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Physiochemical, nutritional and functional characterization of 10 different pear cultivars (*Pyrus* spp.)

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Summary

This study was performed to compare the physiochemical properties and nutritional components including sugars, amino acids, and minerals of 10 common pear cultivars cultivated in Korea (four *Pyrus* spp.). Furthermore, the pear cultivars were characterized for functional properties with respect to phenolic compounds by HPLC/DAD analysis and antioxidant activities using DPPH and ABTS assays. Among the 10 pear cultivars that were tested, Niitaka and Hanareum pears show the best physiochemical properties such as higher sugar/acid ratio and proper firmness. They also showed relatively enriched soluble sugar (12.6 ~ 13.0 g/100 g FW), amino acid (4.5 ~ 7.3 g/100 g DW) or mineral contents with high K/Na ratio. For functional properties, Niitaka and Hanareum pears have significantly higher contents of total phenolics (240 mg/100 g DW), arbutin (103 ~ 124 mg/100 g DW), and chlorogenic acid (11 mg/100 g DW) as well as strong antioxidant activities (49% or 86%) among cultivars. These results indicate that Niitaka, and Hanareum cultivars, could be best for consumption or favorable processing due to excellent product quality and high concentrations of nutritional and functional compounds.

Introduction

Pear fruit (*Pyrus* spp.) is one of the most widely consumed fruits in the world, and the fruit type is comprised of Oriental and Occidental varieties due to different geographical developments. Oriental pears are cultivated mainly throughout Eastern Asia including China, the Koreas, and Japan. The major species of Oriental pears include *Pyrus bretschnrideri, Pyrus ussuriensis, Pyrus pyrifolia, and Pyrus sinkian*, while most Occidental pears belong to the *Pyrus communis* species (Cui et al., 2005). As pear is a seasonal fruit, it is typically eaten fresh and is often found in processed foods such as juice, puree, jellies, and jams. For many years, however, pear has also been used as a herbal medicine for the relief of coughing, and for its antitussive, anti-inflammatory, and diuretic activities (Li et al., 2014).

Recently, researchers have focused on analyses and comparisons involving the nutritional components of pear such as sugars, vitamins, amino acids, minerals, and fatty acids (Tanrioven and Eksi, 2005). These nutrient components play important roles in a qualitative evaluation of pear fruits, wherein attributes such as color, taste, and natural value are assessed (Ashoor and Kanox, 1982). The sugar, amino acid, and fatty acid compounds of eight commercial pear cultivars from China were identified and quantified using HPLC and gas-chromatography (GC) (Chen et al., 2007). During storage, Yali pear from *Pyrus bretschneideri* was also studied for changes of the volatile aroma components, sugars, organic acids, minerals, and amino acids (Wang et al., 2002; Chen et al., 2006). Certain chemicals of pear fruits such as total sugars, titratable acidity (TA), and soluble solids content (SSC) have been foremost quantification parameters because of their influence on the fruit's organoleptic properties (Teng and Liu, 1999). Additionally, Occidental-pear (*Pyrus communis*) and prickly-pear cultivars were studied for soluble solids, total TA, and pH during the ripening process (Hemandez-Perez et al., 2005; Barroca et al., 2006).

Apart from the above nutritional and chemical components, a variety of phenolic compounds such asarbutin, chlorogenic acid, catechin, and epicatechin have also been identified as primary active components in pears (Li et al., 2012; Chaalal et al., 2013; Garcia-Cruz et al., 2013).

The phenolic compounds in pear cultivars have also been further evaluated for beneficial health functions such as antioxidant, anti-inflammatory, and antimicrobial activities. The phenolic compounds of some pear cultivars distributed in Ankara and Bursa, Turkey, and southwestern Germany including arbutin, chlorogenic acid, and epicatechinin were determined by HPLC (Schieber et al., 2001; Tanrioven and Eksi, 2005). The peels and flesh of 10 different pear varieties (*Pyrus* spp.) from China were analyzed for their total-phenolic, total-flavonoid, and total-triterpene contents, and were also measured for antioxidant and anti-inflammatory activities (Cui et al., 2005; Li et al., 2014). The whole and ground seeds of three prickly-pear cultivars were studied for phenolic compounds, *in vitro* antioxidant capacity, and antiradical potential (Chaalal et al., 2013). In another study, the peel, flesh, and cores of three pear cultivars were analyzed for phenolic compounds and antioxidant activity during the ripening process (Zhang et al., 2006).

In our previous work, five unripe pear cultivars (*Pyrus pyrifolia*) were measured for total-phenolic and arbutin contents, characterized with respect to antioxidant activities, and their whitening functions were examined according to the inhibition of tyrosinase and cellular melanin formation (Yim and Nam, 2015). So far, most studies have focused on the physiochemical and/or nutritional properties or the functional characterization of some pear cultivars, but a simultaneous study of all of these has never been conducted for 10 different pear cultivars. This research focused on an analysis and comparison of the physiochemical properties and nutritional components such as minerals, sugars, and amino acids among 10 common pear cultivars that are grown in Korea (four *Pyrus* spp.). Furthermore, the pear cultivars were compared for functional properties with respect to phenolic compounds and antioxidant activity by using HPLC analysis, DPPH assay, and ABTS assay. A more detailed knowledge of the variability of the physiochemical and functional properties of pear cultivars will be helpful in the selection of pear cultivars with more beneficial nutritional and functional properties and favorable processing characteristics.

Materials and methods

Plant materials

Ten pear cultivars from four species were used in this study. To compare the whole-fruit contents of different species and cultivars, the following 8 cultivars of 3 species of Oriental pear (*Pyrus bretschneideri, Pyrus ussuriensis,* and *Pyrus pyrifolia)* and 2 cul-

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tivars of Occidental pear (*Pyrus communis*) were sampled. There are Jules d'Airolles, Abate Fetal (*P. communis*), Laiyangchili, Yali (*P. bretschneideri*), Ingyebae, Cheongbae (*P. ussuriensis*), Wonwhang, Niitaka, Hanareum, and Chuwhang (*P. pyrifolia*). All of the cultivars were picked from 15 year olds trees that were located at an orchard of the Naju National Pear Experimental Station in the Chonnam province of Korea, and were harvested at the mature fruit stage only. Seven to ten fruits from each of the selected standard pear trees were used for the experiments. All of the samples were of a uniform size and consisted of no defects. Each of the whole pear fruits was washed, rapidly cut into thin slices, and lyophilized by freeze-dryer (FD8512, Ilshin, Korea). The samples were then grinded by a pulverizer (FM-681C, Hanil Electric, Korea) and stored at -20 °C in polyethylene bags until further analysis. The methanol extracts of the pear cultivars were prepared for total flavonoid contents, antioxidant capacities, and HPLC analysis of phenolic compounds. The pear powder of 10 cultivars (10 g) had been previously homogenized in a Moulinex stirrer, and was later extracted with 80% ethanol using the soxhlet extraction method at 60 °C for 6 h. The extracts were then filtered through Whatman No 1 filter paper. The residues were extracted again with 80% ethanol using the previously mentioned method, and the extracts were then combined and evaporated to dryness under a vacuum. The dried extract was then prepared at a concentration that consisted of 0.1 g/mL of the freeze-dried pear in methanol. Otherwise, fresh pear fruits from the 10 cultivars were used to determine physical properties or sugar content.

