academicJournals

Vol. 13(22), pp. 2231-2239, 28 May, 2014
DOI: 10.5897/AJB2013.13503
Article Number: F67722F44903
ISSN 1684-5315

http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Exogenous application of natural extracts of persimmon (*Diospyros kaki* Thunb.) can help in maintaining nutritional and mineral composition of dried persimmon

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Received 26 November, 2013; Accepted 16 May, 2014

Persimmon (*Diospyros kaki* Thunb.) fruit is delicious as well as rich in nutritive and medicinal values. The fruit is not available throughout the year and also could not be grown across the world but is liked in many countries. Many people have access only to the dried fruits. Therefore, the demand of quality dry fruit is very high. This study was carried out to investigate the effect of persimmon-peel extracts in maintaining the quality characteristics of dried persimmon. Different treatments applied to the dried fruit were assessed on the basis of physicochemical and organoleptic properties. The findings reveal that dried persimmon sprayed with 10% persimmon-peel extract exhibited the highest overall acceptance value with considerable nutritional and mineral composition as compared to other treatments. The results suggest that application of persimmon-peel extracts could rather be effective to enhance the overall acceptance of dried persimmon fruit together with maintaining its nutritional quality as compared to the commercially available synthetic preservatives.

Key words: Exogenous application, natural extract, nutritional composition, mineral composition, dried persimmon.

INTRODUCTION

Persimmon (*Diospyros kaki* Thunb.) is native to China but has been cultivated in many countries having cold climatic condition. It is a very delicious fruit with different nutrients and phytochemicals such as carbohydrates, organic acids, vitamins, tannins, polyphenols, dietary fiber, carotenoids, etc., which significantly contribute to its taste, color, nutritive and medicinal values (Celik and Ercisli, 2007; Del Bubba et al., 2009; Ebert and Gross, 1985; Gorinstein, 1999). This fruit is seasonal so it is not available throughout the year and also could not be cultivated across the world but is liked in many countries. Therefore, dried fruits could be a good option to them who are living in those areas where persimmon is not produced.

A diet fortified with dry persimmon peel is more efficient than the same diet fortified with dry persimmon pulp. The health-derived benefits are more in the peel due to the presence of carotenoids, polyphenols, ascorbic acid, and dietary fiber as compared to pulp (Gorinstein et al., 1994; 1998). Yokozawa et al. (2007) found the potential benefits of persimmon peel as a valuable source of antioxidant in the diabetic condition which reduced the oxidative stress induced by hyperglycemia. The protective potential of proanthocyanidin from persimmon peel was active against oxidative damage under the aging process since the polymerization of proanthocyanidin plays an important role in retarding aging in a cellular senescence model (Lee et al., 2008).

Different synthetic chemicals have been used as preservative of dried persimmon. To maintain the quality in persimmon, sulfur fumigation is often conducted to prevent surface browning and fungi attacks (Miller, 1984). The hazardous nature of sulfur, however, raises a health risk and food safety concerns (Islam and Hoque, 2013). Sulfur dioxide remained in food causes asthma or allergic reaction to some people. To reduce health risks and maintain essential quality of persimmon during drying, the present study investigated different potential measures. The objective of this research was to develop a safe method for preparing dried persimmon by treating it with natural extracts to eliminate potential health hazards of sulfur. Persimmon fruits were processed with varied concentrations of persimmon-peel extracts and persimmon wine to determine the effect of natural extracts on the quality of the resulting dried fruits. It was expected that the success and adoption of this natural treatment method could play a significant role in strengthening the competitiveness of harmful chemical-free persimmon products.

MATERIALS AND METHODS

Sample materials and chemicals

Persimmon fruits of cultivar *Doongsi*, grown at Sangju Persimmon Experiment Station, Sangju, Korea, were harvested at commercial maturity stage in October 2011. Sulfur powder and prethanol A (commercially available 95% ethanol with chemical formula C_2H_5OH) were purchased from Duksan Pure Chemicals Co. Ltd. (Korea), and red wine containing 15% alcohol produced in 2005 (Cabernet Sauvignon, Australia), was obtained from a local wholesale market in Korea. Glucose, fructose, and sucrose were purchased from Sigma Chemical Co. (St. Louis, Mo, USA).

