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Original Research Article

Quality Characteristics and Antioxidant Potential of Seeds of Native Korean Persimmon Genotypes

Il-Doo Kim[1], Sanjeev Kumar Dhungana[2], Hye-Ryun Kim[2] and Dong-Hyun Shin[2]*

[1]International Institute of Agricultural Research & Development, Kyungpook National University, Daegu 41566, Korea

[2]School of Applied Biosciences, Kyungpook National University, Daegu 41566, Korea

Abstract - Persimmon seeds contain considerable amounts of minerals, amino and organic acids, natural antioxidants and phenolic compounds. The objective of this study was to investigate quality characteristics and antioxidant potential of Korean persimmon seeds. The pH (4.88-4.94), color values, contents of minerals, free amino acids, organic acids, and phenolic compounds and DPPH free radical scavenging potentials of persimmon seed extracts significantly ($p < 0.05$) varied with the genotypes. This study showed that the seeds could be used as a source of different mineral elements (47.14-85.07 ㎎/㎏) without any measureable amount of heavy metals such as arsenic, cadmium, lead and mercury. Similarly, considerable amounts of organic (1550.13-2413.08 ㎎/㎏) and essential amino (50.85-54.03 ㎎/㎏) acids and total phenolic compounds (1227.91-1307.78 ㎍ gallic acid equivalent/g) were also found in the seed extracts, indicating their potential food value as a natural antioxidant. Results of the present study imply that prethanol-A, a food preservative, can be used as an effective extraction to obtain the minerals, organic and free amino acids, and phenolic compounds from the persimmon seeds, which possess a big potential to be commercially used in food, cosmetic and pharmaceutical industries.

Key words - Antioxidant, Native Korean persimmon, Persimmon seed, Quality characteristic

Introduction

Persimmon (*Diospyros kaki* Thunb.) is an important fruit crop in Korea (Kim *et al.*, 2016; Seo *et al.*, 2013). The fruits are a good source of different biologically active compounds including ascorbic acid and condensed tannins, and are considered beneficial against oxidative stress-related diseases and also contain antimutagenic and anticarcinogenic capacities (Bibi and Khattak, 2007; Suzuki *et al.*, 2005). Synthetic antioxidants such as butylated hydroxyanisole, butylated hydroxyltoluene and propyl gallate are less preferred by consumers because of their potential health hazard in long run. In contrary, demand of natural antioxidants in food products has increased (Yu *et al.*, 2002). Persimmon is mainly cultivated for its delicious pulp. However, its peel contains high amounts of polyphenols and carotenoids compared to those in the pulp (Gorinstein *et al.*, 1994). The peel extracts contain medicinal properties such as anti-tumor and multidrug resistance reversing activities and cosmetic value of whitening effect due to tyrosinase inhibition (Fukai *et al.*, 2009; Kawase *et al.*, 2003).

Plant by-products including those of fruits and vegetables seeds, peels, pips, skins, stems, and cores offer improved value to food and pharmaceutical products through a variety of phytochemicals (Guendez *et al.*, 2005; O'Shea *et al.*, 2012). Reports reveal antioxidant potential of seeds from a wide variety of fruits, such as litchi (Prasad *et al.*, 2009), grape (Jayaprakasha *et al.*, 2008), rambutan, mango, tamarind, and berry (Maisuthisakul *et al.*, 2007). Ahn *et al.* (2002) have reported that persimmon seed extracts showed higher radical scavenging activities and higher total tannin concentration than those of grape seed extracts. Seed and calyx extracts of persimmon showed significantly higher antioxidant activities and phenolic contents than the fruit peel and flesh extracts (Jang *et al.*, 2010). Persimmon seed extract could potentially be used as an inexpensive source of natural antioxidant in food and pharmaceutical industries (Akter *et al.*, 2010). In

*Corresponding author. E-mail : dhshin@knu.ac.kr
Tel. +82-53-950-5707

addition, persimmon seeds could also be used as a novel low-cost adsorbent to remove toluidine blue dye from aqueous solution by batch contact adsorption mode (Bretanha, 2016).

Although there are few reports on antioxidant potentials of persimmon seed extracts made in different solvents, no work has been done on the extracts with prethanol-A, an ethanol used in food preservative. Our previous collaborative research works (Bilal *et al.*, 2016; Kim *et al.*, 2017) have also showed high antioxidant potential and phenolic contents in persimmon seeds. This is the first study to investigate the quality characteristics and antioxidant potential of persimmon seeds of three native Korean cultivars extracted in prethanol-A. Further experiments may be required to declare the persimmon seeds safe to use as food since Ministry of Food and Drug Safety has not allowed the seeds as food source so far.

