

Quality Characteristics of ‘Dongchul’ Persimmon (*Diospyros kaki* Thunb.) Fruit Grown in Gangwondo, Korea

Il-Doo Kim¹, Sanjeev Kumar Dhungana², Yong-Gon Chae³, Nan-Kyung Son² and Dong-Hyun Shin^{2*}

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

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

³Department of Hotel & Food Service Industry, Restaurant, Culinary Arts of Wine·Coffee, Daegu Health College, Daegu 41453, Korea

Abstract - Persimmon has long been established as one of the major fruits in Korea. The southern parts of Korea were traditionally the pocket areas for good persimmon production; however, rising temperatures have gradually rendered the southern regions unsuitable for successful harvest. Ecology of fruit growing areas affects the productivity of various types of crops, including fruit trees such as persimmon. The quality characteristics of the fruit of persimmon cv. Dongchul grown in Gangwondo, which lies in the northern part of South Korea, were investigated. Different physicochemical, nutritional, and antioxidant properties of fruit were evaluated to assess the locational effect on the quality of persimmon fruits grown in Gangwondo. The results of this study showed that persimmon cv. Dongchul grown in Gangwondo maintains many of the physicochemical (4.33% crude protein and 4.32% crude fiber), nutritional (total mineral content: 461.51 and vitamin C content: 15.28 mg/100 g), and antioxidant properties (polyphenol content: 633.1 mg gallic acid equivalent/100 g) those are found in other three commercial cultivars ‘Daebong’, ‘Kyengsan Bansi’, and ‘Sangju Doongsi’ grown in Korea. Overall results of this study imply that ‘Dongchul’ cultivar of persimmon could commercially be grown in Kangwondo, Korea.

Key words - Antioxidant, Nutritional property, Persimmon fruit quality, Physicochemical property

Introduction

Persimmon (*Diospyros kaki* Thunb) is one of the most important fruits and has been cultivated from ancient times in Korea (Seo *et al.*, 2013). Consumption of persimmon fruit is considered beneficial to various physiological functions, including protection against oxidative stress-related diseases; it has antimutagenic and anticarcinogenic properties as it is a valuable source of various biologically active compounds (Suzuki *et al.*, 2005). It is rich in antioxidants such as catechins, which are known to have anti-infective, anti-inflammatory, and antihemorrhagic properties, and gallic catechins (Kim *et al.*, 2006). Persimmon fruits are an abundant source of minerals, amino acids, flavonoids, sugars, carotenoids, tannins, terpenoids, vitamins A and C, and others. The anticarcinogenic properties of persimmon are attributed to the high contents of β

-carotene and vitamin A in the fruits (Funayama and Hikino, 1979).

Persimmon has long been established as one of the major fruits in Korea (Kang and Ko, 1997). The area under fruit cultivation has almost doubled in the past 20 years and persimmon has become the most widely grown fruit crop in Korea (Song *et al.*, 2005). The southern parts of Korea were traditionally the pocket areas for good persimmon production; however, rising temperatures have gradually rendered the southern regions unsuitable for production of fruits such as pears, peaches, grapes, and sweet persimmons, the cultivation of which has continuously shifted northwards (Kim *et al.*, 2010). Change in climatic conditions of fruit growing area affects not only the growth of fruit trees but also fruit quality, harvest time, and fruit storage. Climate change in Korea has been proceeding at a rate that is faster than the global average rate (Kim *et al.*, 2010).

Kim *et al.* (1988) established marginal regions for safety

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

cultivation of non-astringent persimmons and, at that time, found that southern parts of Korea, including Cheongnam, Gyeongnam, and Gyeongbuk, were the most suitable areas for non-astringent persimmon production. Since then, the climate conditions have changed, and today persimmon is grown successfully in the northern parts. 'Dongchul' is one of the widely grown persimmon cultivars in commercial plantations in Korea. Currently, little is known about the quality characteristics of persimmon cv. 'Dongchul' cultivated in Gangwondo, which lies in the northern part of South Korea. Therefore, the objective of this study was to investigate the quality characteristics of the persimmon fruit cv. Dongchul, grown in Gangwondo. Production potential of 'Daebong', one of the commercial cultivars of persimmon in Gangwondo, was taken as reference for evaluating that of 'Dongchul'. Both the cultivars are of astringent type.