Preparation of persimmon-peel extracts

Persimmon fruits were washed with tap water and peeled off with a knife and sliced into about 1 cm size. A 200 g of sliced peel was extracted in 1800 ml of 50% prethanol A solution for 24 h. The persimmon peel extract was filtered and concentrated by rotary evaporation. The final concentration of persimmon peel extract was adjusted to 10%.

Preparation of dried persimmon sample

The fruits were washed with tap water and peeled off using peeler. The pedicels of peeled fruits were tied with string and hanged for natural drying. Before kept for drying, the fruits were treated as following: T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; T-2, dried persimmon sprayed with 70% prethanol A solution; T-3, dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; T-4, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); T-5, dried persimmon sprayed with 10% persimmon-peel extract; T-6, control sample (dried persimmon containing no added extract); T-7, dried persimmon burned with sulfur powder for 10 min at 20±1°C; T-8, dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; T-9, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10% persimmon-peel extract; and T-10, dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia).

About seven fruits were tied in 1 m long strings and 2 to 3 strings were tied together while hanging for drying. The strings of persimmons were hung under the eaves of a roof where they got plenty of sun and breeze but were protected from rain. As the fruit dried, a white substance of sugar started appearing on the surface. How long it takes to dry depends on the size of the fruit and the environmental conditions. In this experiment, fruits were dried for 28 days and physical, chemical, and organoleptic analyses were carried out.

Proximate analysis

The moisture, crude protein, ash, and crude fiber content of dried persimmon were determined according to AOAC (1995) approved methods 950.01, 976.05, 955.03, and 962.09, respectively. Three replicates of each experiment were conducted to take data with three samples in each replication.

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Abbreviations: T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; **T-2,** dried persimmon sprayed with 70% prethanol A solution; **T-3,** dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; **T-4,** dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); **T-5,** dried persimmon sprayed with 10% persimmon-peel extract; **T-6,** control sample (dried persimmon containing no added extract); **T-7,** dried persimmon burned with sulfur powder for 10 min at 20±1°C; **T-8,** dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; **T-9,** dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10 % persimmon-peel extract; and **T-10,** dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia).

Color measurement

Color measurement of sample was done by using a Chroma Meter CR-300 (Minolta Corp., Japan). Results were recorded using 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 with D65 illuminant. Color values were measured on three places of outer surface of three samples and the average was taken. Three independent replications were made for data analysis.

Water activity and soluble solids content (°Brix) determination

Water activity (a_w) was measured at 30°C with a Novasina (Samil Ltd., RTD-500, Korea) that allows temperature controlled measurements of a_w. Samples were analyzed for total soluble solids content (SSC) using a digital Refractometer (DR-A1, ATAGO Co. Ltd., Japan) equipped with a Thermostatic water bath set at 20°C. Three replications were made to analyze data with three samples in each replication.

Texture profile analysis

A universal Texture Analyzer TA.XT2 (Stable Micro Systems Ltd., Surrey, England) was used for the texture profile analysis (TPA) (Bourne, 1978) with the probe (P/5 probe, 5 mm diameter). The test speed was 1.0 mm/s, the post test speed 5.0 mm/s, and the distance was 5.0 mm. Samples were tested in triplicates. The following TPA parameters were obtained through the XT.RA dimension software package (SMS, 1992). The mean of three samples was considered for each replication and three replications were made for data analysis. The hardness values were corrected for the different sample areas and expressed as (kg/cm^2).

Determination of free sugar

Free sugars were analyzed using a method of Genard and Souty (1996). A 5 g of each sample was added to 10 ml of distilled water and homogenized using a Homogenizer (Ultra-Turrax T-25, IKA-Labortechnik, Germany), followed by adding 20 ml of distilled water, then by centrifugation at 16,000 × *g* for 30 min. The collected supernatant was filtered through a Sep-Pak C18 cartridge (WAT023501, Waters, USA) and a Millipore 0.45-syringe filter (PVDF, Whatman, Japan). Free sugars were quantified using a high performance liquid chromatography (HPLC) (Model 9300, Younglin, Korea) consisting of a Refractive Index Detector (Triathlon M730D, Younglin, Korea), a column heater set at 85°C, Sugar-Pak (6.5 × 300 mm Alltech, USA), and the mobile phase of deionized-distilled H_2O delivered at 0.5 ml/min. Glucose, fructose, sucrose, and sorbitol, obtained from Aldrich Chemical Co. Inc. (Milwaukee, WI, USA), were used as reference sugars for identification. Manitol was used as the internal standard and the free sugars were expressed as percentage dry weight.