Reagents

Arbutin, gallic acid, catechin, chlorogenic acid, caffeic acid, and *p*-coumaric acid (pheolic-compound standards) were purchased from Wako pure-chemical industries (Japan). Folin-Ciocalteu's phenol reagent, DPPH (1, 1-diphenyl-2-picrylhydrazyl), ABTS (2, 2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid), Trolox (6-hydroxy-2, 5, 7, 8-tetramethyl chromane 2 carboxylic acid), citric acid, and quercetin were purchased from Sigma Chemical Co. (St. Louis, Mo, U.S.A.). HPLC-grade acetonitrile and formic acid (98% purity) were also purchased from Sigma Aldrich-Fluka (St. Louis, Mo, U.S.A.). All of the other solvents and chemicals were of analytical grade.

Physiochemical properties

Weight, SSC, TA, and firmness were analyzed using fresh pears from the 10 cultivars. The fresh weight was measured by weighing 20 randomly chosen pear fruits using an analytical balance. The SSC was determined by a digital refractometer (Model RA-250HE, Kyoto Electronics Co. Ltd., Japan) at 22 °C. The TA was determined by an automatic titrator with sodium hydroxide, and it is expressed as the percentage of citric acid (Valente et al., 2013). Firmness is measured after peel-removal at the two opposite sides on the equator of each pear using a penetrometer with an 8 mm diameter tip. Puncture tests were performed using a TA-XT2 texture analyzer (Stable Micro Systems, Surrey, UK). The work that was required to penetrate the flesh to the maximum penetration depth was retained as the penetrometer-firmness parameter (Valente et al., 2013). This parameter, expressed in N mm, was obtained by calculating the area under the force displacement curve. SSC, TA, and firmness analyses were carried out in quintuplicate on the 10 pear cultivars.

Nutritional compositions: soluble sugars, amino acids, and minerals

Soluble sugar, amino acids, and minerals were determined among the 10 pear cultivars.

Seven to ten fruits from each standard pear trees were selected for the experiments with uniformity in size and no defects. Pooled pears from each cultivar were washed, rapidly cut into thin slices, and grinded with homogenizer for fruit juice or lyophilized by freeze-dryer for dry powder. Soluble sugar composition was determined according to the previous study (Chen et al., 2007), The pear fruit juice (10 g) was milled and diluted to 100 ml with redistilled water, and was then filtered through a 0.45 μm Millipore filter. An aliquot of 20 μl was injected into the HPLC system. A Waters HPLC system (Waters 717 plus Auto sampler, Milford, MA, U.S.A.) with a refractive index detector was employed in a monosaccharide analysis wherein a 5 μm aminopropyl column was utilized (Phenomenex, Torrance, CA, U.S.A.). The mobile phase consisted of acetonitrile-water (85:15, v/v) at a flow rate of 1.5 ml/min, at 30 °C for 20 min. Sucrose, glucose, fructose, and sorbitol (Sigma Chemical Co, St. Louis, Mo, U.S.A.) were used as standards. Chromatographic data were analyzed using Millennium Software (Pharmaceutics International, Hunt Valley, MD, U.S.A.). Sugar contents were expressed in g/100 g of fresh weight (FW).

The amino acid contents of the 10 pear cultivars were determined according to the previous study using an amino-acid analyzer (Hewlett-Packard Amino Quant Series II, HP 1090) (Bora et al., 2003). Pear powder (0.1 g) was added to an ampoule and hydrolysis was carried out using 5 ml of 6 N HCl containing 0.05% mercaptoethanol, at 105 °C for 24 h. Filtered hydrolyzate was dried in a vacuum desiccator and redissolved in 0.1 N HCl. Sample solution (10 μL) was injected directly into the amino-acid analyzer with a reverse-phase column using A buffer (20 mM sodium-acetate, pH 7.2, 0.018% trimethylamine, 0.3% tetrahydrofuron) and B buffer (100 mM sodium-acetate, pH 7.2, 40% acetonitrile, 40% methanol). Double pre-derivatization of the amino acids was achieved by reacting with orthophthalide, which was derivatized with 9-fluorenylmethyl chloroformate. The carrier gas was maintained at a flow rate of 0.45 ml/min, and the gradient was 0% to 60% of channel B in 17 min. An amino-acid standard solution (Sigma Chemical Co, St. Louis, Mo, U.S.A.) was used for obtaining qualitative and quantitative information. Free amino-acid contents were expressed in mg/100 g of dry weight (DW).

Minerals were quantified by using flame atomic-absorption spectrometry (ICPMS) (Hewlett-Packard 4500) according to previous study (Chen et al., 2007). Dried fruit samples (0.5 g) were stored overnight in 10 mL of concentrated HNO_3. Then, 1.5 mL of concentrated $HClO_4$ and 2 mL of concentrated H_2SO_4 were added. The temperature was gradually raised to the range of 200 ~ 250 °C and was maintained until complete charring was achieved. The oven temperature was then raised to 550 °C and maintained for 6 h to 8 h until a white ash remained. The concentrations of each element (K, Ca, Na, Mg, Zn, Fe, or Cu) in the pear fruits was determined using inductively-coupled plasma-flame emission spectrometry (ICP-FES) (Shimadzu AA6701 equipped with Shimadzu HVG-1 hydride vapor generator). A calibration curve to quantitate each mineral was established and the correlation coefficient is higher than 0.995. Mineral contents were expressed in mg/100 g of DW.

Total phenolic and flavonoid contents

The total phenolic content in the extracts of the 10 pear cultivars (0.1 g/mL) was determined using Folin-Ciocalteu's reagent as described in previous study (Cui et al., 2005). The absorbance of each sample was measured at 765 nm with the UV/Visible Spectrophotometer (JP/U-3900, Hitachi, Japan.) after incubation at 25 °C for 2 h. Total phenolic content was calculated from a calibration curve where gallic acid was used as the standard (160 ~ 960 mg/100 g DW). The flavonoid content was measured according to the aluminum-chloride colorimetric method (Boo et al., 2009) and quercetin was used as the standard. The flavonoid content was determined at 506 nm with a spectrophotometer. The data were expressed as mg /100 g DW, and the calibration curve ranged from 40 mg to 840 mg.