Materials and Methods

Plant material and cultivation area

In the present study, persimmon (*Diospyris kaki* Thunb.) cv. Dongchul, grown at Yangyang-gun, Gangwondo, South Korea, was studied for investigating the quality characteristics. Yangyang-gun (38°4'0"N, 128°37'0"E; average sea level 100 m) lies in northern part of South Korea. The average weight of 'Dongchul' persimmon fruits in Gangwondo was 185.19 g and the yield was 148-185 kg per tree which is quite acceptable for commercial production. The physicochemical properties of the fruit of 'Dongchul' were compared with three other commercial cultivars, 'Daebong', 'Kyongsan Bansi', and 'Sangju Doongsi' grown at Yangyang-gun, Gangwon-do in Korea. The fruits were harvested at commercial maturity stage in November of 2013, and were transported to the laboratory within 6 h of harvest. The fruits were washed with tap water to remove all the foreign matters of the surface, and were allowed to surface dry at room temperature. On the same day of harvest the fruits were peeled off using knife and kept for freeze drying without pre-treatment with any chemicals. The freeze dried fruit samples were considered for further analysis.

Chemicals and reagents

Folin-Ciocalteu reagent, gallic acid, 1,1-diphenyl-2-picryl-

hydrazyl (DPPH), and pyrogallol were purchased from Sigma Chemical Co. (St. Louis, MO, USA). All the reagents used in the study were of analytical grade.

Proximate composition analysis

Proximate compositions were determined following standard methods of AOAC (1995): moisture content (AOAC method 950.46), 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 fruit samples.

Quantification of vitamins C and E

Vitamin C content was determined according to standard methods of AOAC (1990 method 984.26).

Vitamin E was analyzed following the modified method of Aaran and Nikkari (1988). Fruit samples (2 g) were minced and mixed with 3 ml of absolute ethanol, 3.1 ml of 10% pyrogallol solution (w/v, in ethanol), and 0.1 ml of 90% KOH (w/v). For saponification, the mixture was incubated at 65°C for 30 min. After cooling, the sample was mixed with 4 ml of distilled water and 3 ml of hexane. After centrifugation (1400 × g, 3 min), the hexane layer was repeatedly washed with distilled water until the color of the water was not changed by phenolphthalein reagent. The remaining water in the hexane solution was removed using Anhydrous Na₂SO₄. The hexane solution was evaporated at 75°C and absolute ethanol (2.5 ml) was used to dissolve vitamin E. The sample solution (0.5 ml) was mixed with 0.1 ml of 2% FeCl₃ solution (w/v, in ethanol) and 0.1 ml of 0.5% 2,2-dipyridyl solution (w/v, in ethanol), and 1.8 ml of absolute ethanol. The absorbance of the final solution was measured at 520 nm. α-Tocopherol (20 mg/ml) in 100 ml of absolute ethanol was used for the standard.

Quantification of organic acids

Organic acid concentrations were measured using HPLC (Ashoor and Knox, 1982). One milliliter of ultrapure water (Milli-Q water purification system, Millipore Australia Pty Ltd., New South Wales, Australia) for every milligram of organic acid was used to prepare standards of pure organic acids (malic, citric, fumaric, succinic, and oxalic acids) as well as standard mixtures (of all acids) for calibration curves

at various final concentrations. Samples were prepared by extracting freeze-dried samples (5 g) in distilled water (25 ml). The samples were flushed with nitrogen and centrifuged at $1660 \times g$ for 15 min. One milliliter of sample was added to 9 ml of distilled water and left overnight at room temperature. The samples were filtered through a $0.22 \mu\text{m}$ syringe filter (Millipore, Billerica, MA, USA). Conditions for the HPLC were as follows: detector, M996 (Waters, Milford, MA, US); refractive index detector (RI, model 410; Waters); mobile phase, 0.005 M H_2SO_4 in water; column, PL Hi-Plex H (Agilent Technologies Inc., Santa Clara, CA, USA), $300 \times 7.7 \text{ mm}$; column temperature, $65 \text{ }^\circ\text{C}$; flow rate, 0.6 ml/min; injection volume, 10 μl .

Quantification of free sugars

Free sugar content was analyzed following the method of Genard and Souty (1996). Each sample (5 g) was added to 10 ml of distilled water and homogenized using a homogenizer (Ultra-Turrax T-25, IKA-Labortechnik, Staufen, Germany). The volume of the sample was adjusted to 20 ml by adding distilled water and then centrifuged at $16000 \times g$ for 30 min. The collected supernatant was filtered through a cartridge (Sep-Pak C18, WAT023501, Waters) and a $0.45 \mu\text{m}$ syringe filter (PVDF, Whatman, Tokyo, Japan). Free sugars were quantified by HPLC (Model 9300, Younglin Co., Anyang, Korea) consisting of a refractive index detector (Triathlon M730D, Younglin Co.), a column heater set at 85°C , and Sugar-Pak ($6.5 \times 300 \text{ mm}$, Alltech, Staten Island, NY, USA); the mobile phase was deionized-distilled H_2O delivered at 0.5 ml/min. The glucose, fructose, sucrose, and sorbitol obtained from Aldrich Chemical Co. Inc. (Milwaukee, WI, USA), were used as reference sugars for identification; mannitol was used as an internal standard. Free sugar content was expressed as mg/100 g sample.