Materials and Methods

Proximate composition analysis

Proximate compositions were determined following standard methods of AOAC (1995): crude protein (AOAC method 928.08), lipid (AOAC method 991.36), fiber (AOAC method 985.29), ash (AOAC method 920.153), and carbohydrate contents (AOAC method 995.13) in persimmon seed samples.

Chemicals and reagents

Folin-Ciocalteu reagent, gallic acid, 1,1-diphenyl-2-pricryl-hydrazyl (DPPH), and pyrogallol were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Prethanol-A was obtained from Duksna Pure Chemicals (Ansanm Krorea). All the chemicals used in the study were of analytical grade.

Seed materials and preparation of extract

Persimmon seeds of three native Korean cultivars, Sanggam Doongsi, Sangju Doongsi and Taechu Dangam (hereafter referred to as SGD-S, SJD-S and TCD-S, respectively) were obtained from Sangju Persimmon Experiment Station (Sangju, Korea). The persimmon seeds used in the study were stored at persimmon seed room of Sangju Persimmon Experiment station of Sangju-city, Gyeongsangbuk-do, Korea. The seeds were collected from the fruits harvested at ready-to-eat maturity stage. Seeds were thoroughly washed with tap water to remove any adhering pulp and kept for drying in hot air drying oven at 50℃ for 72 h. Dried seeds were ground into a fine powder using a blender (FM-681C, Hanil, Gwangju, Korea) and kept into airtight plastic bags for storage at 4℃ until extraction.

Thirty grams of persimmon seed powder was extracted with 300 ㎖ of 80% prethanol-A (Duksan Pure Chemicals, Ansan, Korea), an ethanol used in food preservative, using a shaking incubator (150 rpm, 25℃) for 24 h and filtered through a filter paper. The residues were also extracted two more times as described above. The filtrates (~ 900 ㎖) were combined together and dried using a rotary evaporator (40℃) and the dried extracts were stored at 4℃ for further analyses.

pH and color measurement

A pH meter (Model 250; Beckman Coulter, Inc., Fullerton, CA, USA) was used to measure the pH value of persimmon seed extracts. L* (lightness), a* (redness, + or greenness, −), and b* (yellowness, + or blueness, −) values were measured using a Chroma meter (CR-300; Minolta Corp., Osaka, Japan). A Minolta calibration plate (YCIE=94.5, XCIE= 0.3160, YCIE=0.330) and a Hunter Lab standard plate (L*= 97.51, a*= −0.18, b*= +1.67) were used to standardize the instrument using a D65 illuminant (Kim *et al.*, 2014). Color values were measured directly from 3 zones of persimmon seed extracts and mean values were calculated.

Determination of mineral content

Dry extract sample (0.5 g) was mixed with 15 ㎖ of HNO_3. The mixture was diluted with equal volume of distilled water. Mineral concentration was determined using inductively coupled plasma atomic emission spectrometer (ICP AES; Varian Inc., Victoria, Australia) following the method described by Skujins (1998). The instrument was calibrated using known standards for each mineral. Average value of two replicate samples was reported.

Organic acid composition

The concentration of organic acids was determined using a

HPLC following the method described earlier (Ashoor and Knix, 1982) with some modifications. One milliliter of ultrapure water (Milli-Q water purification system, Millipore, New South Wales, Australia) for every milligram of organic acid was used to prepare standards of pure organic acids (oxalic, tartaric, malic, lactic, acetic and fumaric acids) as well as standard mixtures (of all organic acids) for calibration curves at various final concentrations. Conditions for the HPLC were: detector (M996, Waters, Milford, MA, USA); refractive index detector (RI410, Waters); mobile phase, 0.005mol/L H_2SO_4 in water; column (PL Hi-Plex H, 300×7.7 ㎜, Agilent Technologies, Seoul, Korea); column temperature, 65℃; flow rate, 0.6 ㎖/min : and injection volume, 10 ㎕.

