Evaluation of Total Phenolic Content, Total Antioxidant Activity, and Antioxidant Vitamin Composition of Pomegranate Seed and Juice

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Introduction

Pomegranate (Punica granatum) is one of the oldest known edible fruit that born on the small long-living tree, which is cultivated through the Mediterranean region, Himalayas, and Southeast Asian [1]. The pomegranate fruit can be divided into three anatomical origins: seeds, peel, and arils. Pomegranate fruit is considered as a nutritious fruit due to its biological actions; most of these effects were attributed to its high phenolic content and vitamin C [2]. Pomegranate juice is obtained from arils, which are rich sources of bioactive compound like phenolic and flavonoids [3]. Another part of pomegranate fruit is seeds, which are a rich origins of polyunsaturated (PUFA) mostly linolenic (n-3), and linoleic (n-2). Phenolic content is the main compound attribute for the most of the functional properties of many fruits such as pomegranate and grapes [4]. Reactive oxygen and nitrogen species are constantly produced in vivo for physiological purposes, and often over-produced in pathological situations cause oxidative damage [5]. All oxygen-consuming organisms are used antioxidant such as vitamin C, E, A, and phenolic to protect their possible damage to biological molecules [6]. In the recent years, more attention has been paid to the antioxidants contained in fruits; because epidemiological studies revealed that high fruit intake was associated with reduced mortality and morbidity of some chronic diseases such as cardiovascular diseases, cancers and neurological damage [2].

One of the possible mechanisms was attributed to the antioxidant activity presented in fruits [7]. Some phenolic compounds are even more powerful as antioxidants than vitamin C, E in vitro, and significantly bioavailable, as demonstrated by animal and human studies [8]. Antioxidants have leading role in health maintenance based on their modulation of the oxidation processes in the body [9]. Consequently the search for inexpensive and abundant sources of natural antioxidants is attracting worldwide interest. Consumption of fresh fruits and vegetables to improve human health has been attributed primarily to their high contents of healthful phytochemicals and other micronutrients [10]. This study was conducted to determine antioxidant power of pomegranate fruit, and to compare between two-edible parts of pomegranate (juice and seed) based on antioxidant properties.

Materials and Methods

Chemicals

L-ascorbic acid, α-tocopherol, trans-β-carotene, Ferric Chloride (FeCl$_3$.6H$_2$O), and TPTZ (2,4,6-tri[2-pyridyl]-s-triazine) were purchased from Sigma-Aldrich (St Louis, Mo., USA). Folin-Ciocalletu reagent was from Merck Chemical Supplies (MerckKGaA, Darmstadt, Germany). Gallic acid was obtained from NacalaiTesque, Kyoto, Japan.

Preparation of samples for analysis

Ripe sweet red pomegranate fruits were used in this study, were imported from Spain. The fruit was washed, peeled, and stored. The fruit arils were crushed and squeezed by squeezing machine (National Juicer/Blender). The pomegranate juice (PJ) was filtered to remove any water-insolubletmaterials. Liquid nitrogen and freeze-drying machine was used to make powder from pomegranate juice, and then stored at -18°C. The pomegranate seeds (PS) from the juice preparation were freeze dried at -20°C separately and ground into powder.
preparation of pomegranate seed-juice (PSJ). 0.8 g from PJ powder was added to 0.2 g of PS powder. About 100 g of the powder was mixed with 300 ml of 70% ethanol in distilled water and kept for 3 days at room temperature. The extract was then filtered. Solvent of ethanol was removed by using a rotary evaporator under vacuum at 50°C. The extract was obtained, and kept in the refrigerator.

**Determination of total phenolic content (TPC)**

Total phenolic content was determined according to the method of by using the Folin-Ciocalteu reagent based on colorimetric reduction [11]. The phenolic compounds are oxidized to phenolates by the reagent at alkaline pH in a saturated solution of sodium carbonate resulting in a blue complex. About 1.5 ml of Folin-Ciocalteau (10%, w/v) is added to 300 µl sample, followed by the addition of 1.2 ml of aqueous Na₂CO₃ (7.5%, w/v). The mixture was allowed to stand in the dark for 90 minutes. The absorbance of the blue color solution was read at 760 nm on a UV visible spectrophotometer (Shimadzu, Kyoto, Japan), against blank (distilled water). Total phenolic concentration (mg/ml) of the samples were analyzed in triplicates, and extrapolated from a standard curve, constructed by using Gallic acid as a standard. Results were expressed as Gallic acid equivalents (GAE).

