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Characteristics of Apple, Persimmon, and Strawberry Slices Dried with Maltodextrin

– Research Note –

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Abstract

Apple, persimmon, and strawberry slices were dehydrated after treating with 30, 50, and 80% (w/w) maltodextrin solution. The dried apple, persimmon, and strawberry slices were compared with hot air-dried and freeze-dried samples in terms of rehydration ratio, ascorbic acid, color, and sensory evaluation. The rehydration ratio of maltodextrin-treated samples was greater than that of hot-air or freeze-dried samples. Maltodextrin-treated samples had higher content of ascorbic acid than other dried samples. Additionally, maltodextrin-treated apple, persimmon, and strawberry slices had better color and sensory evaluations than those of freeze-dried or hot-air dried samples. These results suggest that, compared to other drying methods, dehydration of apple, persimmon, and strawberry slices using maltodextrin is very efficient, resulting in good rehydration capacity, minimal destruction of ascorbic acid, and good color and sensory evaluation.

Key words: fruit slices, drying, maltodextrin, rehydration

INTRODUCTION

Dehydrated fruit provides conveniences in transportation and storage, compared to fresh fruit, and can be used as ready-to-eat food (1). However, drying of fruit can cause the loss of quality in flavor and color. In addition, shrinkage following the loss of water and low sorption capacity of the dehydrated fruit can be a problem (1,2).

Freeze-drying is one method for drying food, and is known to result in good quality dehydrated food, especially when compared to hot-air drying which usually causes loss of food quality. However, there are some issues with freeze-drying, such as a long processing time and a high cost (2-5). Therefore, osmotic dehydration is suggested as an alternative to freeze-drying or hot-air drying for improving the quality of dried food. Osmotic dehydration is a simple and low cost process, and is applicable for perishable fruit and vegetable products (4-8). The quality of dried food prepared by osmotic dehydration can be affected by the type and amount of dehydrating agent (1,4,9). In particular, some solutes from the osmotic solution can get inside the plant cell wall, resulting in mechanical and textural changes in the cells (8-10). The amount of water coming out of the fruit is much larger than the counter flux of osmoactive materials, and the water transfer out of the cell is accompanied by loss of vitamins and minerals as well as flavor compounds (11,12).

To resolve the disadvantage of osmotic dehydration method, molecular press dehydration using maltodextrin has been investigated. The method is mainly based on cytorrhysis, which is similar to osmotic dehydration except for the size of dehydrating agent. The major difference is that cytorrhysis occurs outside the plant cell due to the size of dehydrating agent (13,14). Plant cells can be dehydrated as they are contracted by diffusion pressure of specific polymer molecules applied to the cell wall, as long as the polymer's size is bigger than the pores of cell wall so that they cannot be transferred across the cell wall (15). For molecular press dehydration, maltodextrin is suggested as an effective dehydrating agent for dehydration of fruits and vegetables (16,17). It has been also reported that pretreatment of tomatoes with maltodextrin before drying had a better color, texture, and firmness than the control (4).

The objectives of this study were to investigate the effect of maltodextrin as a dehydrating agent on drying of apple, persimmon, and strawberry slices, and to compare this method with hot-air drying and freeze-drying in terms of rehydration ratio, color, and sensory evaluation.

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MATERIALS AND METHODS

Sample preparation

Apples, persimmons, and strawberries were purchased from a local market, and sliced using a cutter to ensure a uniform thickness (1±0.5 mm). Maltodextrin DE 9～12 (Daesang, Gunsan, Korea) was used as a dehydrating agent. The initial moisture contents of apples, persimmons, and strawberries were 86.0, 85.2, and 93.1%, respectively.