Free amino acid composition

Amino acid contents were analyzed following the procedure of Je *et al.* (2005) with some modifications. Extract sample (1 g) was hydrolyzed with 6 N HCl (10 ㎖) in a sealed-vacuum ampoule at 110℃ for 24 h for amino acid composition analysis. The HCl was removed from the hydrolyzed sample using a rotary evaporator and made a known volume of 5 ㎖ with 0.2 M sodium citrate buffer (pH 2.2). The sample was passed through a C-18 Sep Pak (Waters Co., Milford, MA, USA) cartridge and filtered through a 0.22-㎛ membrane filter (Millipore, Billerica, MA, USA). Amino acids were determined using an automatic amino acid analyzer (Biochrom-20, Pharacia Biotech Co., Stockholm, Sweden). All of the samples were run in duplicate and expressed in ㎎/㎏ of dry weight.

Determination of total phenolic content

The total phenol contents of persimmon seed extracts were estimated according to the folin-ciocalteau method (Singleton *et al.*, 1999). Two hundred fifty milliliters of folin-ciocalteau reagent was added to 50 ㎕ of a persimmon seed extract. After 1 min, 750 ㎕ of 20% (w/v) aqueous Na_2CO_3 was added, and the volume was made up to 5 ㎖ with distilled water. A control sample contained all the reaction reagents with the exception of the seed extract. The mixture was incubated for 2 h at room temperature under dark condition and absorbance of the reagent mixtures was measured at 750 ㎚ (Multiskan GO, Microplate Spectrophotometer, Thermo-Fisher Scientic, Vantaa, Finland). Gallic acid was used as standard to prepare a calibration curve. The total phenol contents were determined as gallic acid equivalents (㎍/g of extract), and values were reported as average values of triplicate analyses.

DPPH radical-scavenging activity

DPPH radical scavenging activity was measured according to the method described by Cheung *et al.* (2003) with some modifications. Eight hundred microliters of 0.2 mM DPPH ethanol solution was mixed with 0.2 ㎖ of the persimmon seed extracts and left to stand for 30 min at room temperature under dark condition, after which the absorbance value was measured at 517 ㎚ using a microplate spectrophotometer (Multiskan GO, ThermoFisher Scientic, Vantaa, Finland).

Statistical analysis

The data were analyzed using analysis of variance and the differences among means were determined by Tukey Test using SAS 9.4 (SAS Institute, Inc., Cary, NC, USA). The *P*-values less than 0.05 were considered to be significantly different.

Results

Proximate composition

Crude protein, crude lipid, ash, and carbohydrate contents of the persimmon seeds were not significantly different, however crude fiber was significantly low in TCD-S (Table 1). Results of the present study showed that the proximate composition of persimmon seeds may not vary significantly with the cultivar.

pH and color values of persimmon seed extracts

The pH and color values of persimmon seed extracts of different cultivars were significantly different (Table 2). SGD-S (4.94) had significantly higher pH value than the other two cultivars. SGD-S showed low lightness but high yellowness values compared to SJD-S and TCD-S. The redness values of seed extracts of three persimmon cultivars were in order of SJD-S>SGD-S>TCD-S.

Table 1. Proximate composition of seed extracts of three persimmon cultivars

Proximate composition (%)	Cultivar[z]		
	SGD-S	SJD-S	TCD-S
Crude protein	3.98 ± 0.16a[y]	4.00 ± 0.11a	4.39 ± 0.32a
Crude lipid	1.75 ± 0.04a	1.74 ± 0.02a	1.76 ± 0.03a
Crude fiber	5.21 ± 0.11a	5.13 ± 0.09a	5.00 ± 0.04b
Ash content	12.88 ± 0.09a	12.92 ± 0.07a	13.01 ± 0.09a
Carbohydrate	75.33 ± 1.29a	74.92 ± 1.39a	74.88 ± 1.55a

[z]SGD-S: Sanggam Doongsi seed, SJD-S: Sangju Doongsi seed and TCD-S: Taechu Dangam seed.
[y]Quoted values are means ± SD of triplicate measurements. Values followed by different letters in the same row are significantly different ($p < 0.05$).

Table 2. pH and Hunter's color values of seed extracts of three persimmon cultivars

Sample[z]	pH	Color value[y]		
		L*	a*	b*
SGD-S	4.94 ± 0.01a[x]	88.62 ± 0.05b	-0.40 ± 0.02b	9.52 ± 0.04a
SJD-S	4.89 ± 0.02b	91.88 ± 0.05a	-0.48 ± 0.03a	3.56 ± 0.02c
TCD-S	4.88 ± 0.01b	90.00 ± 0.03a	-0.47 ± 0.02c	5.62 ± 0.06b

[z]SGD-S: Sanggam Doongsi seed, SJD-S: Sangju Doongsi seed and TCD-S: Taechu Dangam seed.
[y]L*, lightness (100, white; 0, black); a*, redness (−, green; +, red); b*, yellowness (−, blue; +, yellow).
[x]Quoted values are means ± SD of triplicate measurements. Values followed by different superscripts in the same column are significantly different ($p < 0.05$).