Determination of mineral content

A 0.5 g of sample was mixed with 15 ml of 65% nitric acid (HNO_3). A solution was diluted with 50 mL of distilled water. Essential minerals were determined by Inductively Coupled Plasma (ICP) Emission Spectrophotometer (38 Plus, Jobin Yvon, Co., France) and heavy metals by Atomic Absorption Spectrometer (Varian Spectra, AA-220 FS, Australia) by following Bond et al. (2005). The instrument was calibrated using known standards for each mineral. Average values of two replicates were used for data analysis.

Sensory properties evaluation

Samples prepared with different treatments were rated for color, taste (sweetness, astringency), texture, and overall acceptance, respectively, on the following scale: 1 point= very bad, 2 point= bad, 3 point = moderate, 4 point = good, 5 point = very good. All the sensory properties were evaluated by 10 panelists (5 women and 5 men) randomly selected in Kyungpook National University, Daegu, Korea. The results showed are the average values of 10 evaluations for each sensory property.

Statistical analysis

All the data were expressed as mean±standard deviation. The statistical analyses were performed using the SPSS software. One-way analysis of variance (ANOVA) was used to test statistical differences between treatments. Duncan's multiple range tests were used to examine the differences among treatment means. Statistical significance level was considered at $p<0.05$.

RESULTS AND DISCUSSION

Peels are removed during the processing of dried persimmon fruit. However, reports indicate that persimmon peel contain high nutritional and medicinal values. The 2-methoxy-4-vinylphenol which is a component of persimmon peel has high antioxidant activity lost along with the peels (Fukai et al., 2009). Son et al. (2013) indicate that persimmon peel might possess a potential anti-atherogenic effect. Therapeutic properties of persimmon peel extract show potential antitumor and multidrug resistance-reversing agents (Kawase et al., 2003). Results of this study also showed that exogenous application of persimmon peel extract not only improves the physical and organoleptic properties but also enhance the nutritive value.

Proximate composition of dried persimmon

Proximate attributes such as crude fiber, protein, moisture, and ash of dried persimmons, exposed to various treatments, were determined. The results of each proximate parameter are given in Table 1. Moisture content of T-6 was the lowest (40.9%) while it was the highest in T-9 (45.5%). There was not any significant difference in the crude protein level among different samples (1.16%-1.37%). Crude fiber content ranged from 1.91 (T-9) to 3.11% (T-5), while the crude ash was found highest (1.42%) in T-6 and the lowest (0.8%) in T-4. Evaluation of proximate and nutrient compositions of food products plays a crucial role in assessing their nutritional significance (Kochhar et al., 2006) and devising safer ways to preserve the essential ingredients of the produce (Pandey et al., 2006). World Health Organization has also emphasized on the need and importance of determining proximate and micronutrients analysis of various

Table 1. Proximate composition of dried persimmon prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Composition (% wet basis)			
	Moisture	**Crude protein**	**Crude fiber**	**Crude ash**
T-1	44.6±0.32[b2)]	1.28±0.12[a]	2.30±0.24[c]	1.08±0.03[d]
T-2	41.7±0.12[e]	1.37±0.21[a]	2.72±0.16[b]	1.12±0.02[d]
T-3	43.8±0.13[c]	1.28±0.17[a]	2.41±0.21[bc]	1.00±0.03[e]
T-4	41.9±0.22[d]	1.29±0.05[a]	2.33±0.19[c]	0.80±0.04[g]
T-5	42.2±0.31[d]	1.20±0.06[a]	3.11±0.20[a]	1.33±0.02[b]
T-6	40.9±0.17[f]	1.22±0.11[a]	2.81±0.18[ab]	1.42±0.02[a]
T-7	42.2±0.19[d]	1.23±0.10[a]	2.16±0.23[cd]	0.91±0.02[f]
T-8	44.3±0.34[b]	1.16±0.09[a]	2.09±0.31[cd]	1.00±0.03[e]
T-9	45.5±0.21[a]	1.18±0.11[a]	1.91±0.21[d]	1.11±0.04[d]
T-10	42.7±0.35[d]	1.24±0.11[a]	2.37±0.11[c]	1.17±0.02[c]

[1)]T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; T-2, dried persimmon sprayed with 70% prethanol Asolution; T-3, dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; T-4, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); T-5, dried persimmon sprayed with 10% persimmon-peel extract; T-6, control sample (dried persimmon containing no added extract); T-7, dried persimmon burned with sulfur powder for 10 min at 20±1°C; T-8, dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; T-9, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10% persimmon-peel extract; and T-10, dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia). [2)]Quoted values are the averages of triplicate experiments. [a-f)]The mean values followed by different superscripts in the same column are significantly different ($p<0.05$).

processed food products. In present study, the proximate parameters were not greatly affected by the various treatments as compared to untreated sample.