Determination of mineral composition

A fraction of the sample (0.5 g) was placed in a cup and treated with 15 ml of nitric acid. The solution was diluted with distilled water (2 ml). Mineral concentrations were determined using an inductively coupled plasma atomic emission spectrometer (ICP AES, Varian Vista Inc., Victoria, Australia) (Skujins, 1998).

Determination of amino acid profile

The amino acids profile was analyzed following the procedure of Je *et al.* (2005) with some modifications. One gram of freeze-dried sample was hydrolyzed with 6N HCl (10 ml) in a sealed-vacuum ampoule at 110°C for 24 h. The HCl was removed from the hydrolyzed sample on a rotary evaporator and the volume was adjusted to 5 ml with 0.2 M sodium citrate buffer (pH 2.2). The sample was passed through a cartridge (C-18 Sep-Pak, Waters) and filtered through a $0.22 \mu\text{m}$ membrane filter (Millipore, Billerica). Amino acids were determined in an automatic amino acid analyzer (Biochrom-20, Pharmacia Biotech, Uppsala, Sweden).

Color value measurement

Values for L^* (lightness: 100 score for white and 0 for black), a^* (redness, + or greenness, -), and b^* (yellowness, + or blueness, -) in dried samples were measured using a Chromameter (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 ($L^* = 82.13$, $a^* = -5.24$, $b^* = -0.55$) were used to standardize the instrument with D65 illuminant (Kim *et al.*, 2013). Color was measured randomly on 3 areas of samples and the average was calculated.

DPPH radical scavenging activity

Scavenging activity of the sample extract was measured with DPPH radicals according to the method of Blois (1958) with some modifications. A DPPH solution was prepared in ethanol at a concentration of $4 \times 10^4 \text{ M}$. A 0.1 ml aliquot of extract was mixed with 2.9 ml of DPPH solution and the mixture was incubated in the dark at room temperature for 30 min. After incubation, absorbance was recorded at 516 nm using a spectrophotometer (Opron 3000, Hanson Technologies Co. Ltd., Seoul, Korea). The inhibitory percentage of DPPH radical in samples was calculated according to Shyu and Hwang (2002) as follows:

$$\text{Scavenging effect (\% inhibition)} = [(A_0 - (A - A_b))/A_0] \times 100$$

where, A_0 is the absorbance of DPPH without sample (control), A is the absorbance of the sample and DPPH, and A_b is the

absorbance of the sample without DPPH (blank).

Determination of total phenolics

Total phenolics (TP) were determined using the Folin-Ciocalteu method (Zheng and Wang, 2001). The absorbance was measured at 725 nm using a spectrophotometer (HP 8452A diode-array, Hewlett-Packard Co., Palo Alto, CA, USA). Gallic acid was used to prepare a calibration curve. The total phenol contents were expressed as gallic acid equivalents (mg GAE/100 g of sample), and values are reported as mean values of triplicate analyses.

Tannin content

Tannin content was examined with a modified Prussian Blue assay method (Graham, 1992; Price *et al.*, 1988). A 0.1 ml of sample extract was added to 3 ml of distilled water, centrifuged at $10000 \times g$ for 15 min, and the supernatant was collected. Phenolics were determined in the supernatant by adding 1 ml of 0.016 M $K_3Fe(CN)_6$ followed immediately by addition of 1 ml of 0.02 M $FeCl_3$ and vortexing (KMC-1300V, Vision Scientific Co. Ltd., Bucheon, Korea) the mixtures. After 15 min, absorbance was measured at 700 nm using a spectrophotometer (HP 8452A diode-array, Hewlett-Packard Co.). The phenolics content was expressed as tannins content (Park, 1999).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using Molecular Evolutionary Genetics Analysis (MEGA) software 4.0 (Analytical Software, Tucson, AZ, USA). Differences

between means at $p \leq 0.05$ were analyzed using the Tukey test. Average values of duplicate measurements of two samples were considered for statistical analysis unless otherwise mentioned. Each sample was composed of 10 fruits of each cultivar.

Results

Proximate composition

The proximate composition of 'Dongchul' persimmon was comparable with that of other three cultivars, 'Daebong', 'Kyengsan Bansi', and 'Sangju Doongsi' (Table 1). The moisture and carbohydrate contents in 'Dongchul' persimmon were not significantly different from those of other three cultivars. The crude lipid (1.8%) of 'Dongchul' was significantly higher than those of other cultivars; however, crude fiber (4.32%) and ash (12.09%) contents were significantly lower in 'Dongchul' persimmon. Crude protein content in 'Daebong' (3.99%) was significantly low as compared to other three cultivars.

