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Color, Tannin Content, and Antioxidant Potential of Dried Persimmon Fruits Prepared after Different Pretreatments

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Abstract: Persimmon fruits are considered as one of the health promoting fruits and have long been considered as one of the major fruits in Korea. Drying is one of the most famous fruit processing techniques. The objective of this study was to investigate the effect of different pretreatments on the color, tannin content, and antioxidant potential of dried persimmon fruit. Hunter's color value of ST (dried persimmon prepared by soaking the fruits into 5% salt solution containing 1% citric acid for 1 min at 65°C) was significantly reduced. Although the tannin content of RB (dried persimmon prepared by spraying rice bran extracts (in 98% ethanol) and 1% citric acid for 2 min at 20°C) was significantly low, the DPPH free radical scavenging potential was high at the end of drying process. The significant differences in the parameters indicated that the color value, tannin content, and antioxidant potential of dried persimmon could be remarkably affected by the pretreatment methods.

Keywords: Antioxidant, Color Value, Drying, Pretreatment, Tannin Content

Introduction

Persimmon (*Diospyros kaki* Thunb.), a fruit containing various health promoting substances (Lia et al., 2013; Butt et al., 2015), is grown in different parts of the world. The fruits contain different bioactive compounds, including ascorbic acids, tannins, and carotenoids, which possess good antioxidant properties (Rao and Rao, 2007; Shahkoomahally et al., 2015; Fu et al., 2016). The fruits were believed to cure various diseases, like hypertension, coughs, frostbite, paralysis, burns and bleeding (Veberic et al., 2010) in the ancient medicine. A research report (Zhang et al., 2016) shows that consumption of persimmon fruit could be beneficial for prevention of atherosclerosis. It also possesses bio-physiological functions, including hypolipidemic, arteriosclerosis prevention, anticancer and antiviral activities (Kamimoto et al., 2014). In Chinese medicine, the consumption of persimmon fruit is considered beneficial against some health problems such as coughs, hypertension, dyspnoea, paralysis, burns, and bleeding because the fruit is rich in different nutrients, including vitamin C, vitamin A, calcium, iron, and phenolic compounds (Nicoleti et al., 2007). An inhibitory effect of persimmon fruits on human lymphoid leukemia cells, mutagenicity of C-nitro and C-nitroso compounds (Achiwa et al., 1997) as well as stroke and the extension of the lifespan of hypertensive rats (Uchida et al., 1995; Xie et al., 2015) have also been reported.

Although a number of reports show that the consumption of the fruits is beneficial for human health, a regular availability of fresh fruits is difficult because it can be grown only in a particular season and in specific climatic regions. In addition, some people are reluctant to have fresh fruits (Byrne, 2002). Under such circumstances, production of high quality processed fruits of persimmon offers a good economic potential.

Among the various fruit processing technologies, drying is one of the oldest methods of food preservation (Dehydration, 1998). Persimmon fruits can be preserved by drying to allow them to be available during the off-seasons when fresh fruits could not be harvested. The dry fruits may retain many of the essential nutritional characteristics of the fresh fruits, offer reduced transportation cost, and resist against the growth of microorganisms which may deteriorate the fresh fruits (Marques et al., 2006). Astringency of some of the persimmon cultivars could also be reduced with drying. Astringency and

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color play important roles in quality characteristics of dried persimmon (Akyildiz et al., 2004).

Persimmon is processed mainly by drying. A number of reports on the effect of drying on persimmon fruits have been available. The objective of this study was to investigate the color, tannin content, and antioxidant potential of dried persimmon pretreated by different methods. This study may provide information about possibility of applying various methods of fruit pretreatment before drying.

Materials and Methods

Chemicals and materials

DPPH (2,2-diphenyl-1-picrylhydrazyl) were purchased from Sigma-Aldrich (St. Louis, MO, USA). All other reagents used were of analytical grade.