Color measurement

The color of the processed persimmon has been known to play an important role in the consumer's acceptability. Table 2 reveals the Hunter's color value of the dried persimmon prepared under different treatment. The control sample (T-6) possessed the highest (43.52) value for lightness while T-2 scored the lowest (30.11). Regarding the redness value, T-6 sample with the highest lightness value showed the lowest (3.28) redness value but it was not true in case of the corresponding lowest lightness value as T-8 which scored the highest (5.68) value for redness.

The yellowness value was highest (4.69) in T-9 and the control sample (T-6) scored the lowest (2.26) yellowness value. T-5 sample which was sprayed with persimmon-peel extract had higher redness and yellowness value than that of T-7 (sample treated with sulfur power). These factors act as a determinant for quality product and are suggested to have a direct impact on the consumer acceptability. Since fruit color changes to yellow or red according to kind and amount of carotenoid as persimmon matures, its dried persimmon surface is more red and better than unripe fruit (Kim et al., 1986).

Water activity and soluble solids content

As shown in Table 3, the soluble solids content (SSC) of samples ranged from 51.2 (T-2 and T-3) to 63.2 (T-5) °Brix. SSC differences among samples were observed significant. The results showed that SSC was higher in persimmon-peel extract sprayed dried than in control sample which might be because of spraying of persimmon-peel extracts.

The water activity (a_w) levels among samples were varied, which ranged 0.85 to 0.94. Water activity is a measure of how efficiently the water present could take part in a chemical reaction. Water activity is also a critical factor that determines shelf life for foods as most of the bacteria do not grow at water activities below 0.91 (Paster, 1968). Thus samples of T-2 (a_w= 0.85), T-3 (a_w=0.90), T-4 (a_w=0.86), T-5 (a_w=0.91), T-6 (a_w=0.87), T-8 (a_w=0.90), T-9 (a_w=0.91) and T-10 (a_w=0.91) were shown to have resistance against microbial attack.

Textural properties of dried persimmon

Textural properties of dried persimmon are presented in Table 4. Hardness value of T-7 sample (4.21 kg/cm^2) was the highest among different samples. T-5 sample revealed moderate value (1.35 kg/cm^2) for hardness whereas T-3 and T-8 samples had 0.88 kg/cm^2. Reports show that high a_w (Kim and Jung, 2011; Chun et al., 2012) and high

Table 2. Hunter's color values of dried persimmons prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Color value[3)]		
	L (Lightness)	a (Redness)	b (Yellowness)
T-1	32.83±2.10[bcd2)]	5.54±0.06[a]	3.45±0.02[c]
T-2	30.11±1.09[d]	5.19±0.09[a]	3.42±0.05[c]
T-3	32.24±0.91[c]	4.90±0.10[b]	3.46±0.04[c]
T-4	33.04±0.81[c]	4.61±0.19[bc]	3.55±0.09[c]
T-5	36.24±2.01[b]	4.88±0.21[b]	4.01±0.05[b]
T-6	43.52±1.51[a]	3.28±0.31[d]	2.26±0.06[d]
T-7	34.56±1.11[bc]	4.52±0.09[c]	3.69±0.10[c]
T-8	32.60±1.92[bcd]	5.68±0.51[a]	3.33±0.21[c]
T-9	33.29±1.81[bc]	5.19±0.67[ab]	4.69±0.31[a]
T-10	31.47±1.00[cd]	5.52±0.58[ab]	2.30±0.27[d]

[1)]Abbreviations are specified in Table 1. [2)]Quoted values are the averages of triplicate experiments; [3)]L, lightness (100, white; 0, black); a, redness (-, green; +, red); b, yellowness (-, blue; +, yellow). [a-f)]The mean values followed by different superscripts in the same column are significantly different ($p<0.05$).