Phenolic compounds by HPLC-DAD

Phenolic compounds from the pear extracts were determined using a Shimadzu Prominance LC-20A HPLC-PAD (photodiode array detector) system using ACE 15 C18 HPLC column (250 × 4.6 mm, Advanced Chromatography Technologies Ltd., Scotland, UK). Pear methanol extract (0.1 g/mL) was filtered through a 0.22 μm filter (Agilent Technologies, Seoul, Korea), and 10 μL of each of the standard and sample solutions were injected into the HPLC system. The mobile phases were 2% (v/v) aqueous acetic acid (solvent A) and 0.5% (v/v) acetic acid in 50% acetonitrile (solvent B). The following binary elution system was applied: 2% B at initial 5 min to wash the column, and a linear gradient of 55% B (50 min), 100% B (10 min), and 10% B (5 min). After 70 min, the organic-phase concentration was brought back to 2% (B) and lasted for 6 min for column equilibration. The flow rate was set at 1 mL/min at 25 °C, and simultaneous monitoring was performed at 280 nm for arbutin, gallic acid, and catechin, and 320 nm for chlorogenic acid, caffeic acid, and *p*-coumaric acid. The phenolics in the HPLC chromatogram were identified by the time of retention. Retention times were 3 min (arbutin), 6 min (gallic acid), 15.4 min (chlorogenic acid), 6.9 min (caffeic acid), 20 min (catechin), and 27 min for *p*-coumaric acid under the conditions of the analysis.

DPPH and ABTS radical-scavenging activity

The DPPH radical scavenging activities of the pear extracts were determined as described previously (Blios, 1958). A 0.25 ml of sample (0.1 g/mL) and 0.8 ml of 0.15 mM DPPH· (methanol) were added and shaken vigorously, followed by incubation at room temperature for 30 min in the dark. The control sample was prepared with 80% ethanol instead of pear extract. The decrease of absorbance in the presence of DPPH· was measured at 517 nm using a spectrophotometer (JP/U-3900, Hitachi, Tokyo, Japan) wherein Trolox was used as a reference compound. The radical-scavenging activity was expressed as a % of the inhibition of DPPH· radicals using the following equation:

DPPH radical scavenging activity (%) = 1 − (sample absorbance/control absorbance) × 100

The ABTS radical scavenging activity of the pear extracts was measured by the ABTS cation decolorization assay with some modifications (Re et al., 1999). The ABTS radical cation (ABTS+·) was produced by a reaction of 7 mM ABTS stock solution with 2.45 mM potassium persulfate, which was allowed to stand in the dark at room temperature for 12 h to 16 h before use. The ABTS+· solution was diluted with methanol to give an absorbance of 0.7 ± 0.01 at 734 nm. The pear extracts (0.1 g/mL) were allowed to react with 2 ml of the ABTS+· solution for 1 min, after which time the absorbances were measured at 734 nm. Trolox was used as the reference compound. The radical-scavenging activity was expressed as the % of the inhibition of ABTS radicals using the following equation:

ABTS radical scavenging activity (%) = (1 − sample absorbance/control absorbance) × 100

Statistical Analysis

All of the experiments were carried out with three replicates and the results were expressed as mean ± standard deviation. The data were analyzed using a one-way ANOVA, and the means of different groups were compared to the Duncan's multiple-range test (DMRT) using the SPSS version 17.0 statistical-software package. Values of $P < 0.05$ are considered significant in all cases.

Results and discussion

Physiochemical properties

The physiochemical properties of the 10 pear cultivars are presented in Tab. 1. The pears that were examined include the following 10 major cultivars of Korea from 4 species: Jules d'Airolles, Abate Fetal (*P. communis*), Laiyangchili, Yali (*P. bretschneideri*), Ingyebae, Cheongbae (*P. ussuriensis*), Wonwhang, Niitaka, Hanareum, and Chuwhang (*P. pyrifolia*).

The level of fresh weight, the SSC, the TA, the ratio of sugar to acid, and the firmness differed considerably across the 10 cultivars. A high sugar/acid ratio and appropriate firmness are considered favorable intrinsic characteristics for the selection of appropriate cultivars to eat fresh due to the beneficial taste effect (Chen et al., 2007). In terms of fruit weight, Niitaka, Wonwhang, and Chwhang pears showed a 2.5 times higher than Yali and Cheongbae pears which have relatively lower weights among pear cultivars. It has been suggested that sugar/acid ratio and hardness can be used as criteria for the ripeness of fresh fruits (Pal and Kumar, 1995). The Jules d'Airolles and Abate Fetal pears in our study show relatively high levels of SSC and

Tab. 1: Physiochemical properties of 10 different pear cultivars.

Species	Cultivars	Weight (g)	SSC[1] (%)	TA[2] (%)	Sugar/acid	Firmness (N)
Pyrus communis	Jules d'Airolles	454 ± 26^{c}	15.4 ± 0.2^{a}	0.37 ± 0.01^{a}	42.0 ± 1.0^{f}	14.7 ± 1.1^{a}
	Abate Fetal	349 ± 20^{d}	14.9 ± 0.1^{b}	0.21 ± 0.00^{b}	70.1 ± 1.4^{cde}	13.3 ± 0.5^{b}
Pyrus bretschneideri	Laiyangchili	289 ± 24^{e}	12.3 ± 0.1^{f}	0.14 ± 0.01^{e}	84.0 ± 1.9^{c}	9.4 ± 0.5^{d}
	Yali	238 ± 34^{f}	10.9 ± 0. 1^{g}	0.21 ± 0.01^{bc}	52.0 ± 1.1^{ef}	7.4 ± 0.1^{e}
Pyrus ussuriensis	Ingyebae	342 ±37^{d}	10.7 ± 0.2^{h}	0.19 ± 0.00^{c}	56.8 ± 1.7^{def}	8.6 ± 0.3^{d}
	Cheongbae	233 ± 11^{f}	12.2 ± 0.2^{f}	0.19 ± 0.00^{b}	64.4 ± 1.1^{cde}	6.7 ± 0.2^{e}
Pyrus pyrifolia	Wonwhang	532 ± 9^{b}	12.3 ± 0.1^{f}	0.16 ± 0.00^{d}	76.4 ± 1.4^{cd}	14.1 ± 0.6^{ab}
	Niitaka	635 ± 49^{a}	12.5 ± 0.1^{e}	0.09 ± 0.02^{f}	138.9 ± 31.2^{b}	11.0 ± 0.4^{c}
	Hanareum	361 ± 5^{d}	14.3 ± 0.1^{c}	0.07 ± 0.01^{g}	192.5 ± 11.7^{a}	11.5 ± 0.8^{c}
	Chuwhang	525 ± 13^{b}	14.0 ± 0. 1^{d}	0.21 ± 0.01^{bc}	66.9 ± 2.2^{cde}	11.1 ± 0.3^{c}

[1] SSC (soluble solids content)
[2] TA (titratable acidity)
[3] Nd (not detected)
Values are means ± SD and means with the same letter within columns are not significantly different (DMRT, $p \leq 0.05$).