Vitamin and tannin content

The persimmon fruit of 'Dongchul' contained significantly high amount of vitamin E (2.79 mg/100 g) as compare to 'Kyengsan Bansi' (1.79 mg/100 g), 'Sangju Doongsi' (1.55 mg/100 g), and 'Daebong' (0.12 mg/100 g). However, vitamin C content was not significantly different among 'Dongchul' (15.28 mg/100 g) and 'Daebong' (13.99 mg/100 g), 'Kyengsan Bansi' (14.12 mg/100 g), and 'Sangju Doongsi' (13.58 mg/100 g). The tannin comprised 0.824%, 0.906%, 1.107%, and 1.201% of fruit in 'Sangju Doongsi', 'Dongchul', 'Kyengsan Bansi', and 'Daebong' on a dry weight basis, respectively.

Table 1. Proximate composition of fruits of four persimmon cultivars grown at Yangyang-gun, Gangwon-do in Korea

Proximate composition (%)	Cultivar			
	Dongchul	Daebong	Kyengsan Bansi	Sangju Doongsi
Moisture content	2.12 ± 0.21a ^z	2.00 ± 0.31a	2.01 ± 0.32a	2.11 ± 0.11a
Crude protein	4.33 ± 0.13a	3.99 ± 0.17b	4.30 ± 0.15a	4.35 ± 0.15a
Crude lipid	1.80 ± 0.02a	1.70 ± 0.03b	1.75 ± 0.04b	1.74 ± 0.03b
Crude fiber	4.32 ± 0.24b	5.12 ± 0.16a	5.11 ± 0.10a	5.13 ± 0.18a
Ash content	12.09 ± 0.04b	13.00 ± 0.07a	13.11 ± 0.05a	13.09 ± 0.09a
Carbohydrate	75.34 ± 1.31a	74.19 ± 1.03a	74.99 ± 1.00a	74.88 ± 1.21a

^zQuoted values are the means ± SD of duplicate experiments. Different letters in the same row followed by average values are significantly different at $p \leq 0.05$.

Table 2. Mineral content of fruits of four persimmon cultivars grown at Yangyang-gun, Gangwon-do in Korea

Element (mg/100 g)	Cultivar			
	Dongchul	Daebong	Kyengsan Bansi	Sangju Doongsi
As	ND ^z	ND	ND	ND
Ca	18.67 ^y	17.66	18.1	17.93
Cd	ND	ND	ND	ND
Cu	0.09	0.08	0.08	0.08
Fe	2.4	2.92	2.53	2.61
Hg	ND	ND	ND	ND
K	413.23	400.21	401.32	407.72
Mg	21.24	20.12	20.02	20.93
Mn	0.72	0.66	0.71	0.69
Na	4.34	3.98	4.02	4.12
Pb	ND	ND	ND	ND
Zn	0.82	0.81	0.8	0.82
Total	461.51	446.44	447.58	454.90

^zND: Not detected.

^yQuoted values are the means of duplicate experiments.

Mineral content

Potassium was the most abundant element found in all four cultivars ‘Dongchul’, ‘Sangju Doongsi’, ‘Kyengsan Bansi’, and ‘Daebong’ (413.23, 407.72, 401.32, and 400.21 mg/100 g, respectively), whereas the amount of Cu was the lowest (0.09, 0.08, 0.08, and 0.08 mg/100 g, respectively). Total mineral content of ‘Dongchul’ (461.51 mg) was higher than those of other three commercial cultivars (Table 2). Elements As, Pb, Cd, and Hg were not detected in dried fruit sample of either cultivar.

Free amino acids content

The amounts of amino acids play a vital role in determining the nutritional qualities of fruits, vegetables, and food products (Basarova and Janousek, 2000). Twenty-two free amino acids were evaluated in four persimmon cultivars (Table 3). Among these 22 free amino acids, citrulline content was the highest (172.95, 161.12, 170.21, and 171.33 mg) followed by homocysteine (41.81, 40.18, 39.12, and 40.11 mg), phosphoserine (35.06, 34.12, 34.11, and 35.00 mg), glutamic acid (32.58, 30.12, 31.00, and 31.98 mg), serine (15.77, 17.22, 16.66, and 16.99 mg), aspartic acid (14.08, 13.01, 13.69, and 14.00 mg), carnosine (13.24, 12.98, 12.99, and 13.20 mg), and valine

(12.24, 12.00, 12.01, and 12.21 mg/100 g) in ‘Dongchul’, ‘Daebong’, ‘Kyengsan Bansi’, ‘Sangju Doongsi’, respectively). Seventeen amino acids (1-Methylhistidine, 3-Methylhistidine, Alanine, Ammonium chloride, Anserine, Asparagine, Cystathionine, Cystine, Histidine, Hydroxyproline, Lysine, Methionine, Phenylalanine, Taurine, Urea, α -Aminoadipic acid, α -Aminobutyric acid, and β -Aminoisobutyric acid) were not detected in either cultivar. Total free amino acid content was higher in ‘Dongchul’ (410.39 mg/100 g) than in other three cultivars (Table 3).