Table 3. Mineral contents (㎎/㎏) of seed extracts of three persimmon cultivars

Element	Sample[z]		
	SGD-S	SJD-S	TCD-S
K	1.69 ± 0.03a[y]	1.46 ± 0.02c	1.55 ± 0.10b
Mg	1.11 ± 0.02a	0.46 ± 0.03c	0.89 ± 0.11b
Ca	69.66 ± 1.13a	33.29 ± 1.80c	43.00 ± 1.21b
Na	8.11 ± 0.03a	7.70 ± 0.20b	6.99 ± 0.13c
Fe	0.60 ± 0.02c	2.20 ± 0.06a	1.70 ± 0.09b
Zn	3.60 ± 0.13a	1.70 ± 0.08c	2.20 ± 0.11b
Mn	0.30 ± 0.01a	0.33 ± 0.02a	0.32 ± 0.03a
As	ND[x]	ND	ND
Cd	ND	ND	ND
Hg	ND	ND	ND
Pb	ND	ND	ND
Total	85.07	47.14	56.65

[z]SGD-S: Sanggam Doongsi seed, SJD-S: Sangju Doongsi seed and TCD-S: Taechu Dangam seed.
[y]Quoted values are means ± SD of triplicate measurements. Values followed by different superscripts in the same row are significantly different ($p < 0.05$).
[x]ND: non-detected.

Determination of mineral content

The amounts of the six out of seven minerals measured in the seed extracts of three persimmon cultivars were significantly different (Table 3). Ca (33.29−69.66 ㎎/㎏) was the most abundant and Mn (0.30−0.33 ㎎/㎏) the least abundant elements found in all the cultivars. Total mineral

content of SGD-S (85.07 ㎎/㎏) was higher than that of SJD-S (47.14) and TCD-S (56.65).

Determination of organic acids

Table 4 shows that organic acid contents of seed extracts of three persimmon cultivars significantly vary. Malic acid (1000.23−1821.33 ㎎/㎏) was found as the most abundant organic acid followed by oxalic acid (396.21−450.33 ㎎/㎏). The amount of malic acid was significantly high whereas that of oxalic acid was significantly low in TCD-S. Amount of citric acid was significantly high in TCD-S (300.66 ㎎/㎏) followed by SJD-S (267.31 ㎎/㎏), however, that of succinic acid was significantly high in SJD-S (30.16 ㎎/㎏). Total amount of organic acids in TCD-S (2737.77 ㎎/㎏) was almost 1.5 folds higher than that of the other two cultivars (1847.60 and 1977.94 ㎎/㎏in SJD-S and SGD-S, respectively).

Determination of free amino acid

A total of 30 free amino acids were identified, out of which 10, seven, and 13 were essential, non-essential, and other free amino acids, respectively (Table 5). The amount of 22 amino acids varied significantly among the three cultivars. The highest amount of total free amino acids was found in TCD-S (582.02 ㎎/㎏) followed by SJD-S (551.89 ㎎/㎏) and the least in SGD-S (522.87 ㎎/㎏).

DPPH radical scavenging activities and total phenol contents

Free radical scavenging potentials of persimmon seed extracts were measured through DPPH. The DPPH and total phenolic content of different extracts were significantly ($p < 0.05$) different (Table 6). TCD-S had significantly low DPPH scavenging potential and total phenol contents among the three cultivars.

Discussion

Significant variations were observed in the physico-chemical characteristics and antioxidant potentials of seed extracts of three native Korean persimmon genotypes. The variations might be due to the genotypic difference (Jin and Song, 2012; Moghaddama *et al.*, 2013; Mratinic *et al.*, 2011). The seeds contained considerable amounts of mineral elements. However, heavy metals like As, Cd, Pb and Hg were not detected in the seed extracts of all the three cultivars. The seed extracts also contained the minerals such as Zn and Fe, which are often lacking in the human diet (Wang *et al.*, 2015). Organic acids and sugars account for maintaining the quality and nutritional value in food materials. Organic acids also possess a protective role against different diseases because of their antioxidant activities (Valentão *et al.*, 2005). The organic acids present in persimmon seeds increase their potential use

