 <sup>f</sup>                                                      |
| <i>Phyllanthus emblica</i> Linn.          | DW      | 3.48±0.03 <sup>a</sup>                          | 46.18±0.05 <sup>e</sup>                                                              | 7.72±0.03 <sup>c</sup>                                                      |
|                                           | E80     | 3.88±0.02 <sup>ab</sup>                         | 38.95±0.07 <sup>f</sup>                                                              | 6.26±0.01 <sup>d</sup>                                                      |
| <i>Phyllanthus acidus</i> (L.) Skeels.    | DW      | 10.93±0.56 <sup>e</sup>                         | 6.51±0.03 <sup>k</sup>                                                               | 0.75±0.01 <sup>j</sup>                                                      |
|                                           | E80     | 10.41±0.15 <sup>e</sup>                         | 5.02±0.05 <sup>j</sup>                                                               | 0.66±0.01 <sup>k</sup>                                                      |
| <i>Antidesma thwaitesianum</i> Müll. Arg. | DW      | 5.07±0.03 <sup>c</sup>                          | 33.02±0.05 <sup>e</sup>                                                              | 4.52±0.01 <sup>f</sup>                                                      |
|                                           | E80     | 7.38±0.22 <sup>d</sup>                          | 28.60±0.11 <sup>i</sup>                                                              | 2.80±0.01 <sup>e</sup>                                                      |
| <i>Ziziphus oenopia</i> (L.) Mill.        | DW      | 15.35±0.28 <sup>f</sup>                         | 31.54±0.23 <sup>h</sup>                                                              | 2.72±0.01 <sup>h</sup>                                                      |
|                                           | E80     | 31.47±0.31 <sup>g</sup>                         | 26.73±0.04 <sup>f</sup>                                                              | 2.07±0.01 <sup>i</sup>                                                      |
| <i>Terminalia chebula</i> Retz.           | DW      | 3.73±0.01 <sup>ab</sup>                         | 80.85±0.10 <sup>a</sup>                                                              | 13.10±0.06 <sup>a</sup>                                                     |
|                                           | E80     | 3.81±0.01 <sup>ab</sup>                         | 65.93±0.11 <sup>b</sup>                                                              | 10.66±0.02 <sup>b</sup>                                                     |

Values (Mean±SD) in the same column with the same lower-case letter(s) are not significant different as determined by Duncan's test at p<0.05, DW: Distilled water, E80: 80% ethanol, nd: Not detected

moderate levels of DPPH IC<sub>50</sub> at 6.71±0.04 mg mL<sup>-1</sup> and total phenolic compounds at 8.18±0.03 mg gallic acid eq g<sup>-1</sup> of dry weight of vegetable.

The fruits extracts that were found to have significantly high levels of both antioxidant activities and total phenolic compounds are those derived from *T. chebula* (extracted by DW and E80) which giving DPPH IC<sub>50</sub> at 3.73±0.01 and 3.81±0.01 mg mL<sup>-1</sup>, FRAP antioxidant activities at 80.85±0.10 and 65.93±0.11 mmol FeSO<sub>4</sub> g<sup>-1</sup> of dry weight of fruit and total phenolic compounds at 13.10±0.06 and 10.66±0.02 mg gallic acid eq g<sup>-1</sup> of dry weight of fruit, respectively (Table 2). Also, *P. emblica* extracts (DW and E80) were shown to have significant levels of DPPH IC<sub>50</sub> at 3.48±0.03 and 3.88±0.02 mg mL<sup>-1</sup>, respectively, but rather moderate levels of FRAP antioxidant activities and total phenolic compounds.

**Antibacterial activities:** For vegetable extracts, only *M. oleifera* and *L. aromatica* extracts were found to have antibacterial activities against all four tested bacteria (Table 3). The highest antibacterial activities was found in the E80 extract of *M. oleifera* that could inhibit *S. aureus*, *S. epidermidis*, *S. pyogenes* and *P. acnes* by producing

inhibition zones with the diameters of 1.50±0.12, 1.57±0.18, 1.50±0.23 and 2.50±0.27 cm, respectively, followed by the E80 extract of *L. aromatica* that produced inhibition zone at 1.20±0.06, 1.20±0.12, 0.93±0.07 and 1.27±0.12 cm, respectively. Moderate inhibition activities were found in the DW extract of *M. oleifera* which producing zone at 1.03±0.43, 1.10±0.50, 1.17±0.57 and 1.53±0.48 cm, respectively.