TA, while Ingyebae and Cheongbae pears have lower SSC and TA levels. The sugar/acid ratios of Jules d'Airolles, Abate Fetal, Ingyebae, and Cheongbae pears are the lowest with ratios of 42 ~ 70%. However, Niitaka and Hanareum pears have the highest soluble solids but the lowest acid contents. The sugar/acid ratios of Niitaka and Hanareum pears are 2 to 3 times higher than those of other pears with ranging from 138% to 192%. The fruit firmness is relatively very high for the Jules d'Airolles and Abate Fetal pears with 13.3 ~ 14.7 N, whereas it is low for the Ingyebae and Cheongbae pears with 6.7 ~ 8.6 N. The fruit firmness of Niitaka and Hanareum pears are moderate with 11 N. The sugar/acid ratios of our pear cultivars (42 ~ 192%) are similar or slightly higher than those of major pear cultivars from China (23 ~ 125%) (CHEN et al., 2007). Some studies report that the sugar/acid ratio of pear fruit is not only affected by the ripeness but also the pear cultivar or cultivation conditions (HEMANDEZ-PEREZ et al., 2005; BARROCA et al., 2006). Among the 10 tested pear cultivars, the Niitaka and Hanareum pears show the best physiochemical properties such as higher sugar/acid-ratio levels and proper firmness.

Nutritional compositions: soluble sugars, amino acids, and minerals

Soluble sugars

Sugars are one of the biochemical components of fruit quality, and their kinds and amount directly influence fruit-flavor components such as sweetness (MORIGUCHI et al., 1992). Fructose, glucose, sucrose, and sorbitol were identified in this study as the principal saccharides of each pear fruit (Tab. 2). Regarding the total sugar contents, the Jules d'Airolles, Abate Fetal, Hanareum, and Chuwhang pears showed relatively high contents while Laiyangchili pear had low. For individual sugars, fructose is the predominant sugar, accounting for 35% to 56% of the total sugars. The fructose contents in the pears are approximately 2 times higher than glucose or sorbitol contents. Interestingly, Laiyangchili pear contains remarkably higher sorbitol content than the other pears. As the sweetness characteristic of the fruit, a large variety of sucrose levels was observed among the pear cultivars, ranging from 0.2 to 3.0 g per 100 g FW. The determined values of the sucrose in pears were much lower by approximately 5 ~ 10 times than fructose contents.

The trends of the fructose and glucose contents across the 10 cultivars are similar to the trend of the total soluble sugar contents. However, sugar contents of the pears show different patterns from those of fructose or glucose. Since sugar contents of the Jules d'Airolles, Wonwhang, and Niitaka cultivars are clearly high but those of Laiyangchili is relatively low among cultivars. Among four pear species, *P. communis* (Jules d'Airolles, Abate Fetal) and *P. pyrifolia* (Hanareum, Chuwhang) pears possess relatively higher soluble sugar contents, whereas *P. Bretschneideri* (Laiyangchili, Yali) and *P. ussuriensis* (Ingyebae, Cheongbae) pears have relatively lower soluble sugar contents (Tab. 1 and 2). The quantification of the glucose and fructose contents in this study agrees with the previously reported ranges for pear (MORIGUCHI et al., 1992; CHEN et al., 2007). In this study, the species and geographical origin influence the sugar and phenolic contents more than the other factors (CHEN et al., 2007; LI et al., 2012).

Amino acids

Six amino acids out of the 15 kinds of free amino acid standards were determined from the 10 pear cultivars and are presented in Tab. 3. The amino acids of the 10 pear cultivars are aspartic acid, glutamic acid, proline, threonine, valine, and phenylalanine in descending order of abundance. The most abundant amino acids of the 10 pears in this study are aspartic acid and glutamic acid. These results agree with the existing research that reports glutamic acid as the major amino acid among 15 free amino acids with respect to the major pear cultivars (CHEN et al., 2007). The role of glutamic acid has been reported as the provision of the characteristic ''umami taste'' to foods with high, free glutamate content such as cheese, tomato, and mushrooms, which are also major ingredients in cooking (BELLISLE, 1999). Regarding the total free amino acid contents, Niitaka, and Chuwhang pears show relatively high contents in our study, with 6.8 ~ 7.3 g/100 g DW, whereas the Jules d'Airolles and Abate Fetal pears contain low contents, with 1.8 ~ 2.1 g/100 g DW. Large variations of proline values are shown among the pear cultivars, ranging from 3 ~ 190 g/100 g DW (Tab. 3). This pattern agreed with a previous report concerning proline content among pear cultivars (CHEN et al., 2007). Among the pears tested, Cheongbae pear had significantly higher proline content and was one of disease resistant cultivars. Since proline plays an important role in plant growth and defense as a key determinant of many cell wall proteins. It accumulates both under stress and non-stress conditions as a beneficial solute in plants (STINTZING et al., 2001). This may be the reason why Cheongbae pear results in significantly high proline content (STINTZING et al., 2001).

Tab. 2: Soluble sugar compositions of 10 different pear cultivars (g/100 g FW).