Drying process

Sliced apples, persimmons, and strawberries (200 g) were dehydrated at 25°C for 10 hr in a low density polyethylene bag containing 30, 50, and 80% (w/w) maltodextrin solution. Samples were then centrifuged at 376× *g* for 5 min and placed in an incubator at 25°C to eliminate any remaining water. For freeze-drying, samples (200 g) were frozen at -70°C and lyophilized (FD-5508, Ilshin Lab Co., Seoul, Korea). For hot-air drying, the same amount of samples were dried using a hot air dryer (HB-502LP, Hanbaek Co., Bucheon, Korea) at 70°C. Final moisture contents of all dried apples, persimmons, and strawberries samples were in the range of 5±1%.

Measurement of rehydration ratio

The dried samples were rehydrated in water at 25°C for 10, 20, 30, 40, 50, and 60 min. Dried samples (1 g) were immersed in 50 mL water. After rehydration, samples were drained for 2 min to remove excess water which is physically entrapped on the surface. All samples were weighed under the same experimental conditions. Triplicate measurements were carried out and rehydration ratio was calculated as the ratio of grams of water absorbed per sample weight (g).

Ascorbic acid content

Extraction of ascorbic acid from the samples was carried out using 5% metaphosphoric acid, and ascorbic acid content was determined using high performance liquid chromatography (Young Lin Instrument Co., Ltd., Anyang, Korea) with a C_{18} column according to the method of Lee and Coates (18).

Color measurement

Color of samples was analyzed using a colorimeter (CR-300 Minolta Chromameter, Minolta Camera Co., Osaka, Japan). Samples were placed on a white standard plate and Hunter values (L, a, b) were determined. Hunter L, a, and b values for the standard plate were L=98.34, a=-0.03, and b=1.62. Three measurements were taken at different locations of each sample.

Sensory evaluation

Samples were analyzed for their freshness, texture, odor, color, and overall acceptability by 7 trained panelists. Sensory qualities of samples were evaluated using a 9-point hedonic scale method. Sensory scores were 9～8, very good; 7～6, good; 5～4, fair; 3～2, poor; 1, very poor.

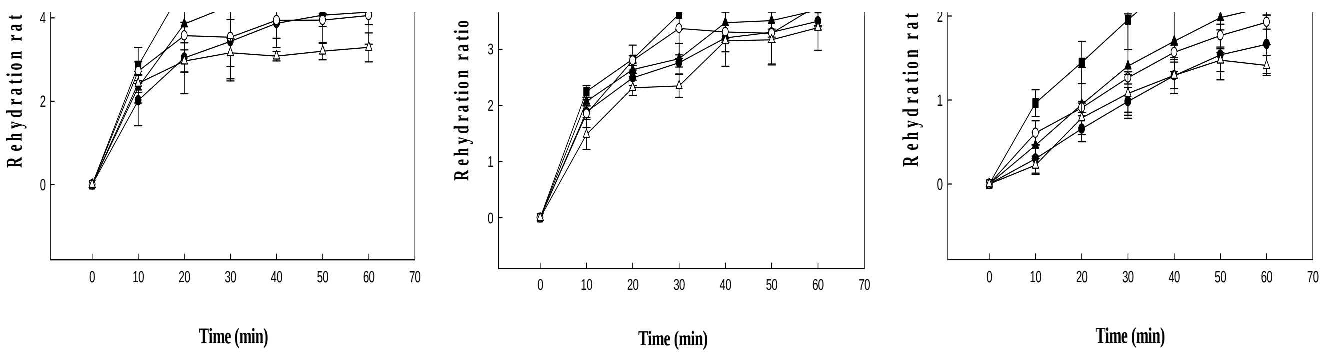
Statistical analysis

Analysis of variance and Duncan's multiple range tests were performed to analyze the results using a SAS program (SAS Institute, Inc., Cary, NC).

RESULTS AND DISCUSSION

Measurement of rehydration ratio

A major advantage of molecular press dehydration is its rehydration capacity (13-15). The rehydration ratio of dried fruit over time is shown in Fig. 1. A remarkable increase in the rehydration ratio for maltodextrin-treated apple, persimmon, strawberry slices is observed within the initial period of 30 min, whereas the rehydration ratio for hot-air and freeze dried samples required more than 30 min to reach equilibrium. Among the samples, the largest rehydration capacity was observed for maltodex-



(a) Apple (b) Persimmon (c) Strawberry

Fig. 1. Rehydration ratio of dried apple, persimmon, and strawberry slices. Bars represent standard error. ●: maltodextrin 30%, ▲: maltodextrin 50%, ■: maltodextrin 80%, ○: freeze drying, △: hot air drying.