Preparation of dried persimmon samples

Persimmon (*Diosyris kaki* Thunb.) cv. Chungdobansi grown at Sangju Persimmon Research Institute (Sangju, Gyeongsangbuk-do, South Korea) was considered in the present study. The average weight of fruits was 200 g and the yield was 148–185 kg per tree which was quite acceptable for commercial production. The fruits were harvested at commercial maturity stage in October of 2017 and were transported to the laboratory within 6 h of harvest.

The fruits were washed with tap water and kept at room temperature for surface drying. The astringency of the persimmon fruits were removed by treating with ethylene gas for 24 h and then the fruits were peeled off manually using a peeler. The peeled fruits were cut into four pieces and subjected to different treatments before drying. The samples were named according to the treatments as control: dried persimmon prepared without any treatment; SF: dried persimmon prepared by fumigation with sulfur powder for 15 min at container (1 m × 1 m × 1 m); ST: dried persimmon prepared by soaking the fruits into 5% salt solution containing 1% citric acid for 1 min at 65°C; RB: dried persimmon prepared by spraying rice bran extracts (in 98% ethanol) and 1% citric acid for 2 min at 20°C; HC: dried persimmon prepared by soaking in 50 ppm sodium hypochloride for 1 min at 20°C; MS: dried persimmon prepared by soaking into 0.5% sodium metabisulfite for 1 min at 20°C; AC: dried persimmon prepared by soaking into 1% N-acetylcysteine for 1 min at 20°C. The treated fruits were dried at room temperature.

Color measurement

Hunter's color value in terms of L*(lightness), a*(redness, + or greenness, –), and b*(yellowness, + or blueness, –) of the dried persimmon fruits 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 on 3 zones of the dried fruits and mean values were reported.

Tannin content

Tannin content was determined following 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×*g* for 15 min, and the supernatant was collected. The phenolic compound of the fruits was determined by adding 1 mL of 0.016 M $K_3Fe(CN)_6$ in the supernatant followed immediately by addition of 1 mL of 0.02 M $FeCl_3$ and mixing using a vortexer. After 15 min, the absorbance value of reaction mixture was measured at 700 nm using a spectrophotometer (HP 8452A Diode-Array, Hewlett-Packard Co., Palo Alto, CA, USA). The phenolics content was expressed as tannins content as described earlier (Park, 1999).

DPPH radical scavenging activity

DPPH radical scavenging activity was measured following the method described by Cheung et al. (2003) with some modification. A 0.8-mL of a 0.2 mM DPPH ethanol solution was mixed with 0.2 mL of the fruit extract using a vortexer and allowed to stand for 10 min at room temperature under dark condition, and then the absorbance value was measured at 520 nm using a microplate spectrophotometer (Multiskan GO, Thermo Fisher Scientic, Vantaa, Finland).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using SAS9.4 (SAS Institute Inc., Cary, NC, USA). Significant differences between the treatment means were separated using Tukey test at $p \leq 0.05$.

Results and Discussion

Color values of dried persimmon

Hunter's color value of the fruits was significantly varied during the drying period with the pretreatment methods applied (Table 1). Overall result showed that the L* (50.40–33.20), a* (21.5–812.31), and b* (54.13–18.91) values of ST was significantly low compared to other samples.

The color of dried persimmon is considered to have a vital role in the consumers' acceptability (Akyildiz et al., 2004). The fruit color changes to yellow or red based on the type and amount of carotenoid as persimmon matures, dried persimmon surface possesses more redness than unripe fruit (Kim et al., 1986). The difference in color values of ST might be due to pretreatment of the fruits at higher temperature (65°C), which could be attributed to the nonenzymatic browning reaction occurring at higher temperatures (Carcel et al., 2010).