**Determination of ferric reducing antioxidant power (FRAP) assay**

The FRAP assay was presented as a method for assessing “antioxidant power” according to adapted procedure from [12]. Ferric to ferrous ion reduction at low pH causes a colored complex. The FRAP reagent was prepared with mixture 200 ml acetate buffer 300 mM (pH 3.6), 20 ml TPTZ (2,4,6-tri(22-pyridyI)-s-triazine), in 10 ml acid (1.4 M). The mixture was located in conical flask (wrapped with aluminum foil), and agitated at 100 rpm with an orbital shaker for 15 minutes at room temperature [14]. The mixture collected was filtered through Whatman (No. 4) filter paper (Milipore, USA), and 30 μl in triplicates was immediately used for HPLC analysis. The techniques were used to identify the peak of vitamin C on the chromatogram; comparing the retention time and spiking test with that of L-ascorbic acid (Sigma, Co. Chemical, St. Louis, USA). Ascorbic acid standard was prepared by dissolving 100 mg of L-ascorbic acid in a metaphosphoric acid (0.3 M) and acetic acid (1.4 M) solution at the final concentration of 1 mg/ml.

**Estimation of vitamin E (α-Tocopherol)**

Estimation of α-tocopherol (vitamin E) was conducted by using high performance liquid chromatography (HPLC). Extraction for vitamin E was obtained according to the method described by Amin, Cheah and Abdulnabi [14,15]. 5 mg of sample was added with 20 ml methanol. Then, the mixture was mixed with 60 ml CCl₄ methanol (3:1) and agitated at 100 rpm with an orbital shaker for 20 minutes. The CCl₄ fraction was separated from the aqueous phase in a separatory funnel, and dried over Na₂SO₄. Rotary evaporator was exploited to evaporate the filtrate to dryness under pressure 45°C. The extract lipid fraction was saponified by refluxing in the presence of 0.5 g ascorbic acid with 4 ml of 30% methanolic potassium hydroxide (KOH) for 30 minutes at the boiling point of methanol. After cooling, the flask at room temperature 15 ml of salted water was added and the analogues of tocopherol were extracting twice with 40 ml petroleum ether in a separatory funnel. The ether fractions were washed twice with distilled water, collected, and dried over anhydrous sodium sulphate (Na₂SO₄). Rotary evaporator was exploited to evaporate the solvent at 45°C. The residues were dissolved in 5 ml of
HPLC grade hexane. The vitamin E determined by a reverse-phase HPLC technique. Samples were conducted in triplicates, and separation conditions in Table 1. The peak for vitamin E also recognized based on comparing the retention time and spiking test what that of α-tocopherol (Sigma, Co. Chemical, St Louis, USA). 10 mg of α-tocopherol was weighed and dissolved in pure n-hexane to give stock solution 100 μg/ml. The solution was stored in a brown bottle and kept as stock in the fridge at 5°C.

### Statistical analysis

All data were reported as mean ± S.E.M of triplicate determination. One-way analysis of variance (ANOVA) with significant differences between means determined at p<0.05, measured with post-hoc multiple comparisons and Tukey's test were performed with SPSS (version 21, IBM U.S.A). In addition, Pearson correlation was used to demonstrate the correlation between total antioxidant activity and total phenolic content.

### Results and Discussion

#### Total phenolic content

The total phenolic content (TPC) of pomegranate was determined through analysis of Folin-Ciocalteau method that it is shown in Table 2. One-way ANOVA test was conducted to explore the level of phenolic content between PS, PJ, and PSJ, as measured by Gallic acid. Post-hoc comparison using the Tukey HSD test indicated that the mean score for PSJ was significantly (p<0.05) different from group PS and PJ. Moreover, The PSJ(2696 ± 49 mgGAE/L) exhibited high amount of TPC. This value for PJ was the same range for red wine (generally above 2000 mg/L), and twice that found in green tea (1029 ± 36) [16]. The total phenolic calculated for pomegranate juice reached 2100 mg/L, which was good in agreement with the Folin-Ciocalteu method. This finding showed that PSJ has high level of total phenolic content compared to other fruits juice such as orange and berries, even red wine. Besides, TPC in PSJ was higher than two other parts (PS and PJ) separately.