Table 3. Water activity (a_w) and soluble solids content (SSC) of dried persimmon prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Parameter[3)]	
	A_w	SSC (°Brix)
T-1	0.94 ± 0.02[a2)]	57.8 ± 0.2[c]
T-2	0.85 ± 0.03[c]	51.2 ± 0.1[f]
T-3	0.90 ± 0.01[b]	51.2 ± 0.2[f]
T-4	0.86 ± 0.03[bc]	52.3 ± 0.3[e]
T-5	0.91 ± 0.01[ab]	63.2 ± 0.2[a]
T-6	0.87 ± 0.02[bc]	55.6 ± 0.3[d]
T-7	0.92 ± 0.01[ab]	52.0 ± 0.4[e]
T-8	0.90 ± 0.03[ab]	52.3 ± 0.3[e]
T-9	0.91 ± 0.03[ab]	60.2 ± 0.2[b]
T-10	0.91 ± 0.04[ab]	63.0 ± 0.1[a]

[1)] T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; T-2, dried persimmon sprayed with 70% prethanol A solution; T-3, dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; T-4, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); T-5, dried persimmon sprayed with 10% persimmon-peel extract; T-6, control sample (dried persimmon containing no added extract); T-7, dried persimmon burned with sulfur powder for 10 min at 20±1°C; T-8, dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; T-9, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10% persimmon-peel extract; and T-10, dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia). [2)]Quoted values are the averages of triplicate experiments. [3)]A_w, water activity; SSC, soluble solids content. [a-f)]The mean values followed by different superscripts in the same column are significantly different ($p<0.05$).

soluble solids content (°Brix) decrease hardness (Özdemir et al., 2009). Results of this study also showed lower hardness value in T-5 than T-6, which might be due to higher a_w and SSC in the former sample (Table 3).

Effect of treatments on free sugar content of dried persimmon

The results of sugar content, as glucose and fructose, of dried persimmon after treatments are shown in Table 5. The glucose levels ranged between 15.50 to 28.90%. The results show that the application of persimmon peel extracts increased the glucose content significantly. Fructose levels were found to have 26.10% in T-5, 19.02% in T-6 and the lowest (14.36%) in T-1. Fructose content of T-5 sample was the highest among the samples.

Total free sugar content of T-5 sample was higher than that of T-6 and showed higher preference by consumers to the persimmon peel extract sprayed dried persimmon over sample without any treatment. Sucrose was not detected in all samples (data not shown). The quantities of sugar in fully mature fruit of persimmon can vary greatly among different cultivars and also it can be affected by the processing methods (Senter et al., 1991).

Mineral contents of dried persimmon

Essential minerals contents of dried persimmons treated with different chemicals and natural extracts are shown in

Table 4. Textural properties of dried persimmon prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Parameter		
	Hardness (Kg/cm^2)	Cohesiveness	Springiness (%)
T-1	1.06±0.01$^{g2)}$	85.40±0.03^{e}	86.08±0.03^{e}
T-2	1.21±0.02^{e}	93.56±0.03^{a}	93.33±0.02^{b}
T-3	0.88±0.01^{i}	65.79±0.02^{i}	70.26±0.04^{h}
T-4	1.12±0.02^{f}	58.70±0.02^{j}	68.89±0.02^{i}
T-5	1.35±0.02^{d}	92.30±0.02^{b}	95.11±0.02^{a}
T-6	3.36±0.03^{b}	81.41±0.04^{h}	83.45±0.03^{f}
T-7	4.21±0.03^{a}	84.91±0.02^{f}	86.44±0.03^{e}
T-8	0.88±0.01^{i}	86.74±0.03^{d}	88.84±0.03^{c}
T-9	0.99±0.01^{h}	88.38±0.03^{c}	88.08±0.02^{d}
T-10	1.43±0.02^{c}	82.77±0.02^{g}	81.73±0.03^{g}

[1)]T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; T-2, dried persimmon sprayed with 70% prethanol A solution; T-3, dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; T-4, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); T-5, dried persimmon sprayed with 10% persimmon-peel extract; T-6, control sample (dried persimmon containing no added extract); T-7, dried persimmon burned with sulfur powder for 10 min at 20±1°C; T-8, dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; T-9, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10% persimmon-peel extract; and T-10, dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia).[2)]Quoted values are the averages of triplicate experiments. [a-j)]The mean values followed by different superscripts in the same column are significantly different ($p<0.05$).