Table 1. Hunter's color values of dried persimmon prepared by different treatments during drying

Color value[1)]	Sample	Drying periods (days)			
		0	2	4	6
L*	Control	53.59±1.20^{b}	42.66±1.00^{c}	38.21±1.30^{cd}	35.17±0.17^{c}
	SF	57.64±1.85^{a}	53.33±1.25^{a}	41.12±1.20^{b}	37.68±0.16^{b}
	ST	50.40±1.81^{c}	42.21±0.96^{c}	39.00±0.38^{c}	33.20±0.21^{d}
	RB	56.54±1.51^{a}	50.17±0.88^{b}	45.67±1.25^{a}	33.69±0.31^{d}
	HC	58.36±1.64^{a}	43.67±1.62^{c}	36.22±1.22^{d}	40.25±1.20^{a}
	MS	57.74±2.14^{a}	43.12±1.02^{c}	42.13±0.25^{b}	41.20±1.31^{a}
	AC	58.32±1.02^{a}	48.17±1.11^{b}	38.21±0.21^{c}	35.66±1.11^{c}
a*	Control	23.13±0.28^{b}	18.02±0.13^{c}	18.00±0.08^{b}	18.42±0.13^{c}
	SF	23.60±1.61^{ab}	21.77±1.00^{b}	14.00±1.02^{d}	15.21±0.21^{d}
	ST	21.58±1.40^{c}	16.21±1.17^{d}	12.31±1.31^{e}	12.41±0.70^{ef}
	RB	26.18±1.50^{a}	22.31±0.21^{b}	23.66±1.32^{a}	22.13±0.61^{a}
	HC	25.39±1.50^{a}	22.00±0.51^{b}	14.31±0.25^{d}	12.23±0.52^{f}
	MS	24.29±1.80^{a}	23.00±0.32^{a}	18.71±0.71^{b}	19.12±0.59^{b}
	AC	25.51±0.90^{a}	18.91±0.42^{c}	16.27±0.61^{c}	13.17±0.60^{e}
b*	Control	54.00±1.70^{b}	29.88±1.21^{b}	25.12±0.07^{c}	25.81±0.51^{d}
	SF	59.01±1.87^{a}	45.60±1.31^{a}	28.71±0.08^{b}	38.16±0.21^{b}
	ST	54.13±0.09^{b}	26.77±0.69^{e}	20.45±0.05^{e}	18.91±0.31^{f}
	RB	60.21±0.15^{a}	38.12±1.00^{b}	38.41±0.12^{a}	38.66±0.09^{b}
	HC	60.16±0.48^{a}	32.96±1.31^{c}	22.31±0.70^{d}	20.12±0.66^{e}
	MS	59.19±1.02^{a}	46.68±1.24^{a}	28.98±0.69^{b}	40.17±0.78^{a}
	AC	59.58±1.30^{a}	45.12±0.96^{a}	28.99±0.88^{b}	30.02±0.31^{c}

[1)]Samples are defined in preparation of dried persimmon samples (Materials and Methods).
[2)]L*, lightness (100, white; 0, black); a*, redness (–, green; +, red); b*, yellowness (–, blue; +, yellow).
[3)]Quoted values are means ±SD of triplicate measurements. Values followed by different letters in the same column are significantly different ($p<0.05$).

Tannin content of dried persimmon

The pretreatment of persimmon fruit significantly affected the tannin content of dry fruits (Table 2). The tannin content of ST (966.02 ppm) was significantly low at onset of drying process compared to AC (1603 ppm) followed by SF (1528.38 ppm). A significantly high tannin content was found in ST (15.16 ppm) and the control (16.12 ppm), whereas the lowest content was found in HC (3.14 ppm) at the end of drying.

Tannins are one of the important bioactive molecules present in persimmon (Ahn et al., 2002; Vázquez-Gutiérrez et al., 2013). Although the effect of high temperature (65°C) treatment was observed on the low tannin content (Rakić et al., 2004) during the initial period of drying, the effect was not found on the final product. However, report shows that high temperature treatment adversely affects the nutritional value of the persimmon fruits since the health-benefiting effect of phytochemical like citric acid depends on temperature and is more effective at lower temperatures (Carcel et al., 2010).