Species	Cultivars	Sucrose	Glucose	Fructose	Sorbitol	Total[1]
Pyrus communis	Jules d'Airolles	2.72 ± 0.01^{c}	2.46 ± 0.01^{f}	6.29 ± 0.01 ^{d}	2.13 ± 0.01 ^{h}	13.6 ± 0.4^{c}
	Abate Fetal	1.58 ± 0.10 ^{e}	3.36 ± 0.01^{b}	6.61 ± 0.02 ^{b}	2.98 ± 0.01 ^{d}	14.5 ± 0.1^{a}
Pyrus bretschneideri	Laiyangchili	0.26 ± 0.01^{i}	2.05 ± 0.01^{i}	5.04 ± 0.01 ^{g}	3.69 ± 0.01 ^{a}	11.1 ± 0.3^{h}
	Yali	0.53 ± 0.05^{g}	2.30 ± 0.02 ^{g}	4.83 ± 0.02 ^{h}	3.56 ± 0.01 ^{b}	11.2 ± 0.1^{g}
Pyrus ussuriensis	Ingyebae	0.84 ± 0.01^{f}	2.26 ± 0.02^{h}	6.21 ± 0.01^{e}	1.73 ± 0.01^{i}	11.0 ± 0.1^{h}
	Cheongbae	0.39 ± 0.01^{h}	3.90 ± 0.01 ^{a}	5.12 ± 0.02^{f}	3.01 ± 0.02^{c}	12.4 ± 0.1^{f}
Pyrus pyrifolia	Wonwhang	3.06 ± 0.01^{a}	2.82 ± 0.01^{d}	4.47 ± 0.02 ^{i}	2.18 ± 0.01 ^{g}	12.5 ± 0.2^{e}
	Niitaka	2.78 ± 0.01^{b}	2.88 ± 0.02^{c}	4.21 ± 0.02 ^{j}	2.71 ± 0.01 ^{e}	12.6 ± 0.1^{e}
	Hanareum	1.56 ± 0.01^{g}	2.40 ± 0.03^{f}	6.36 ± 0.01 ^{c}	2.71 ± 0.01 ^{e}	13.0 ± 0.1^{d}
	Chuwhang	1.92 ± 0.02^{d}	2.79 ± 0.01 ^{e}	6.80 ± 0.01 ^{a}	2.56 ± 0.01 ^{f}	14.1 ± 0.3^{b}

[1] Total sugar is the sum of individual sugars. Value are means ± SD (n = 3), and means with the same letter within columns are not significantly different (DMRT, $P \leq 0.05$).

Tab. 3: Major amino-acid compositions of 10 different pear cultivars (mg/100 g DW).

Species	Cultivars	Proline	Valine	Threonine	Aspartic acid	Glutamic acid	Phenylalanine	Total[1]
Pyrus communis	Jules d'Airolles	73.0 ± 1.6^{c}	2.9 ± 0.1^{gh}	16.6 ± 2.5^{d}	1582 ± 102^{f}	491 ± 19de	1.17 ± 0.14^{h}	2167 ± 113^{ef}
	Abate Fetal	129.9 ± 9.4 ^{b}	nd[2]	nd	1151 ± 141^{g}	583 ± 52^{c}	2.56 ± 0.15^{g}	1867 ± 192^{f}
Pyrus bretschneideri	Laiyangchili	12.7 ± 1.1^{e}	6.8 ± 0.9^{def}	16.1 ± 1.5^{d}	1833 ± 68 ^{f}	533 ± 35 ^{cd}	6.71 ± 0.31^{c}	2408 ± 47^{e}
	Yali	9.1 ± 0.4^{e}	8.4 ± 1.1^{cd}	15.3 ± 0.6^{d}	3061 ± 164 ^{e}	1009 ± 45 ^{a}	5.86 ± 0.21 ^{d}	4109 ± 199^{d}
Pyrus ussuriensis	Ingyebae	18.8 ± 2.4 ^{e}	4.1 ± 0.5 ^{fg}	nd	5951 ± 195 ^{b}	478 ± 19 ^{de}	4.13 ± 0.15 ^{f}	6457 ± 207^{b}
	Cheongbae	190.7 ± 11.9^{a}	37.4 ± 4.6^{a}	58.2 ± 8.5^{a}	4475 ± 311 ^{c}	402 ± 31 ^{e}	3.80 ± 0.34^{f}	5168 ± 368^{c}
Pyrus pyrifolia	Wonwhang	38.4 ± 3.0^{d}	10.7 ± 0.5^{bc}	16.2 ± 0.8^{d}	1906 ± 55^{f}	406 ± 47 ^{e}	8.58 ± 0.39^{b}	2387 ± 100^{e}
	Niitaka	17.5 ± 2.0^{e}	7.6 ± 1.1 ^{cde}	24.2 ± 2.4^{c}	6785 ± 418^{a}	479 ± 88 ^{de}	9.66 ± 0.41 ^{a}	7324 ± 508^{a}
	Hanareum	4.2 ± 0.5^{e}	13.6 ± 2.9^{b}	28.0 ± 2.3^{c}	4034 ± 244^{d}	450 ± 55de	3.81 ± 0.26^{f}	4535 ± 291^{d}
	Chuwhang	3.1 ± 0.7^{e}	4.9 ± 0.7^{efg}	36.0 ± 2.1^{b}	5894 ±161^{b}	908 ± 49 ^{b}	5.18 ± 0.08^{e}	6852 ± 203^{b}

[1] Total means the sum of individual amino acids
[2] Nd (not detected). Value are means ± SD (n = 3), and means with the same letter within columns are not significantly different (DMRT, $P \leq 0.05$).

Minerals

Minerals are dietary requirements for humans and exert various physiological effects. The mineral compositions of the 10 pear cultivars are listed in Tab. 4. K and Ca are minerals that are essential for controlling the salt balance, bone structure, and functions of the human body. Mg is also useful to the body as a minor component of bones and plays a catalytic role in respiration. With respect to macrominerals, K is the most abundant mineral in pears, followed by Na, Ca, and Mg. The K/Na ratio may be useful for compensating for high Na levels in a typical human diet. The K/Na ratio is relatively higher at Cheongbae and Chuwhang pear but lower at Laiyangchili among 10 cultivars since Cheongbae and Chuwhang pears contained relatively high contents of potassium among cultivars (Tab. 4). The 10 cultivars show similar calcium (20 ~ 33 mg/100 g DW) and magnesium levels (10 ~ 26 mg/100 g DW). For microminerals, Zn is especially important for the normal functioning of the immune system, and Fe is the major component of essential biological compounds such as transferrin, ferritin, and haemoglobin (BRODY, 1994). Large variations of Zn values are shown among the pear cultivars, ranging from 0.8 mg to 3.0 mg/100 g DW (Tab. 4). Meanwhile, other microminerals such as Fe, Cu, and Mn show similar values among the pear cultivars. Cheongbae pear has higher amounts of microminerals than the other pears. Micromineral levels obtained in this work are similar to those obtained from other studies. However, the contents of macrominerals in the pear cultivars are much lower than those of other cultivars (Tab. 4), and this may be due to the differences between pear cultivars rather than the individual method that we used (CHEN et al., 2007; SALVADOR et al., 2010).

Soluble sugars, amino acids, and mineral compositions are important factors for qualitatively evaluating the nutritional value of fruits and their potential use for different products. Among the 10 pear cultivars that we investigated, Niitaka, Hanareum and Chuwhang pears show the highest levels of biologically-active chemical compounds.