For fruit extracts, inhibition of all four tested bacteria were found when applying with the extracts of *T. chebula* (E80) that producing clear zones against *S. aureus*, *S. epidermidis*, *S. pyogenes* and *P. acnes* at 1.37±0.03, 1.57±0.03, 1.23±0.12 and 1.68±0.06, respectively (Table 4). Moreover, the extracts of *P. emblica* (E80) could also inhibit these four bacteria by inducing clear zones at 1.68±0.06, 1.59±0.05, 1.23±0.12 and 1.68±0.06, respectively.

Streptomycin (10 IU mL<sup>-1</sup>) was used as positive control group and inhibited *S. aureus*, *S. epidermidis*, *S. pyogenes* and *P. acnes* by producing clear zone at 3.47±0.15, 1.57±0.07, 1.83±0.03 and 1.63±0.07 cm, respectively. The solvents, DW and E80, were used as negative control groups and they did not show any inhibition against these four bacteria.

Table 3: Antibacterial activities of vegetable extracts

| Vegetables                                | Solvent | Inhibition zone (cm) |                       |                    |                 |
|-------------------------------------------|---------|----------------------|-----------------------|--------------------|-----------------|
|                                           |         | <i>S. aureus</i>     | <i>S. epidermidis</i> | <i>S. pyogenes</i> | <i>P. acnes</i> |
| <i>Nepenthes oleracea</i> Lour.           | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | 0.73±0.03       |
| <i>Limnophila aromatica</i> (Lamk.) Merr. | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | 1.20±0.06            | 1.20±0.12             | 0.93±0.07          | 1.27±0.12       |
| <i>Coccinia grandis</i> (L.) J. Voigt     | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | -               |
| <i>Basella alba</i> Linn.                 | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | -               |
| <i>Scaevola androgynus</i> (Linn.) Merr.  | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | -               |
| <i>Moringa oleifera</i> Lam.              | DW      | 1.03±0.43            | 1.10±0.50             | 1.17±0.57          | 1.53±0.48       |
|                                           | E80     | 1.50±0.12            | 1.57±0.18             | 1.50±0.23          | 2.50±0.27       |

The size of cork borer is 0.6 cm

Table 4: Antibacterial activities of fruit extracts

| Fruit                                     | Solvent | Inhibition zone (cm) |                       |                    |                 |
|-------------------------------------------|---------|----------------------|-----------------------|--------------------|-----------------|
|                                           |         | <i>S. aureus</i>     | <i>S. epidermidis</i> | <i>S. pyogenes</i> | <i>P. acnes</i> |
| <i>Flacourtia indica</i> (Burm.f.) Merr.  | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | 1.03±0.07       |
| <i>Phyllanthus emblica</i> Linn.          | DW      | 1.20±0.06            | 1.20±0.06             | 1.00±0.00          | 1.30±0.06       |
|                                           | E80     | 1.68±0.06            | 1.59±0.05             | 1.23±0.12          | 1.68±0.06       |
| <i>Phyllanthus acidus</i> Skeels          | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | -               |
| <i>Antidesma thwaitesianum</i> Muell. Arg | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | 1.10±0.21       |
| <i>Ziziphus oenoplia</i> (L.) Mill        | DW      | -                    | -                     | -                  | -               |
|                                           | E80     | -                    | -                     | -                  | -               |
| <i>Terminalia chebula</i> Retz.           | DW      | 1.23±0.03            | 1.20±0.06             | 1.00±0.00          | 1.30±0.06       |
|                                           | E80     | 1.37±0.03            | 1.57±0.03             | 1.23±0.12          | 1.68±0.06       |

The size of cork borer is 0.6 cm

## DISCUSSION

In this study, the extracts of vegetables, *L. aromatica*, *S. androgynus* and *B. alba*, were shown to have good antioxidant activities. The phenolic compounds (especially flavonoids) and essential oils in the vegetables extracts have been indicated to strongly promote extracts' antioxidant activities (Guimaraes *et al.*, 2010). In this study, high levels of total phenolic compounds in the extract of *S. androgynus* (DW) could play an important role on promoting its antioxidant activities. The previous report suggested that the extract of Indonesian *S. androgynus* (extracted by 95% ethanol) was found to have high level of total phenolic compounds at 1.49±0.15 mg gallic acid eq g<sup>-1</sup> fresh weight (Andarwulan *et al.*, 2010). Moreover, the extract of *L. aromatica* (E80) was found to have strong aroma and thus could be assumed that it may contain high quantity of essential oil which may contribute to its high antioxidant activities. In addition, the ethanolic extract of *B. alba* leaves was reported to have robust antioxidant properties and provide strong protection against chemical carcinogenesis induced hepatocarcinogenesis in animal model (Reddy *et al.*, 2008).