Organic acid and free sugar content

The predominant organic acid was malic acid which was significantly high in ‘Daebong’ (813.0 mg/100 g) and ‘Kyengsan Bansi’ (800.2 mg/100 g) than in ‘Dongchul’, (704.0 mg/100 g) and ‘Sangju Doongsi’ (703.1 mg/100 g). However, the other three organic acids citric, fumaric, and succinic were not significantly different among four cultivars (Table 4).

Amount of three free sugars fructose, glucose, and sucrose were higher in ‘Daebong’ (6.12, 11.92, and 0.18 g/100 g) than in ‘Dongchul’ (5.14, 10.67, and 0.12 g/100 g), ‘Kyengsan Bansi’ (6.00, 10.69, and 0.15 mg/100 g), and ‘Sangju Doongsi’ (6.08, 10.12, and 0.17 mg/100 g); however significant

Table 3. Free amino acid content of fruits of four persimmon cultivars grown at Yangyang-gun, Gangwon-do in Korea

Amino acid (mg/100 g)	Cultivar			
	Dongchul	Daebong	Kyengsan Bansi	Sangju Doongsi
Arginine	9.19 ^z	9.00	8.99	8.85
Aspartic acid	14.08	13.01	13.69	14.00
Carnosine	13.24	12.98	12.99	13.20
Citrulline	172.95	161.12	170.21	171.33
Ethanolamine	11.45	10.40	9.99	10.88
Glutamic acid	32.58	30.12	31.00	31.98
Glycine	1.68	1.00	1.59	1.60
Homocysteine	41.80	40.18	39.12	40.11
Hydroxylysine	0.41	0.21	0.31	0.38
Isoleucine	7.20	6.12	7.12	7.00
Leucine	5.40	6.00	5.99	6.01
Ornithine	2.20	2.00	2.20	2.31
Phosphoethanolamine	4.51	4.91	4.88	4.90
Phosphoserine	35.06	34.12	34.11	35.00
Proline	6.88	6.00	6.05	6.98
Sarcosine	5.61	5.91	5.71	5.81
Serine	15.77	17.22	16.66	16.99
Threonine	8.63	7.12	8.01	8.12
Tyrosine	4.74	4.61	4.71	4.69
Valine	12.24	12.00	12.01	12.21
β-Alanine	0.87	0.88	0.89	0.92
γ-Aminobutyric acid	3.90	3.11	3.21	3.51
Total	410.39	388.02	399.44	406.78

^zQuoted values are the means of duplicate experiments.

Table 4. Organic acid content of fruits of four persimmon cultivars grown at Yangyang-gun, Gangwon-do in Korea

Organic acid (mg/100 g)	Cultivar			
	Dongchul	Daebong	Kyengsan Bansi	Sangju Doongsi
Citric acid	237.2 ± 10.21a ^z	230.2 ± 9.88a	235.2 ± 7.71a	239.3 ± 6.70a
Fumaric acid	100.7 ± 12.12a	90.2 ± 8.99a	95.3 ± 10.00a	97.2 ± 9.88a
Malic acid	704.0 ± 18.31b	813.0 ± 16.21a	800.2 ± 13.01a	703.1 ± 10.21a
Succinic acid	319.4 ± 20.12a	300.1 ± 19.88a	310.2 ± 15.33a	315.9 ± 15.66a
Total	1124.1	1433.5	1440.9	1355.5

^zQuoted values are the means ± SD of duplicate experiments. Different letters in the same row followed by average values are significantly different at $p \leq 0.05$.

difference was found only for sucrose.

Color value and antioxidant properties

The color (lightness, redness, and yellowness) value of the

fruit was measured using a Hunter Lab Miniscan colorimeter (Hunter Associates Laboratory, Inc., Reston, VA, USA).

There was no significant difference in color values of 'Dongchul' and other three cultivars.

DPPH radical scavenging properties and total polyphenol content reflect antioxidant properties. DPPH radical scavenging capacity of ‘Dongchul’, ‘Daebong’, ‘Kyengsan Bansi’, and ‘Sangju Doongsi’ fruit were 75.97, 70.12, 71.77, and 72.00%, respectively. The total polyphenol content of ‘Dongchul’ (633.1 mg) was higher than that of other three cultivars (‘Daebong’, ‘Kyengsan Bansi’, and ‘Sangju Doongsi’) (531.1, 582.1, and 596.8 mg GAE/100 g, respectively).