(a) Apple (b) Persimmon (c) Strawberry

Fig. 2. Photos of maltodextrin-treated apple, persimmon, and strawberry slices after rehydration.

trin-treated fruit slices, in which the mass increased six-fold during 1 hr soaking in water (Fig. 1). In contrast, freeze- or hot-air dried fruit slices absorbed less water than the maltodextrin-treated one. Fig. 1 indicates that rehydration ratios of 80% maltodextrin-treated apple, persimmon, strawberry slices were the highest at 6.71, 4.52, and 2.70, while those of hot-air dried samples were the lowest at 3.29, 3.38, and 1.63. The reason for this difference is mainly due to the rate of water removal and degree of shrinkage of the dried samples (1). The results also indicate that the high temperature of hot-air drying can cause a detrimental effect, resulting in lower diffusion of water through the surface during rehydration (19). Thus, the difference can be attributed to the fact that different drying methods have differing effects on lattice forces inside plant tissue as well as interactions between the surrounding medium and the matrix (20). In addition, the lower rehydration ratio for the hot-air dried samples can represent the damage done to the cell wall by hot air. On the contrary, the maltodextrin-treated samples showed an increase in rehydration ratio that can be explained by molecular press dehydration (1).

Our results demonstrate that the three different fruit slices have a similar rehydration pattern, but the final rehydration ratio was dependent on the chemical composition of the sample and its mechanical resistance. Thus, the different methods affect drying rate as well as final quality of the dried food (21). Photos of maltodextrin-treated fruit slices after rehydration demonstrate the better quality of the samples dried in this manner, especially in terms of rehydration capacity (Fig. 2). Therefore, this study clearly indicates that drying fruit with the maltodextrin method is better than either the hot-air or freeze-drying method to maintain the fruit's quality closer to that of the raw state. The results also demonstrate that maltodextrin-treated fruit can be used as an ingredient in a fresh salad or a topping on cake or bread after rehydration, in the place of raw fruit.

Ascorbic acid content

The amount of ascorbic acid in samples is shown in Table 1. Ascorbic acid content in apple, persimmon, and strawberry slices were in the range of 0.77～1.44, 2.13～3.17, and 4.35～6.22 mg/g. These values are in good agreement with those reported by other studies (22-24). Ascorbic acid contents of the dried samples represent an overall decrease compared to the control. Among the dried samples, those treated with 80% maltodextrin had the highest content of ascorbic acid. In addition, ascorbic acid content increased with increasing concentration of maltodextrin. The results suggest that the maltodextrin solution acts like an edible coating, resulting in a less ascorbic acid loss (4). It should be also noted that 30 and 50% maltodextrin-treated samples had similar results

Table 1. Ascorbic acid content of freeze dried, hot-air dried, and maltodextrin-treated apple, persimmon, and strawberry slices

		Ascorbic acid (mg/g)
Apple	Control	1.44 ± 0.060^{a}
	Freeze drying	1.15 ± 0.027^{c}
	Hot-air drying	0.77 ± 0.024^{d}
	Maltodextrin (30%)	1.13 ± 0.026^{c}
	Maltodextrin (50%)	1.11 ± 0.085^{c}
	Maltodextrin (80%)	1.28 ± 0.140^{b}
Persimmon	Control	3.77 ± 0.064^{a}
	Freeze drying	2.70 ± 0.055^{e}
	Hot-air drying	2.31 ± 0.022^{c}
	Maltodextrin (30%)	2.13 ± 0.001^{f}
	Maltodextrin (50%)	2.50 ± 0.016^{d}
	Maltodextrin (80%)	3.12 ± 0.044^{b}
Strawberry	Control	6.22 ± 0.010^{a}
	Freeze drying	5.01 ± 0.134^{d}
	Hot-air drying	3.35 ± 0.590^{b}
	Maltodextrin (30%)	4.67 ± 0.036^{c}
	Maltodextrin (50%)	5.15 ± 0.030^{b}
	Maltodextrin (80%)	5.27 ± 0.001^{b}

Control: raw material.
[a-f]Means with different letters are significantly different ($p<0.05$) by Duncan's multiple range test.