Table 5. Free sugar content of dried persimmon treated prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Free sugars (% weight basis)	
	Glucose	Fructose
T-1	17.73±1.31$^{cd2)}$	14.36±1.61^{d}
T-2	22.20±2.00^{bc}	25.53±2.38^{ab}
T-3	15.50±1.21^{d}	15.46±1.31^{d}
T-4	26.95±2.00^{ab}	18.66±0.11^{c}
T-5	28.90±1.09^{a}	26.10±1.51^{a}
T-6	20.12±1.51^{c}	19.02±1.00^{bc}
T-7	24.83±0.99^{b}	21.19±0.92^{bc}
T-8	24.01±1.02^{b}	20.12±1.81^{bc}
T-9	20.58±2.12^{c}	19.02±1.71^{bc}
T-10	24.01±2.01^{bc}	22.29±1.92^{b}

[1)] T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; T-2, dried persimmon sprayed with 70% prethanol A solution; T-3, dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; T-4, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); T-5, dried persimmon sprayed with 10% persimmon-peel extract; T-6, control sample (dried persimmon containing no added extract); T-7, dried persimmon burned with sulfur powder for 10 min at 20±1°C; T-8, dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; T-9, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10% persimmon-peel extract; and T-10, dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia).[2)]Quoted values are the averages of triplicate experiments.[a-d)]The mean values followed by different superscripts in the same column are significantly different ($p<0.05$).

Table 6. Mineral contents of dried persimmon prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Element (mg/kg)						
	K	Mg	Ca	Na	Fe	Zn	Mn
T-1	4479±6[e2)]	495±5[d]	522±5[b]	77±2[a]	61±2[a]	ND	ND
T-2	4487±7[e]	402±4[h]	440±2[e]	52±1[e]	45±1[d]	ND	ND
T-3	4651±6[d]	430±3[f]	367±3[g]	54±1[e]	51±1[c]	ND	ND
T-4	4378±9[g]	473±4[f]	453±4[d]	69±1[c]	53±2[bc]	ND	ND
T-5	4100±8[h]	392±4[g]	418±5[f]	51±2[e]	48±1[d]	ND	ND
T-6	6312±7[a]	709±3[a]	423±7[f]	61±1[d]	46±1[d]	ND	ND
T-7	4414±6[f]	519±2[b]	525±6[b]	71±2[b]	54±1[bc]	ND	ND
T-8	4406±9[f]	476±5[f]	539±3[a]	68±2[c]	55±1[b]	ND	ND
T-9	4832±8[c]	512±2[c]	538±4[a]	78±2[a]	56±1[b]	ND	ND
T-10	4923±8[b]	483±3[e]	471±5[c]	67±1[c]	53±1[bc]	ND	ND

[1)]Abbreviations are specified in Table 1. [2)]Quoted values are the average of duplicate experiments. [3)]ND, not detected. [a-h)]Means values followed by different superscripts with a column indicate significant differences ($p<0.05$).

Table 6. Heavy metals such as arsenic (As), lead (Pb), cadmium (Cd) and mercury (Hg) were not detected in any sample (data not shown). Some essential minerals like zinc (Zn) and manganese (Mn) were also not detected; however, potassium (K), magnesium (Mg), calcium (Ca), sodium (Na) and iron (Fe) were found in varying amounts. The composition of K (6312 mg/kg) and Mg (709 mg/kg) were significantly high in T-6 as compared to other samples. Mineral levels of all samples were shown in the order of K (4100 to 6312 mg/kg) > Mg (392 to 709 mg/kg) > Ca (367 to 539 mg/kg) > Na (51 to 78 mg/kg) > Fe (45 to 61 mg/kg). These results indicate the mineral levels in dried persimmons increase or decrease depending on the treatment. Results reveal that high K and Mg could be obtained in untreated sample, however, levels of Ca, Na, and Fe could be enhanced with application of different chemicals and/or persimmon peel extracts.