Discussion

The values for protein and ash contents in ‘Dongchul’ persimmon are higher than those previously reported by Celik and Ercisli (2008). The difference in composition of persimmon fruit must be due to the cultivar variation (Moghaddama *et al.*, 2013; Mratinic *et al.*, 2011; Jin and Song, 2012). Vitamin C content in the cultivar Hachiya grown in Turkey was 12 mg 100/g of fruit (Celik and Ercisli, 2008). The amount of vitamin C found in the present study is in agreement with the study of Mowat and George (1994), whereas the tannin content is significantly higher in ‘Dongchul’ than in ‘Sangju Doongsi’ but lower than those of ‘Daebong’ and ‘Kyengsan Bansi’. The difference in tannin content may be due to differences in cultivar since pomological properties of fruit are strongly affected by the genotypes (Moghaddama *et al.*, 2013; Mratinic *et al.*, 2011). The vitamin C and tannins in the fruit are major factors determining persimmon fruit nutritional value and quality. Celik and Ercisli (2008) also found higher concentration of potassium in the persimmon fruit compared with other elements. In a study of Lee *et al.* (2012), the amounts of aspartic and glutamic acids were the highest among seventeen detected amino acids. The contents of these two amino acids were not much different to those found in the present study, and slight variation in their content might be due to the genotype. Lee *et al.* (2012) and Verberic *et al.* (2010) reported similar values, except for succinic acid, which they did not detect in the fruit juice of 11 persimmon cultivars. Earlier studies have shown that organic acids and sugars are associated with the aroma and sensation of sweetness in various fruits (Colaric *et al.*, 2005) and are responsible for retaining the quality and nutritional value in food products (Ashoor and Knox, 1982). Specifically,

organic acids have a protective role against various diseases because of their antioxidant activities (Valentão *et al.*, 2005). Results of this study for free sugar content are similar to those reported in previous studies (Lee *et al.*, 2012; Veberic *et al.*, 2010). Changes in fruit color are closely related to an increase in sugars and a decrease in firmness. Color value is considered an important maturity index (Testoni, 2002) and consumers’ preference (Bolek and Obuz, 2014) for persimmon fruits. DPPH radical scavenging assay is widely used for evaluating the antioxidant capacity of plant extracts. It is superior to other similar essays, because it is unaffected by certain side reactions, including metal ion chelation and enzyme inhibition that do happen in other essays with free radicals such as the hydroxyl radical and superoxide anion (Yildirim *et al.*, 2000). The DPPH radical scavenging potential of ‘Dongchul’ found in this study was higher than that of the cultivar Triumph (Park *et al.*, 2006). The polyphenol content of persimmon fruit determined in this study is in the range of other persimmon cultivars (Jang *et al.*, 2010; 2011). Phenolic compounds are considered to provide antioxidant properties to food products, crops, vegetables and natural plants (Abeyasinghe *et al.*, 2007; Maksimovic *et al.*, 2005; Rice-Evans *et al.*, 1995). Therefore, higher total polyphenol content in ‘Dongchul’ than in other three commercial cultivars signifies the potentiality of its commercial cultivation in Gangwondo as antioxidant rich cultivar.

The fruit of ‘Dongchul’ grown in Gangwondo, which lies in the northern part of South Korea and is a new area for its commercial production, contained many of the physicochemical, nutritional, and antioxidant properties those are found in other three commercial cultivars commercially grown in Korea. The nutrient contents of ‘Dongchul’ persimmon fruit were not found deteriorated irrespective of its cultivation in new agro-climatic zone, although the climate change has affected the persimmon growing areas in Korea. Overall results of the present study indicate that ‘Dongchul’ persimmon could commercially be grown in Gangwondo, Korea.