Table 2. Tannin content (ppm) of dried persimmon prepared by different treatments during drying

Sample[1)]	Drying period (days)			
	0	2	4	6
Control	1439.35±23.51[ab]	179.11±8.91[a]	50.29±2.31[b]	16.12±1.23[a]
SF	1528.38±87.75[ab]	185.31±8.71[a]	60.37±3.51[a]	13.15±1.33[b]
ST	966.02±15.19[d]	95.22±9.81[c]	51.22±4.21[b]	15.16±2.11[ab]
RB	1266.42±62.18[c]	121.17±10.12[b]	42.23±3.12[c]	4.17±1.00[d]
HC	1513..40±46.98[b]	132.16±11.88[b]	98.00±3.00[d]	3.14±0.89[e]
MS	1479.52±16.39[b]	136.04±6.55[b]	42.12±2.12[c]	7.16±1.12[c]
AC	1603.15±42.29[a]	133.02±8.32[b]	43.03±2.00[c]	4.18±1.01[d]

[1)]Samples are defined in preparation of dried persimmon samples (Materials and Methods).
[2)]Quoted values are means ±SD of triplicate measurements. Values followed by different letters in the same column are significantly different (p<0.05).

DPPH radical scavenging activities

The DPPH radical scavenging potential of persimmon fruits were not significantly (p>0.05) different at the beginning of drying, however it varied significantly (p<0.05) afterwards (Table 3). The highest DPPH radical scavenging potential was found in RB (59.21%) followed by AC (58.35%) at 2 days of drying. The relative value of DPPH for RB was reduced compared to the other samples except for AC at 4 days of drying. The DPPH value was significantly low for ST (58.31%) at the end of drying process.

The reduced DPPH free radical scavenging of ST might be due to the pretreatment of fruits at higher temperature (65°C). High temperature reduces the antioxidant potential of bioactive compounds (Yoshioka et al., 1990, Cao et al., 2006).

Table 3. DPPH radical scavenging activities (%) of dried persimmon prepared by different treatments during drying

Sample[1)]	Drying periods (days)			
	0	2	4	6
Control	56.29±1.73[a]	57.66±0.37[b]	58.18±1.30[ab]	61.17±1.35[a]
SF	56.82±0.76[a]	56.78±0.62[b]	57.12±1.21[ab]	61.60±1.31[a]
ST	55.31±0.62[a]	56.72±1.11[b]	58.72±0.78[a]	58.31±1.23[b]
RB	55.58±0.42[a]	59.21±1.20[a]	52.17±0.85[c]	61.17±1.64[a]
HC	54.29±0.95[a]	49.31±1.32[c]	59.31±0.78[a]	60.13±1.33[ab]
MS	56.48±0.81[a]	48.37±1.22[c]	56.92±0.25[b]	62.31±1.20[a]
AC	55.35±1.21[a]	58.35±0.55[ab]	47.31±1.21[d]	61.35±0.98[a]

[1)]Samples are defined in preparation of dried persimmon samples (Materials and Methods).
[2)]Quoted values are means ±SD of triplicate measurements. Values followed by different letters in the same column are significantly different (p<0.05).

In conclusion, the persimmon fruits were subjected to different methods of treatment before drying in order to investigate the effect of different pretreatments on the color, tannin content, and antioxidant potential on the dry fruits. The results showed that Hunter's color value of ST (dried persimmon prepared by soaking the fruits into 5% salt solution containing 1% citric acid for 1 min at 65°C) was significantly reduced. Although the tannin content of RB (dried persimmon prepared by spraying rice bran extracts (in 98% ethanol) and 1% citric acid for 2 min at 20°C) was significantly low, the DPPH free radical scavenging potential was high at the end of drying process. The results indicated that the color value, tannin content, and antioxidant potential of dried persimmon could be affected by the pretreatment methods.

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