The extracts of *T. chebula* fruit were shown to have very strong antioxidant activities and high levels of total phenolic compounds. Recent reports have suggested that an antioxidant protein (~16 kDa) from *T. chebula* fruit has been successfully purified and characterized and it may be a major compound responsible for antioxidant activities of *T. chebula* fruit (Srivastava *et al.*, 2012). Also, there are a number of previous reports that showed the strong antioxidant properties and high levels of phenolic compounds of the extracts derived from *T. chebula* fruit (Pfundstein *et al.*, 2010; Saleem *et al.*, 2002; Nampoothiri *et al.*, 2011; Tubtimdee and Shotipruk, 2011). These results hence supported the findings of strong antioxidant activities and high levels of total phenolic compounds of *T. chebula* fruit extracts in this study. In addition, although *P. emblica* extracts was found to have slightly lower FRAP antioxidant activities and total phenolic compounds, they were found to have strong DPPH IC<sub>50</sub> similar to previous reports (Liu *et al.*, 2008a,b; Luo *et al.*, 2009, 2011).

This study showed that the E80 extracts of *M. oleifera*, *L. aromatica*, *T. chebula* and *P. emblica* were found to have antibacterial activities against *Staphylococcus aureus*, *Staphylococcus epidermidis*,

*Streptococcus pyogenes* and *Propionibacterium acnes*. As the negative control group using 80% ethanol alone showed no inhibition against these four bacteria, it is therefore unlikely that the residual ethanol in plant extracts could have any effect on their antibacterial activities. Furthermore, the antibacterial effects of these vegetable and fruits extracts have been previously reported. The extracts of *M. oleifera* were shown to inhibit *Salmonella typhi*, *Pseudomonas aeruginosa* and *S. aureus* (Doughari *et al.*, 2007; Caceres *et al.*, 1991). Also, the nanoparticles that applied with phenolic compounds (tannins) derived from *T. chebula* aqueous extract were shown to be effective at inhibiting *S. aureus* and *Escherichia coli* (Kumar *et al.*, 2012). Moreover, the water extract of *T. chebula* was found to contain a heat stable agent(s) that could strongly inhibit *Helicobacter pylori* (Malekzadeh *et al.*, 2001). The extracts of *P. emblica* were also previously found to inhibit *S. aureus* due to a variety of its phenolic compounds (Mayachiew and Devahastin, 2008).

## CONCLUSION

In this study, the antioxidant and antibacterial activities of Thai local vegetables and fruits have been illustrated. The results in this study may suggest the potentials of the extracts derived from *S. androgynous*, *L. aromatica*, *B. alba*, *M. oleifera*, *T. chebula* and *P. emblica* for application in cosmetic and/or therapeutic products due to their high levels of antioxidant activities and/or total phenolic compounds. These edible plants may be used as alternative to synthetic chemicals particularly because of their safety and ample amount in many local areas of Thailand.

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## REFERENCES

Amagase, H. and N.R. Farnsworth, 2011. A review of botanical characteristics, phytochemistry, clinical relevance in efficacy and safety of *Lycium barbarum* fruit (Goji). Food Res. Int., 44: 1702-1717.

Andarwulan, N., R. Batari, D.A. Sandrasari, B. Bolling and H. Wijaya, 2010. Flavonoid content and antioxidant activity of vegetables from Indonesia. Food Chem., 121: 1231-1235.

Butsat, S. and S. Siriamornpun, 2010. Antioxidant capacities and phenolic compounds of the husk, bran and endosperm of Thai rice. Food Chem., 119: 606-613.

Caceres, A., O. Cabrera, O. Morales, P. Mollinedo and P. Mendia, 1991. Pharmacological properties of *Moringa oleifera*. 1: Preliminary screening for antimicrobial activity. J. Ethnopharmacol., 33: 213-216.

Chanwitheesuk, A., A. Teerawutgulrag and N. Rakariyatham, 2005. Screening of antioxidant activity and antioxidant compounds of some edible plants of Thailand. Food Chem., 92: 491-497.

Doughari, J.H., M.S. Pukuma and N. De, 2007. Antibacterial effects of *Balanites aegyptiaca* L. Drel. and *Moringa oleifera* Lam. on salmonella typhi. Afr. J. Biotechnol., 6: 2212-2215.

Guimaraes, R., M.J. Sousa and I.C.F.R. Ferreira, 2010. Contribution of essential oils and phenolics to the antioxidant properties of aromatic plants. Ind. Crops Prod., 32: 152-156.

Kaisoon, O., I. Konczak and S. Siriamornpun, 2011. Potential health enhancing properties of edible flowers from Thailand. Food Res. Int., 46: 563-571.

Kubola, J., S. Siriamornpun, and N. Meeso, 2011. Phytochemicals, vitamin C and sugar content of Thai wild fruits. Food Chem., 126: 972-981.