Sensory characteristics of dried persimmon

Sensory characteristics of the dried persimmons were determined by color, sweetness, astringency, texture, and overall taste (Table 7). Sensory evaluations showed that T-5, T-8 and T-9 were the highly preferable samples to the consumers. Color score of T-5 sample was the highest among others. The highest score for sweetness was found to T-10 sample and overall taste to T-5. Overall taste of T-5 sample might be enhanced with the application of 10% concentrated persimmon-peel extracts. Sodium metabisulfite treatment gives the best physical, chemical, and microbiological results over the untreated dried persimmon, the latter gives the highest sensory scores (Bölek and Obuz, 2014). However, results of this study shows that use of 10% concentrated persimmon-peel extracts imparted the best overall taste than that of untreated dried persimmon, but beyond 15% extracts, overall taste was negatively affected (data not shown). Results of higher sensory properties signified that application of persimmon-peel extracts on the preparation of dried persimmon could be more effective to enhance the overall acceptance of dried persimmon.

Conclusions

The results of the present study portray beneficial effects of various natural extract treatments and conditions on the dried persimmons. The findings revealed that dried persimmon when sprayed with 10% persimmon-peel extract for 2 min at 20±1°C could exhibit higher acceptance values as compared to other treatments. The impacts of different treatments on the free sugar, color, texture and mineral values were interesting as compared to control. However, further analysis of phytochemicals and other parameters could be useful to understand various regulations happening during the fruit development and processing.

It is evident from these results that application of persimmon-peel extracts in the preparation of dried persimmon could be effective as it avoids the use of health hazardous chemical preservatives and also to some extent restores the nutritive and medicinal properties lost with the peeled out skin before drying.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This work was supported in part by Grants from R&D project to overcome Free Trade Agreement (FTA) program

Table 7. Sensory characteristics of dried persimmon prepared with application of different chemicals and/or persimmon peel extracts.

Sample[1)]	Characteristic				
	Color	Sweetness	Astringency	Texture	Overall acceptance
T-1	3.1±0.2[b2)]	3.6±0.1[a]	2.1±0.3[a]	3.5±0.1[a]	3.1±0.1[c]
T-2	3.1±0.1[b]	3.6±0.2[a]	2.1±0.2[a]	3.6±0.3[ab]	3.2±0.2[bc]
T-3	3.2±0.2[b]	3.7±0.1[a]	2.1±0.2[a]	3.6±0.2[a]	3.2±0.1[bc]
T-4	3.2±0.2[b]	3.6±0.2[a]	2.2±0.2[a]	3.5±0.1[a]	3.5±0.2[b]
T-5	4.1±0.1[a]	3.9±0.3[a]	1.3±0.3[b]	3.8±0.2[a]	4.2±0.2[a]
T-6	2.5±0.3[c]	3.2±0.1[b]	2.2±0.1[a]	3.3±0.3[ab]	2.9±0.3[c]
T-7	2.9±0.1[bc]	3.1±0.1[b]	2.2±0.3[a]	3.2±0.1[b]	3.0±0.1[c]
T-8	3.2±0.2[b]	3.9±0.3[a]	1.7±0.4[ab]	3.5±0.2[ab]	4.1±0.1[a]
T-9	3.3±0.3[b]	3.9±0.2[a]	1.8±0.2[ab]	3.6±0.1[a]	4.1±0.2[a]
T-10	3.1±0.2[b]	4.3±0.2[a]	1.2±0.3[c]	3.7±0.2[a]	3.9±0.3[ab]

[1)] T-1, dried persimmon soaked in 70% prethanol A solution for 2 min at 20±1°C; T-2, dried persimmon sprayed with 70% prethanol A solution; T-3, dried persimmon soaked in Medilox (60 ppm Hypochlorous acid) for 2 min at 20±1°C; T-4, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid); T-5, dried persimmon sprayed with 10% persimmon-peel extract; T-6, control sample (dried persimmon containing no added extract); T-7, dried persimmon burned with sulfur powder for 10 min at 20±1°C; T-8, dried persimmon sprayed with 70% prethanol A followed by spraying with 10% persimmon-peel extract; T-9, dried persimmon sprayed with Medilox (60 ppm Hypochlorous acid) followed by spraying with 10% persimmon-peel extract; and T-10, dried persimmon sprayed with wine (Alcohol 15%, Cabernet Sauvignon, Australia). [2)]Quoted values are the mean of triplicate determinations, mean of n = 10 based on 5-point scores (very poor, 1; poor, 2; fair, 3; good, 4; very good, 5). [a-d)]Mean values followed by different superscripts within a column indicate significant differences (p<0.05).

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