Epidemiology studies have demonstrated that consumption of fruits and vegetables with high phenolic content correlated with reduction of cardiovascular, cerebrovascular diseases, and cancer mortality [17]. Phenolic compounds in pomegranate may produce their beneficial effects by scavenging free radicals [2].

#### Table 2: Total antioxidant activity (TAA) of pomegranate by FRAP assay and Total phenolic content (TPC) by Folin-Ciocalteau method.

Values were expressed as mean ± S.E.M (n=3), different lowercase letters indicate significant difference at p<0.05

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TAA</th>
<th>TPC</th>
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<tbody>
<tr>
<td>Pomegranate juice (PJ)</td>
<td>32 ± 5.1a</td>
<td>2502 ± 54a</td>
</tr>
<tr>
<td>Pomegranate seed (PS)</td>
<td>20 ± 2.8b</td>
<td>165 ± 49b</td>
</tr>
<tr>
<td>Pomegranate seed + juice (PSJ)</td>
<td>47 ± 5.5c</td>
<td>2696 ± 49c</td>
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#### Total antioxidant activity

The antioxidant activity of pomegranate was determined by using FRAP assay, which was ferric reducing antioxidant power (FRAP) that it is shown in Table 2. ANOVA test was conducted to explore the level of antioxidant activity between PS, PJ, and PSJ as measured by FRAP value. Post-hoc comparison using the Tukey HSD test indicated that the mean score TAA for PSJ (47 ± 5.5 mmol/L Fe^2+) was significantly (p<0.05) different from PS, and PJ. The antioxidant activity of Pomegranate components has been reported in the many studies [18-20]. The antioxidant capacity of pomegranate juice was shown to be higher than red wine, and green tea, based on the evaluation of the free radicals scavenging activity, and iron reducing capacity of the juice [16]. Furthermore, fruits have relationship between, antioxidant composition, and antioxidant activity, and those with high antioxidant activity generally contain more antioxidants [7]. Current study proved that pomegranate fruits were a rich possessed source of dietary antioxidants. Moreover, these nutrient characteristics are more significant in PSJ compared to other parts of pomegranate (seed or juice) separately.

#### Correlation between total antioxidant activity (TAA) and total phenolic content (TPC)

Data were obtained from this survey showed strong correlation between antioxidant activity and total phenolic content (Figure 1). Statistical analysis showed that there are strong positive correlation between TAA and TPC (Pearson correlation r² = 0.91 at p<0.05).

### Antioxidant vitamins composition

Antioxidant vitamins composition in pomegranate was measured by HPLC and the results are summarized in Table 3. Results showed that pomegranate juice could be a complimentary source of vitamin C and A (58 ± 0.6 mg/100 g, 22.8 ± 0.7 µg/100 g). These concentrations are comparable to other fruits or vegetables such as apples, apricots, carrots, cherries, or peaches and better than plums or pears [21]. Vitamin C is the most important vitamin in fruits and more than 90% of vitamin C in human diets are supplied by fruits, and vegetables. These vitamins work both or synergistically to prevent or delay oxidative reaction that lead to degenerative disease [22]. However, this study revealed that pomegranate juice contained low level of vitamin E (0.07 ± 0.01 mg/100 g).

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Conclusions

These findings suggested that pomegranate seed-juice has high level of phenolic content and antioxidant activity, which were positively correlated. Moreover, pomegranate juice could be acomplementary source of vitamin C and A. In addition, the result concluded that the combination of seed and juice have higher antioxidant activity than two other parts (seed and juice) separately. Therefore, pomegranate seed-juice has possessed a potential source of natural antioxidant; which can be used as treatment for chronic diseases relative to over-production of free radicals.

Acknowledgement

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References


Table 3: Vitamin composition of pomegranate juice. Value expressed as mean ± S.E.M; each value is a mean of triplicate reading

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Juice</th>
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<tbody>
<tr>
<td>Vitamin C (mg/100 g)</td>
<td>57.8 ± 0.59</td>
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<tr>
<td>Vitamin A (µg/100 g)</td>
<td>22.8 ± 0.69</td>
</tr>
<tr>
<td>Vitamin E (mg/100 g)</td>
<td>0.07 ± 0.01</td>
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