Functional characterization: total phenolics and flavonoids, phenolic compounds by HPLC, and antioxidant activity

Total phenolic and flavonoid contents

The total phenolic and flavonoid contents of the 10 cultivars (*Pyrus* spp.) are presented in Fig. 1. The 10 pear cultivars that were tested have total phenolic contents ranging from 109 ~ 261 mg/100 g DW, while the flavonoid contents were between 68 mg and 177 mg/100 g

Tab. 4: Mineral compositions of 10 different pear cultivars (mg/100 g DW).

Species	Cultivars	Macro minerals				Micro minerals			
		K	Na	Ca	Mg	Zn	Fe	Cu	Mn
Pyrus communis	Jules d'Airolles	170 ± 36^{ab}	70 ± 9^{ab}	23 ± 5^{ab}	16 ± 6^{abc}	3.01 ± 0.51 ^{a}	4.32 ± 0.31^{de}	1.20 ± 0.20^{c}	1.11 ± 0.10^{c}
	Abate Fetal	170 ± 10^{ab}	57 ± 6^{ab}	20 ± 6^{b}	10 ± 1^{c}	2.21 ± 0.61^{b}	6.00 ± 0.32 ^{b}	0.72 ± 0.10^{d}	0.51 ± 0.09^{e}
Pyrus bretschneideri	Laiyangchili	157 ± 47^{bcd}	83 ± 4 ^{a}	30 ± 4^{ab}	23 ± 1^{ab}	1.32 ± 0.22^{c}	4.32 ± 0.71^{de}	1.61 ± 0.44^{ab}	0.55 ± 0.08^{e}
	Yali	140 ± 10^{bcd}	63 ± 5 ^{ab}	26 ± 5^{ab}	17 ± 1^{abc}	2.32 ± 0.50^{ab}	2.15 ± 0.80^{f}	0.92 ± 0.11^{cd}	2.32 ± 0.21 ^{a}
Pyrus ussuriensis	Ingyebae	150 ± 10^{bcd}	57 ± 5 ^{ab}	23 ± 5^{ab}	20 ± 1^{abc}	2.81 ± 0.51^{ab}	4.42 ± 0.32^{de}	1.61 ± 0.31^{b}	0.71 ± 0.04 ^{d}
	Cheongbae	210 ± 10^{a}	60 ± 4^{ab}	33 ± 5^{a}	26 ± 5^{a}	2.72 ± 0.31 ^{ab}	5.52 ± 0.40^{bc}	2.00 ± 0.11 ^{a}	1.41 ± 0.11 ^{b}
Pyrus pyrifolia	Wonwhang	123 ± 6^{cd}	50 ± 7^{b}	20 ± 2^{b}	17 ± 5 ^{abc}	2.62 ± 0.11^{ab}	12.8 ± 0.22^{a}	0.81 ± 0.11^{d}	1.12 ± 0.10^{c}
	Niitaka	140 ± 10^{bcd}	60 ± 6^{ab}	23 ± 5^{ab}	13 ± 5^{bc}	1.35 ± 0.40^{c}	4.12 ± 0.50^{de}	nd	0.52 ± 0.05^{e}
	Hanareum	120 ±11^{d}	57 ± 6^{ab}	20 ± 1^{b}	20 ± 3^{abc}	1.10 ± 0.10^{c}	3.50 ± 0.40^{e}	0.91 ± 0.09^{cd}	0.40 ± 0.04^{e}
	Chuwhang	167 ± 15^{bc}	60 ± 4^{ab}	23 ± 5^{ab}	20 ± 3^{abc}	0.80 ± 0.21^{c}	4.90 ± 1.10^{cd}	0.60 ± 0.04^{d}	0.42 ± 0.03^{e}

Value are means ± SD (n = 3), and means with the same letter within columns are not significantly different (DMRT, $P \leq 0.05$).

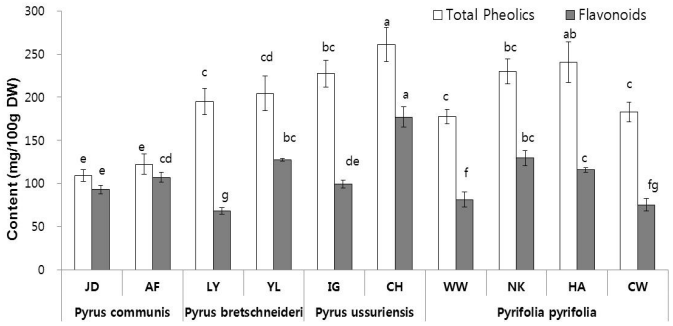

Fig. 1: Total phenolic and flavonoid contents of 10 different pear cultivars. Value are means ± SD ($n = 3$). Different letters (a to g) of each indicate significant difference at $P < 0.05$ according to DMR test. The cultivars used are Jules d'Airolles (JD), Abate Fetal (AF), Laiyangchili (LY), Yali (YL), Ingyebae (IG), Cheongbae (CH), Wonwhang (WW), Niitaka (NK), Hanareum (HA), and Chuwhang (CW).

DW. Among the species tested, the Cheongbae, Niitaka, and Hanareum pears have significantly higher total phenolic contents with 230 ~ 261 mg/100 g DW, while Jules d'Airolles and Abate Fetal show lower value of 109 ~ 120 mg/100 g DW. The flavonoid content followed a similar trend to that of the total phenolic content, with higher values from 115.7 mg ~ 129.5 mg/100 g DW in Cheongbae, Niitaka, and Hanareum. Here, Niitaka, the representative cultivar with above 70% domestic production, has higher values for total phenolics and flavonoids.

In general, total phenolic contents in pear cultivars are higher by about 1.2 ~ 3.0 times than those of flavonoid contents. This agrees with the research that reports the concentrations of phenolics of both Oriental and Occidental pears as much greater than those of flavonoids (Galvis-Sanchez et al., 2003; Valente et al., 2013; Li et al., 2014). The total phenolic contents of the 10 pears (261 mg/100 g DW) were similar or less than those of other studies (263 ~ 823 mg/100 g DW) (Cui et al., 2005; Li et al., 2012; 2014). It could be reasoned from different cultivated environments, cultivars or detection methods. With respect to total phenolic content (Fig. 1), our values are comparable with the contents in other kinds of fruit such as guava (179 mg/100 g FW), banana (51 mg/100 g FW), and peach (112 ~ 126 mg/100 g FW) (Veberic et al., 2008; Arranz et al., 2009).

Phenolic compounds by HPLC-DAD

The different phenolic compounds in the ethanol extracts of the 10 pears were determined by HPLC/DAD. The phenolic contents of the 10 pears were comprised of one phenolic glucoside (arbutin), one flavanol (catechin), and three phenolic acids (chorogenic acid, caffeic acid, and gallic acid) and are given in Tab. 5. Some variations ($P < 0.05$) of the phenolic concentrations were noted among the 10 pear samples. The phenolic content varies greatly among the pear cultivars according to Tab. 5.