Table 2. Hunter color values of freeze dried, hot-air dried, and maltodextrin-treated apple, persimmon, and strawberry slices

		L	a	b
Apple	Control	78.92±0.93[a]	-5.25±0.17[b]	23.72±1.45[b]
	Freeze drying	71.02±2.12[b]	-4.57±0.89[b]	27.21±2.83[b]
	Hot-air drying	58.22±1.81[c]	5.12±0.97[d]	30.63±1.88[a]
	Maltodextrin (30%)	64.69±1.08[ba]	-4.87±0.84[b]	24.99±1.27[b]
	Maltodextrin (50%)	76.14±5.88[ba]	-4.30±0.33[b]	23.93±1.43[b]
	Maltodextrin (80%)	78.90±0.74[a]	-4.75±2.28[b]	26.39±1.39[b]
Persimmon	Control	60.83±0.72[b]	3.53±0.12[c]	39.74±2.83[ba]
	Freeze drying	80.37±4.07[a]	1.30±0.34[b]	31.29±2.12[c]
	Hot-air drying	58.65±0.57[c]	8.44±1.00[a]	37.18±1.06[b]
	Maltodextrin (30%)	59.81±0.55[b]	4.03±1.01[b]	40.50±1.95[a]
	Maltodextrin (50%)	60.98±0.38[b]	3.99±1.58[b]	41.98±3.62[a]
	Maltodextrin (80%)	69.18±1.70[b]	4.05±0.77[b]	41.97±3.48[a]
Strawberry	Control	56.37±3.55[b]	17.44±2.63[b]	18.84±0.38[ba]
	Freeze drying	71.02±2.12[a]	15.81±3.04[a]	17.93±2.68[b]
	Hot-air drying	31.90±0.78[d]	11.13±2.02[c]	20.89±2.07[a]
	Maltodextrin (30%)	50.51±2.07[b]	16.08±0.87[b]	17.53±2.71[b]
	Maltodextrin (50%)	51.40±0.46[c]	16.37±0.73[b]	17.95±2.50[b]
	Maltodextrin (80%)	56.72±0.64[c]	17.22±0.90[b]	15.73±1.54[b]

Control: raw material.
[a-c]Means with different letters are significantly different ($p<0.05$) by Duncan's multiple range test.

with freeze dried samples and had higher ascorbic acid content than hot-air dried samples. In particular, the ascorbic acid content of hot-air dried samples was subsequently the lowest among the samples. These results indicate that the high temperature during hot-air drying led to a considerable decrease in ascorbic acid content, likely due to oxidation and destruction of ascorbic acid.

Color measurement and sensory evaluation

The experimental results of lightness (L), redness (a), and yellowness (b) for the dried apple, persimmon, and strawberry slices are shown in Table 2. Color differences were distinct between the control and the hot-air dried apple, persimmon, and strawberry slices. Hot-air dried apple slices had lower lightness value than the freeze-dried or maltodextrin-treated apples. In addition, the hot-air dried apple slices had higher redness than those of the other dried samples, and also had more intense dark color (Table 2). However, there was little difference between maltodextrin-treated samples and the control. The dried persimmon also showed no significant difference in surface color between the control and maltodextrin-treated samples (Table 2). The results demonstrate that maltodextrin treatment delays degradation of chlorophyll and carotene pigments, as previously reported (25). On the other hand, color values of the freeze- or hot-air dried samples were changed, compared to the control. Lightness was significantly higher in the freeze-dried samples, while redness was lower than the control, which was presumably affected by whiteness of the surface of the frozen samples. Yellowness values were also lower than those of maltodextrin-treated samples. Color changes by freeze drying were reported by other studies (4,26). In addition, hot-air dried samples had considerably lower lightness and higher redness compared to the control, indicating that high temperature during drying could result in a dark color (27).