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References

- Aaran, R.K. and T. Nikkari. 1988. HPLC method for the simultaneous determination of beta-carotene, retinol and alpha-tocopherol in serum. *J. Pharma. Biomed. Anal.* 6:853-857.
- Abeyasinghe, D.C., X. Li, C.D. Sun, W.S. Zhang, C. H. Zhou and K.S. Chen. 2007. Bioactive compounds and antioxidant capacities in different edible tissues of citrus fruit of four species. *Food Chem.* 104:1338-1344.
- AOAC. 1990. Official Methods of Analysis of AOAC International. 15th ed. Method 984.26, Arlington, Virginia, USA: Association of Official Analytical Chemists.
- AOAC. 1995. Official Methods of Analysis of AOAC International. 16th ed. Methods 950.46, 928.08, 991.36, 985.29, 920.153, 995.13, Arlington Virginia, USA: Association of Official Analytical Chemists.
- Ashoor, S.H. and J.M. Knox. 1982. Determination of organic acids in foods by high-performance liquid chromatography. *J. Chromatogr.* 229:288-292.
- Basarova, G. and J. Janousek. 2000. Importance of amino acids in beer technology and quality. *Kvasny Prumysl* 46:314-318.
- Blios, M.S. 1958. Antioxidant determinations by the use of a stable free radical. *Nat.* 181:1199-1202.
- Bolek, S. and E. Obuz. 2014. Quality characteristics of Trabzon persimmon dried at several temperatures and pretreated by different methods. *Tur. J. Agric. For.* 38:242-249.
- Celik, A. and S. Ercisli. 2008. Persimmon cv. Hachiya (*Diospyros kaki* Thunb.) fruit: some physical, chemical and nutritional properties. *Int. J. Food Sci. Nutr.* 59:599-606.
- Colaric, M., R. Veberic, F. Stampar and M. Hudina. 2005. Evaluation of peach and nectarine fruit quality and correlations between sensory and chemical attributes. *J. Sci. Food Agric.* 85:2611-2616.
- Funayama, S. and H. Hikino. 1979. Hypotensive principles of *Diospyros kaki* leaves. *Chem. Pharm. Bull.* 27:2865-2868.
- Genard, M. and M. Souty. 1996. Modeling the peach sugar contents in relation to fruit growth. *J. Am. Soc. Hort. Sci.* 121:1122-1131.
- Graham, H.N. 1992. Green tea composition, consumption and polyphenol chemistry. *Prev. Medic.* 21:334-350.
- Jang, I.C., E.K. Jo, M.S. Bae, H.J. Lee, K.I. Jeon, E. Park, H.G. Yuk, G.H. Ahn and S.C. Lee. 2010. Antioxidant and antigenotoxic activities of different parts of persimmon (*Diospyros kaki* cv. Fuyu) fruit. *J. Med. Plants Res.* 4:155-160.
- Jang, I.C., W.G. Oh, G.H. Ahn, J.H. Lee and S.C. Lee. 2011. Antioxidant activity of 4 cultivars of persimmon fruit. *Food Sci. Biotechnol.* 20:71-77.
- Je, J.Y., P.J. Park, W.K. Jung and S.K. Kim. 2005. Amino acid changes in fermented oyster (*Crassostrea gigas*) sauce with fermentation periods. *Food Chem.* 91:15-18.
- Jin, Y.O. and W.S. Song. 2012. Antioxidant activity of *Pyrus serotina* fruit in different cultivars and parts. *Korean J. Plant Res.* 25(4):498-503 (in Korean).
- Kang, S.M. and K.C. Ko. 1997. The persimmon industry and research activities in Republic of Korea. *Acta Horticulturae* 436:33-41.
- Kim, C.G., S.M. Lee, H.K. Jeong, J.K. Jang, Y.H. Kim and C.K. Lee. 2010. Impacts of climate change on Korean agriculture and its counterstrategies. Hoigi-dong, Seoul, Korea: Korea Rural Economic Institute.
- Kim, I.D., J.W. Lee, S.J. Kim, J.W. Cho, S.K. Dhungana, Y.S. Lim and D.H. Shin. 2013. Exogenous application of natural extracts of persimmon can help in maintaining nutritional and mineral composition of dried persimmon. *Afr. J. Biotechnol.* 13:2231-2239.
- Kim, S.Y., S.M. Jeong, S.J. Kim, K.I. Jeon, E. Park, H.R. Park and S.C. Lee. 2006. Effect of heat treatment on the antioxidative and antigenotoxic activity of extracts from persimmon (*Diospyros kaki* L.) peel. *Biosci. Biotechnol. Biochem.* 70:999-1002.
- Kim, Y.S., S.B. Joung, D.S. Son, K.K. Lee, J.S. Park and U.J. Lee. 1988. Studies on the establishment of the safety-cultivation region of non-astringent persimmon. Research Report. Suwon, Korea: Rural Development Administration (Hortic). pp. 56-76.
- Lee, J.H., Y.B. Lee, W.D. Seo, S.T. Kang, J.W. Lim and K.M. Cho. 2012. Comparative studies of antioxidant activities and nutritional constituents of persimmon juice (*Diospyros kaki* L. cv. Gapjubaekmok). *Prev. Nutr. Food Sci.* 17:141-151.
- Maksimovic, Z., D. Malenic and N. Kovacevic. 2005. Polyphenol contents and antioxidant activity of *Maydis stigma* extracts. *Bioresource Technol.* 96:873-877.
- Moghaddama, E.G., H.A. Moghaddamb and S. Piric. 2013. Genetic variation of selected Siah Mashhad sweet cherry genotypes grown under Mashhad environmental conditions in Iran. *Crop Breeding J.* 3:45-51.