Table 4. Organic acid composition (㎎/㎏ of dry weight) of seed extracts of three persimmon cultivars

Organic acid	Sample[z]		
	SGD-S	SJD-S	TCD-S
Oxalic acid	450.33 ± 5.71a[y]	420.11 ± 6.96b	396.21 ± 7.00c
Tartaric acid	61.11 ± 1.98c	70.23 ± 1.60a	65.31 ± 2.00b
Malic acid	1120.34 ± 7.22b	1000.23 ± 6.98c	1821.33 ± 10.33a
Lactic acid	23.12 ± 1.66b	24.44 ± 1.39b	110.11 ± 2.01a
Acetic acid	36.66 ± 0.98a	35.12 ± 0.78a	20.12 ± 0.99b
Fumaric acid	ND[x]	ND	ND
Citric acid	261.21 ± 3.21c	267.31 ± 2.31b	300.66 ± 4.15a
Succinic acid	25.17 ± 1.21b	30.16 ± 0.80a	24.03 ± 0.79b
Total	1977.94	1847.60	2737.77

[z]SGD-S: Sanggam Doongsi seed, SJD-S: Sangju Doongsi seed and TCD-S: Taechu Dangam seed.
[y]Quoted values are means ± SD of triplicate measurements. Values followed by different superscripts in the same row are significantly different ($p < 0.05$).
[x]ND: non-detected.

Table 5. Free amino acid content (㎎/㎏ of dry weight) of seed extracts of three persimmon cultivars

Amino acid	Sample[z]		
	SGD-S	SJD-S	TCD-S
Essential amino acid			
Arginine	9.40 ± 0.89b	9.31 ± 0.98b	13.12 ± 0.66a
Histidine	4.11 ± 0.03a	4.00 ± 0.04b	1.12 ± 0.02c
Isoleucine	9.21 ± 1.02a[y]	9.81 ± 1.03a	8.99 ± 0.92a
Leucine	11.29 ± 1.31a	10.21 ± 0.91a	12.21 ± 0.88a
Lysine	2.17 ± 0.04a	2.00 ± 0.03b	1.02 ± 0.03c
Methionine	5.31 ± 0.06b	5.21 ± 0.05b	6.70 ± 0.07a
Phenylalanine	12.21 ± 0.98a	12.33 ± 2.11a	10.11 ± 0.99b
Threonine	18.35 ± 2.13a	19.28 ± 2.11a	18.21 ± 1.98a
Tryptophan	13.11 ± 0.21a	12.88 ± 0.31a	9.22 ± 0.19b
Valine	12.00 ± 1.21b	14.73 ± 1.30a	14.00 ± 1.41a
Sub-total	97.16	99.76	94.70
Non-essential amino acid			
Alanine	28.75 ± 1.00b	28.39 ± 2.22b	32.33 ± 1.11a
Aspartic acid	3.62 ± 0.39c	5.92 ± 0.21a	4.71 ± 0.70b
Glycine	16.22 ± 1.21a	16.55 ± 1.09a	10.27 ± 1.80b
Glutamic acid	26.96 ± 0.98a	27.33 ± 1.29a	26.00 ± 1.62a
Proline	10.31 ± 1.31b	14.20 ± 1.21a	16.92 ± 1.71a
Serine	26.00 ± 1.63a	28.45 ± 1.92a	26.31 ± 1.82a
Tyrosine	9.11 ± 0.70a	9.21 ± 0.60a	9.14 ± 0.59a
Sub-total	120.97	130.05	125.68
Other free amino acid			
Carnosine	11.21 ± 1.02b	11.30 ± 1.29b	15.21 ± 1.43a
Citruline	89.33 ± 1.02b	91.42 ± 7.70a	100.02 ± 8.78a
Ethanolamine	15.11 ± 1.60a	15.21 ± 2.00a	16.19 ± 1.31a
1-Methylhistidine	3.11 ± 0.04b	1.62 ± 0.05c	5.71 ± 0.03a
Homocystine	150.11 ± 10.22b	162.32 ± 5.88b	181.31 ± 8.98a
Hydroxylysine	2.81 ± 0.03a	2.02 ± 0.03c	2.51 ± 0.02b
Ornithine	4.21 ± 0.05b	4.31 ± 0.07b	4.51 ± 0.01a
Phosphoserine	13.31 ± 0.21b	16.21 ± 1.31a	14.30 ± 2.02ab
Sarcosine	4.60 ± 0.12b	4.55 ± 0.32b	7.37 ± 0.61a
α-Aminobutyric acid	3.23 ± 0.02a	3.00 ± 0.03b	2.92 ± 0.04b
β-Alanine	2.20 ± 0.21b	2.60 ± 0.31ab	2.98 ± 0.05a
β-Aminoisobutyric acid	2.30 ± 0.03b	2.71 ± 0.07a	2.69 ± 0.02a
γ-Aminobutyric acid	3.21 ± 0.21c	4.81 ± 0.35b	5.92 ± 0.55a
Sub-total	304.74	322.08	361.64
Grand total	522.87	551.89	582.02