In terms of total phenolic content, Cheongbae, Niitaka, and Hanareum show higher levels of 135.2 ~ 161.2 mg/100 g DW, but Jules d'Airolles and Abate Fetal display lower levels of 60.6 ~ 81.0 mg/100 g DW. The 10 pears show similar trends in the contents of the four phenolic constituents with the exception of catechin (Tab. 5).

The highest amounts were exhibited in the case of arbutin, followed by chlorogenic acid, caffeic acid, and gallic acid, with a trace of catechin, over 10 tests. Arbutin is the predominant compound across all of the cultivars, accounting for 43% to 72% of the total phenolic compounds. The chlorogenic acid contents of the pears are approximately 20% to 50% of the arbutin content, but are slightly higher than the caffeic acid content or gallic acid content. The amounts of catechin in pears are also quite low with large variations (1.0 ~ 11.9 mg/100 g DW).

Arbutin (4-hydroxyphenyl β-D glucopyranoside) is the main phenolic constituent in pear fruit and attracted attention for its wide use as an antioxidant or human skin whitening agent for the prevention of unnecessary spots and freckles (Maeda and Fukuda, 1996). Chlorogenic acid is a potential chemopreventive agent, and possesses important bioactivities including antioxidant, antitumor, and immune system enhancement activities (Krakauer, 2002). In particular, the contents of arbutin and chlorogenic acid among the cultivars seem to be positively correlated with the trend of the total phenolic contents (Tab. 5 and Fig. 1). The arbutin and chlorogenic acid contents obtained from the Cheongbae, Niitaka, and Hanareum cultivars are obviously higher than those of the other cultivars, ranging from 103.7 ~ 124.4 mg and 11.0 ~ 20.7 mg per 100 g DW, respectively. This agrees with the report that Niitaka contains greater arbutin and chlorogenic acid concentrations than the other cultivars, like Chuwhang or Hosui (Zhang et al., 2006). Interestingly, the Occidental pears, Jules d'Airolles and Abate Fetal displayed total phenolic or arbutin amounts that are half those of the other 8 cultivars from Oriental pears (Tab. 5 and Fig. 1). It shows similar result with other

Tab. 5: Phenolic compounds of 10 different pear cultivars (mg/100 g DW).

Species	Cultivars	Arbutin	Gallic acid	Catechin	Chlorogenic acid	Caffeic acid	Total[1]
Pyrus communis	Jules d'Airolles	26.21 ± 2.21^{h}	7.85 ± 0.11 ^{d}	5.09 ± 0.18^{d}	11.59 ± 0.11^{c}	9.89 ± 0.21^{bc}	60.6 ± 2.1^{i}
	Abate Fetal	41.15 ± 1.22 ^{g}	7.95 ± 0.11^{d}	10.46 ± 0.86^{b}	11.64 ± 0.17 ^{c}	9.88 ± 0.11^{bc}	81.0 ± 2.2^{h}
Pyrus bretschneideri	Laiyangchili	79.85 ± 1.33 ^{ef}	9.12 ± 0.23 ^{ab}	3.17 ± 0.13 ^{f}	11.86 ± 0.24^{c}	9.42 ± 0.80^{c}	113.3 ± 3.2^{e}
	Yali	84.94 ± 2.57 ^{d}	8.76 ± 0.20^{abc}	1.06 ± 0.17^{h}	16.86 ± 0.50^{b}	10.55 ± 0.41 ^{a}	122.1 ± 2.6^{cd}
Pyrus ussuriensis	Ingyebae	78.15 ± 1.35^{f}	9.40 ± 0.30^{a}	11.98 ± 0.84^{a}	11.30 ± 0.22^{cd}	9.90 ± 0.13^{bc}	120.6 ± 4.0^{d}
	Cheongbae	116.01 ± 2.55^{b}	8.36 ± 0.72^{bcd}	5.91 ± 0.22^{c}	20.78 ± 0.12^{a}	10.16 ± 0.15^{ab}	161.2 ± 2.5^{a}
Pyrus pyrifolia	Wonwhang	79.71 ± 1.45 ^{ef}	8.46 ± 0.10^{bcd}	1.25 ± 0.04^{h}	11.16 ± 0.25 ^{cd}	nd[2]	100.5 ± 4.2^{g}
	Niitaka	124.45 ± 2.67^{a}	8.36 ± 0.15^{bcd}	1.20 ± 0.09 ^{h}	11.21 ± 0.14^{cd}	nd	145.2 ± 7.3^{b}
	Hanareum	103.75 ± 5.62^{c}	8.27 ± 0.08^{cd}	2.47 ± 0.05^{g}	11.08 ± 1.02^{d}	9.69 ± 0.73^{bc}	135.2 ± 5.6^{c}
	Chuwhang	82.82 ± 2.21^{de}	8.39 ± 0.05^{bcd}	3.44 ± 0.04 ^{e}	5.51 ± 1.00^{e}	9.85 ± 0.12^{bc}	110.0 ± 2.4 ^{f}

[1] Total means the sum of individual phenolic compounds

[2] Nd (not detected).

Value are means ± SD (n = 3), and means with the same letter within columns are not significantly different (DMRT, $P \leq 0.05$).

study in that the mean concentration of arbutin in Oriental pear cultivars is twice as high as that of Occidental pear cultivars (CUI et al., 2005). However, differences exist between the findings of our study and previously research that reports much higher concentrations of chlorogenic acid in Occidental pears than Oriental pears (CUI et al., 2005). Our results show that the concentrations of chlorogenic acid in the Oriental pear cultivars are similar to or slightly higher than those of the Occidental pear cultivars. The values of chlorogenic acid in pears could be attributed to the different cultivars rather than their geographical origin (LI et al., 2014; CHEN et al., 2006).

It is worth mentioning that the Yali pear contains remarkably higher amounts of chlorogenic acid or caffeic acid than the other pears, with values of 16.8 mg or 10.5 mg/100 per g DW, respectively. Besides arbutin and chlorogenic acid, caffeic acid, gallic acid, and catechin are also important biologically active constituents of pear and variations of their levels are similar among the 10 pear cultivars. No detectable amounts of caffeic acid were found in the Wonwhang or Niitaka pears. This result agrees with the study that reported that caffeic acid was not detectable in the Niitaka cultivar (ZHANG et al., 2006). Abate Fetal and Ingyebae cultivars display the highest amounts of catechin, from 10.5 ~ 11.9 mg/100 g DW. The 10 pears do not have measurable amounts of *p*-coumaric acid, with the exception of Laiyangchili (5.7 mg/100 g DW).