- Mowat, A.D. and A.P. George. 1994. Persimmon: *In* Schaffer, B. and P.C. Andersen (eds.), Handbook of Environmental Physiology of Fruit Crops. CRC Press, Boca Raton, FL, (USA). pp. 209-232.
- Mratinic, E., B. Popovski, T. Milošević and M. Popovska. 2011. Analysis of morphological and pomological characteristics of apricot germplasm in FYR Macedonia. *J. Agr. Sci. Tech.* 13:1121-1134.
- Park, Y.S. 1999. Carbon dioxide-induced flesh browning development as related to phenolic metabolism in 'Niitaka' pear during storage. *J. Kor. Soc. Hort. Sci.* 40:567-570.
- Park, Y.S., S.T. Jung, S.G. Kang, E. Delgado-Licon, A.L.M. Ayala, M.S. Tapia, O. Martinez-Belloso, S. Trakhtenberg and S. Gorinstein. 2006. Drying of persimmons (*Diospyros kaki* L.) and the following changes in the studied bioactive compounds and the total radical scavenging activities. *LWT-Food Sci. Technol.* 39:748-755.
- Price, K.R., M.J.C. Rhodes and K.A. Barnes. 1988. Flavonol glycoside content and composition of tea infusions made from commercially available teas and tea products. *J. Agric. Food Chem.* 46:2547-2522.
- Rice-Evans, C.A., N.J. Miller, G.P. Bolwell, P.M. Bramley and J.B. Pridham. 1995. The relative antioxidant activities of plant-derived polyphenolic flavonoids. *Free Radic. Res.* 22:375-383.
- Seo, D.H., K.M. Jung, S.J. Kim and K.M. Kim. 2013. Development of EST-SSR markers and analysis of genetic diversity using persimmon (*Diospyros kaki* Thunb) cultivars collecting from domestic. *Korean J. Plant Res.* 26(4):491-502 (in Korean).
- Shyu, Y.S. and L.S. Hwang. 2002. Antioxidant activity of the crude extract of crude extract of lignan glycosides from unroasted Burma black sesame meal. *Food Res. Int.* 35:357-365.
- Skujins, S. 1998. Handbook for ICP-AES (Varian-Vista). A short guide to Vista series. Version 1.0, VarianInt, AG. Zug., Switzerland: ICP-AES operation.
- Song, W.D., T.C. Kim, Y.D. Choo and S.M. Kang. 2005. Science and industry of persimmon in the Republic of Korea: *In* Park, Y.M. and S.M. Kang (eds.), Proceedings of 3rd International Symposium on Persimmon, 5-7 October 2004; Jinju, Korea: International Society for Horticultural Science.
- Suzuki, T., S.H.F. Someya and M. Tanokura. 2005. Comparative study of catechin compositions in five Japanese persimmons (*Diospyros kaki*). *Food Chem.* 93:149-152.
- Testoni, A. 2002. Post-harvest and processing of persimmon fruit: *In* Bellini, E. and E. Giordani (eds.), First Mediterranean Symposium on Persimmon (Options Méditerranéennes: Série A. Séminaires Méditerranéens Vol. 51). Zaragoza, CIHEAM-IAMZ, Spain. pp. 53-66.
- Valentão, P., P.B. Andrade, J. Rangel, B. Ribeiro, B.M. Silva, P. Baptista and R.M. Seabra. 2005. Effect of the conservation procedure on the contents of phenolic compounds and organic acids in chanterella (*Cantharellus cibarius*) mushroom. *J. Agric. Food Chem.* 53:4925-4931.
- Veberic, R., J. Jurhar, M. Mikulic-Petkovsek, F. Stampar and V. Schmitzer. 2010. Comparative study of primary and secondary metabolites in 11 cultivars of persimmon fruit (*Diospyros kaki* L.). *Food Chem.* 119:477-483.
- Yildirim, A., A. Mavi, M. Oktay, A.A. Kara, O.F. Algur and V. Bilaloglu. 2000. Comparison of antioxidant and antimicrobial activities of tilia (*Tilia argentea* Desf Ex DC), sage (*Salvia triloba* L.), and black tea (*Camellia sinensis*) extracts. *J. Agric. Food Chem.* 48:5030-5034.
- Zheng, W. and S.Y. Wang. 2001. Antioxidant activity and phenolic compounds in selected herbs. *J. Agric. Food Chem.* 49:5165-5170.

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