[z]SGD-S: Sanggam Doongsi seed, SJD-S: Sangju Doongsi seed and TCD-S: Taechu Dangam seed.
[y]Quoted values are means ± SD of triplicate measurements. Values followed by different letters in the same row are significantly different ($p < 0.05$).

Table 6. DPPH radical scavenging activities and total phenol contents of seed extracts of three persimmon cultivars

Sample[z]	DPPH[y] (% Inhibition)	Total phenol content (GAE[x] μg/g)
SGD-S	89.12 ± 0.87a[w]	1307.78 ± 2.11a
SJD-S	88.96 ± 0.31a	1234.03 ± 2.21b
TCD-S	80.21 ± 1.02b	1227.91 ± 1.82c

[z]SGD-S: Sanggam Doongsi seed, SJD-S: Sangju Doongsi seed and TCD-S: Taechu Dangam seed.
[y]DPPH: DPPH free radical scavenging activity.
[x]Gallic acid equivalents.
[w]Quoted values are means ± SD of triplicate measurements. Values followed by different letters in the same column are significantly different ($p < 0.05$).

as a source of natural antioxidants. Short-chain organic acid like acetic acid in persimmon seeds offers a good potential to be used as food preservative (Mari *et al.*, 2016). The health benefits of vinegars in regulating blood glucose level, lipid metabolism and weight loss are attribute mainly to acetic acids present (Chen *et al.*, 2016). The ratio of essential to non-essential amino acids for seed extracts of all the cultivars was more than 0.38. Food materials having high ratios of essential to non-essential amino acids are considered well balanced for protein deposition (Reeds, 2000). One of the most abundant non-essential amino acids in the seed extracts was glutamic acid. γ-Amino-*n*-butyric acid (GABA) is principally synthesized in plants by decarboxylation of glutamic acid (Nikmaram *et al.*, 2017). GABA and glycine are good for learning and memory, relieving anxiety, sedation, anticonvulsant, and muscle relaxation functions (Krogsgaard-Larsen, 1989; Mody *et al.*, 1994; Oh and Oh, 2004). GABA containing foods are also considered as brain foods and possess multiple bioactive functions like blood pressure and cholesterol regulation, improving cerebral blood flow, reducing insomnia, depression and pain (Dhakal *et al.*, 2012). GABA is also reported to have anti-diabetic effect (Nikmaram *et al.*, 2017). The difference in DPPH radical scavenging potentials among cultivars might be due to the variation in the amount and form of phytochemicals including tannin, the main phenolic compound of persimmon (Jang *et al.*, 2011). The elevated levels of reactive oxygen species, which are produced in the organisms as a result of normal physiological functions, can pose a risk to cells by lipids peroxidation, proteins oxidation, nucleic acids destruction, enzyme inhibition, programmed cell death activation pathway, and eventually cells death (Mishra *et al.*, 2011; Srivastava and Dubey, 2011). The phenolic compounds present in the seed extracts possess antioxidant potentials and scavenge the free radicals thereby protect the cells death (Rice-evans *et al.*, 1995; Maksimovic *et al.*, 2005).

In conclusion, this study reveals that pH and color values of persimmon seeds may differ with the genotypes. The seeds could be a good source of different mineral elements without any detectable trace of heavy metals like As, Cd, Pb and Hg. Similarly, considerable amount organic acids present in the seeds increases its food value as a natural antioxidant. The seeds also contained various essential amino acids. In addition, the seed extracts of persimmon were good free radical scavengers and the total phenolic content was also high. This study shows that prethanol-A, a food preservative, may be used as an effective solvent to extract the minerals, organic and free amino acids, and phenolic compounds from the persimmon seeds, which possess a high potential to be utilized in food, cosmetic and pharmaceutical industries.

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