Analysis of the dried strawberry slices also indicated that there is a color change in the hot-air- and freeze-dried samples compared to control (Table 2). In particular, the hot-air dried sample had lower values of lightness and redness and higher value of yellowness, compared to the control. In contrast, the freeze dried samples had higher lightness than the control, while they had lower value of redness and yellowness. Compared with hot-air and freeze dried samples, maltodextrin-treated strawberry slices maintained significant level of the inherent lightness, redness, and yellowness. The similar results were also reported in the previous studies (13,14). Taken together, our results indicate that maltodextrin-treated samples have a minimal damage on color of fruit.

Sensory qualities of maltodextrin-treated apple, persimmon, and strawberry slices are observed to be same in quality compared to the control, and better than other drying methods (Table 3). In addition, sensory evaluation results indicate that there is no difference among maltodextrin-treated samples at different concentrations. Sensory qualities of the freeze-dried samples were acceptable, except for the texture, which can be damaged during the freeze-drying process due to the growth of

Table 3. Sensory evaluation of freeze dried, hot-air dried, and maltodextrin-treated apple, persimmon, and strawberry slices

		Organoleptic parameter				
		Odor	Color	Texture	Appearance	Overall
Apple	Control	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]
	Freeze drying	6.38±0.74[c]	6.38±1.06[b]	5.13±0.99[c]	6.75±1.39[c]	6.50±0.93[c]
	Hot-air drying	4.50±0.93[d]	4.38±1.06[c]	5.25±0.71[c]	4.75±0.71[d]	4.63±0.92[d]
	Maltodextrin (30%)	6.13±0.83[c]	6.75±1.04[b]	7.63±0.52[b]	7.13±0.83[cb]	6.25±0.71[c]
	Maltodextrin (50%)	7.75±0.46[b]	7.13±0.83[b]	7.63±0.74[b]	7.75±0.71[b]	7.50±0.53[b]
	Maltodextrin (80%)	8.13±0.64[b]	7.13±0.64[b]	7.88±0.64[b]	7.50±0.76[cb]	7.50±0.53[b]
Persimmon	Control	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]
	Freeze drying	6.50±1.73[c]	6.25±1.20[c]	5.00±0.93[d]	7.00±1.07[b]	7.38±1.06[b]
	Hot-air drying	3.63±1.73[d]	5.25±0.83[d]	6.00±1.41[c]	5.13±2.17[c]	5.00±2.07[c]
	Maltodextrin (30%)	7.75±0.66[b]	7.25±0.66[b]	8.00±0.53[b]	7.63±0.92[b]	7.25±0.71[b]
	Maltodextrin (50%)	8.25±0.43[ba]	7.38±0.70[b]	8.00±0.76[b]	7.75±1.04[b]	7.13±0.83[b]
	Maltodextrin (80%)	7.25±0.43[bc]	7.38±0.70[b]	8.00±0.53[b]	7.50±0.53[b]	7.50±0.53[b]
Strawberry	Control	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]	9.00±0.00[a]
	Freeze drying	5.00±1.77[c]	6.75±1.04[b]	4.00±1.20[c]	7.50±1.07[b]	6.75±1.03[b]
	Hot-air drying	4.00±1.07[d]	4.50±1.69[c]	4.75±1.04[c]	3.63±0.92[d]	4.25±1.28[c]
	Maltodextrin (30%)	7.13±0.64[b]	7.13±0.64[b]	6.25±0.71[b]	5.50±1.60[c]	7.00±0.93[b]
	Maltodextrin (50%)	7.25±0.71[b]	7.63±0.74[b]	6.88±0.83[b]	7.00±0.53[b]	7.25±0.71[b]
	Maltodextrin (80%)	7.50±0.76[b]	7.50±0.76[b]	6.88±0.64[b]	6.88±0.99[b]	7.00±1.07[b]