Kumar, K.M., M. Sinha, B.K. Mandal, A.R. Ghosh, K.S. Kumar and P.S. Reddy, 2012. Green synthesis of silver nanoparticles using *Terminalia chebula* extract at room temperature and their antimicrobial studies. Spectrochim. Acta Part A: Mol. Biomol. Spectrosc., 91: 228-233.

Liu, X., C. Cui, M. Zhao, J. Wang, W. Luo, B. Yang and Y. Jiang, 2008a. Identification of phenolics in the fruit of emblica (*Phyllanthus emblica* L.) and their antioxidant activities. Food Chem., 109: 909-915.

Liu, X., M. Zhao, J. Wang, B. Yang and Y. Jiang, 2008b. Antioxidant activity of methanolic extract of emblica fruit (*Phyllanthus emblica* L.) from six regions in China. J. Food Comp. Anal., 21: 219-228.

Lou, W., M. Zhao, B. Yang, G. Shen and G. Rao, 2009. Identification of bioactive compounds in *Phyllanthus emblica* fruit and their free radical scavenging activities. Food Chem., 114: 499-504.

Luo, W., M. Zhao, B. Yang, J. Ren, G. Shen and G. Rao, 2011. Antioxidant and antiproliferative capacities of phenolics purified from *Phyllanthus emblica* L. fruit. Food Chem., 126: 277-282.

- Malekzadeh, F., H. Ehsanifar, M. Shahamat, M. Levin and R.R. Colwell, 2001. Antibacterial activity of black myrobalan (*Terminalia chebula* Retz) against *Helicobacter pylori*. Int. J. Antimicrob. Agents, 18: 85-88.
- Mayachiew, P. and S. Devahastin, 2008. Antimicrobial and antioxidant activities of Indian gooseberry and galangal extracts. LWT-Food Sci. Technol., 41: 1153-1159.
- Murillo, E., D. Giuffrida, D. Menchaca, P. Dugo, G. Torre, A.J. Melendez-Martinez and L. Mondello, 2012. Native carotenoids composition of some tropical fruits. Food Chem., (In Press).
- Nampoothiri, S.V., A. Prathapan, O.L. Cherian, K.G. Raghu, V.V. Venugopalan and A. Sundaresan, 2011. *In vitro* antioxidant and inhibitory potential of *Terminalia bellerica* and *Emblica officinalis* fruits against LDL oxidation and key enzymes linked to type 2 diabetes. Food Chem. Toxicol., 49: 125-131.
- Oke, F., B. Aslim, S. Ozturk and S. Altundag, 2009. Essential oil composition, antimicrobial and antioxidant activities of *Satureja cuneifolia* Ten. Food Chem., 112: 874-879.
- Pfundstein, B., S.K.E. Desouky, W.E. Hull, R. Haubner, G. Erben and R.W. Owen, 2010. Polyphenolic compounds in the fruits of Egyptian medicinal plants (*Terminalia bellerica*, *Terminalia chebula* and *Terminalia horrida*): Characterization, quantitation and determination of antioxidant capacities. Phytochemistry, 71: 1132-1148.
- Podsedeck, A., 2007. Natural antioxidants and antioxidant capacity of brassica vegetables: A review. LWT-Food Sci. Technol., 40: 1-11.
- Reddy, G.D., R. Kartik, C.V. Rao, M.K. Unnikrishnan and P. Pushpangadan, 2008. PP-044 *Basella alba* extract act as antitumour and antioxidant potential against N-nitrosodiethylamine induced hepatocellular carcinoma in rats. Int. J. Infect. Dis., 12: S68-S68.
- Saleem, A., M. Husheem, P. Harkonen and K. Pihajala, 2002. Inhibition of cancer cell growth by crude extract and the phenolics of *Terminalia chebula* Retz fruit. J. Ethnopharmacol., 81: 327-336.
- Srivastava, P., H.N. Raut, R.S. Wagh, H.M. Puntambekar and M.J. Kulkarni, 2012. Purification and characterization of an antioxidant protein (~16 kDa) from *Terminalia chebula* fruit. Food Chem., 131: 141-148.
- Tan, A.C., I. Konczak, I. Ranizan and D.M.Y. Sze, 2011. Antioxidant and cytoprotective activities of native Australian fruit polyphenols. Food Res. Int., 44: 2034-2040.
- Tubtimdee, C. and A. Shotipruk, 2011. Extraction of phenolics from *Terminalia chebula* Retz with water-ethanol and water-propylene glycol and sugaring-out concentration of extracts. Sep. Purif. Technol., 77: 339-346.
- Wootton-Beard, P.C. and L. Ryan, 2011. Improving public health?: The role of antioxidant-rich fruit and vegetable beverages. Food Res. Int. J., 44: 3135-3148.