DPPH and ABTS radical-scavenging activity

The antioxidant activities of the 10 pear extracts were evaluated by DPPH· or ABTS+· radical scavenging assays (Fig. 2). DPPH· can only be dissolved in organic media (especially in alcohols), not in aqueous media, and this limits the ability to interpret the role of hydrophilic antioxidants. In contrast, ABTS+· can be solubilized in either aqueous or organic media, allowing for the interpretation of the roles of hydrophilic and lipophilic antioxidants.

With regard to the DPPH· scavenging activity, the 10 pear cultivars show significant differences ($P > 0.05$) with DPPH bleaching abilities from 20.5 ~ 58.8%. The free radical scavenging activity of the pear cultivars increased linearly with increases of the sample concentration (data not shown). It was reported that the antioxidant capacities of the pear extracts according to a DPPH assay were significantly different among the pear cultivars, ranging from 10 ~ 85% (LI et al., 2014; 2012). Among the cultivars examined in this study, the Cheongbae, Niitaka, and Hanareum cultivars have the highest antioxidant activities, whereas Occidental pears, Jules d'Airolles and Abate Fetal cultivars, displayed relatively lower activities. This result was similar to that of other study (LI et al., 2012), whereby the antioxidant activity of Occidental pear (*P. communis*) was lower than those of Oriental pears (*P. bretschneideri* or *P. ussuriensis*). Pear cultivars showed similar activity values when the antioxidant capacities per serving (100 g) were compared in other study (GALVIS-SANCHEZ et al., 2003). In comparison to other fruits, the pear fruits show slightly lower antioxidant activities with 59%. Chinese plum and peach are reported to have antioxidant activities of 80.9% and 76.8%, respectively, at the same sample concentrations of 100 mg/mL (LEE et al., 2008; KIM et al., 2009).

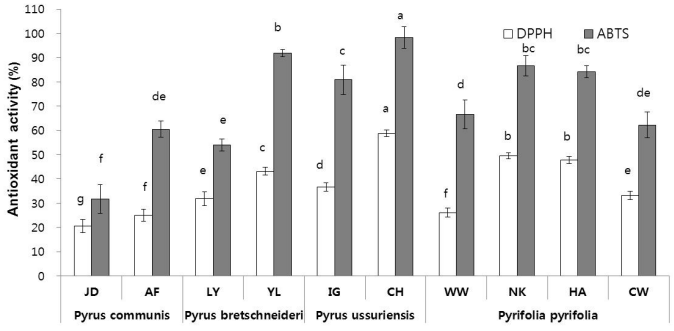

Fig. 2: Antioxidant activities of 10 different pear cultivars according to DPPH and ABTS assays. Value are means ± SD ($n = 3$). Different letters (a to g) of each indicate significant difference at $P < 0.05$ according to DMR test. The cultivars used are Jules d'Airolles (JD), Abate Fetal (AF), Laiyangchili (LY), Yali (YL), Ingyebae (IG), Cheongbae (CH), Wonwhang (WW), Niitaka (NK), Hanareum (HA), and Chuwhang (CW).

In terms of ABTS+· radical scavenging activity, 10 pear cultivars show similar values ranging from 31.7 ~ 98.3% of antioxidant activity, although some differences were observed among the cultivars ($P < 0.05$). For the 10 pear cultivars, the antioxidant capacities by the two methods show sound agreement. Cheongbae, Niitaka, and Hanareum presented the strongest ABTS+· bleaching activities (84 ~ 98%), while Jules d'Airolles and Abate Fetal showed the lowest DPPH scavenging capacity (31.7 ~ 60.5%) (Fig. 2). Cheongbae, Niitaka, and Hanareum, with high total phenolic, flavonoid, and arbutin contents, exhibited significantly higher antioxidant abilities than the other cultivars (Fig. 1 and 2). Therefore, it can be deduced that total-phenolic and flavonoid contents provide major contributions to the antioxidant capacities of pears. A number of studies have reported that phenolic compounds including arbutin and chlorogenic acid are the main phytochemicals responsible for the antioxidant capacities of vegetables and fruits (DU et al., 2009; SALTA et al., 2010). The phenolic compounds of pears provide a much greater contribution to antioxidant capacity than vitamin C (GALVIS-SANCHEZ et al., 2003).

The sugar/acid ratio of pear was commonly used to determine the flavor quality of fruit, which is consistent with the preference of consumers for pear fruit. It was noteworthy that sugar/acid ratios of Niitaka, and Hanareum pears had the highest among cultivars due to their highest soluble solids but the lowest acid content. Sugar/acid ratios in Niitaka, and Hanareum pears were 139 or 192, which are greater values than found in the other study, ranged from 23 ~ 125 (CHEN et al., 2007). Niitaka, and Hanareum pears considered as appropriate cultivars for eating fresh at home or commercial pear juice concentrates.

Besides high sugar/acid ratios, Niitaka, and Hanareum pears possess enriched nutritional or functional compounds as well as strong antioxidant activities. Niitaka is the representative cultivar with above 70% domestic production in Korea due to high yield. However, Niitaka pear showed relatively lower sweetness but Chuwhang pear had high sweetness and late maturing of flower. Thus, Hanareum pear is hybrid progeny of Niitaka × Chuwhang to increase the sweetness of Niitaka. According to Tab. 2 and 3, it seems to be successful to produce optimum pear, Hanareum with high yield and sweetness. Further research should be conducted to produce excellent pear cultivars with enhanced stress or disease resistant property by hybridization of Niitaka or Hanareum × Cheongbae.

Pear quality, nutrition, and function are affected by many factors such as fruit cultivar, region diversity, and cultivation condition. Here, our research can provide ten pears chemical and functional composition characteristics. This work will provide valuable information for further research on such fruits, and will also provide insights into the potential health benefits of the pear fruit, thereby supporting its nutritional and functional applications.

Conclusions

Current study is a first evaluation report on physiochemical and nutritional properties as well as functional characterization of 10 pear cultivars in Korea (four *Pyrus* spp.). Among pear cultivars investigated, Niitaka, and Hanareum pears showed optimum physiochemical properties like high sugar/acid ratio and high nutritional compounds

such as sugars, amino acids, and minerals. In addition, Niitaka, and Hanareum pears possessed higher phenolic and flavonoid contents, enriched arbutin and chlorogenic acid, and strong antioxidant activity. Those results indicate that Niitaka, and Hanareum cultivars, could be best for consumption or favorable processing due to excellent product quality and high concentrations of nutritional and functional compounds.

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