Control: raw material.
[a-d]Means with different letters are significantly different ($p<0.05$) by Duncan's multiple range test.

ice crystals (7). In contrast, hot-air dried samples had lower scores in terms of odor, color, texture, appearance, and overall aspect than other drying methods. These results are in agreement with other reports regarding the effects of hot-air drying (28,29).

In summary, these results suggest that the drying of fruit slices using maltodextrin is a very efficient method, resulting in good rehydration capacity, minimal destruction of ascorbic acid, and favorable color and sensory evaluations.

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REFERENCES

1. Rastogi NK, Nayak CA, Raghavarao KSMS. 2004. Influence of osmotic pre-treatments on rehydration characteristics of carrots. *J Food Eng* 65: 287-292.
2. Karathanos V, Angela S, Karel M. 1993. Collapse of structure during drying of celery. *Drying Tech* 11: 1005-1023.
3. Kaymak-Ertekin F. 2002. Drying and rehydration kinetics of green and red peppers. *J Food Sci* 67: 168-175.
4. Dermesonlouoglou EK, Giannakourou MC, Taoukis P. 2007. Stability of dehydrofrozen tomatoes pretreated with alternative osmotic solutes. *J Food Eng* 78: 272-280.
5. Giannakourou MC, Taoukis PS. 2003. Stability of dehydrofrozen green peas pretreated with nonconventional osmotic agents. *J Food Sci* 68: 2002-2010.
6. Piotrowksi D, Lenart A, Wardzyński A. 2004. Influence of osmotic dehydration on microwave-convective drying of frozen strawberries. *J Food Eng* 65: 519-525.
7. Kowalska A, Lenart A. 2001. Mass exchange during osmotic pretreatment of vegetables. *J Food Eng* 49: 137-140.
8. Singh B, Panesar PS, Nanda V. 2008. Osmotic dehydration kinetics of carrot cubes in sodium chloride solution. *Int J Food Sci Tech* 43: 1364-1370.
9. Moura CP, Masson ML, Yamamoto CI. 2005. Effect of osmotic dehydration in the apple (*Pyrus malus*) varieties Gala, Gold and Fuji. *Thermal Eng* 4: 46-49.
10. Castelló ML, Igual M, Fito PJ, Chiralt A. 2009. Influence of osmotic dehydration on texture, respiration, and microbial stability of apple slices (Var. Granny Smith). *J Food Eng* 91: 1-9.
11. Uddin MB, Ainsworth P, İbanoğlu S. 2004. Evaluation of mass exchange during osmotic dehydration of carrots using response surface methodology. *J Food Eng* 65: 473-477.
12. Matusek A, Merèsz P. 2002. Modelling of sugar transfer during osmotic dehydration of carrots. *Periodica Polytechnica Ser Chem Eng* 46: 83-92.
13. Kim MH, Kim MK, Yu MS, Song YB, Seo WJ, Song KB. 2009. Dehydration of sliced ginger using maltodextrin and comparison with hot-air dried and freeze-dried ginger. *Korean J Food Sci Tech* 41: 146-150.
14. Kim MK, Kim MH, Yu MS, Song YB, Seo WJ, Song KB. 2009. Dehydration of carrot slice using polyethylene glycol and maltodextrin and comparison with other drying methods. *J Korean Soc Food Sci Nutr* 38: 111-115.
15. Yoo MS, Seo HC. 2003. Molecular press dehydration method for vegetative tissue using the solid phase of water soluble polymer substances as a dehydrating agent. *WO Patent* 03/039273.
16. Lenart A. 1996. Osmo-convective drying of fruits and vegetables: Technology and application. *Drying Tech* 14: 391-413.
17. Yoo MS. 2005. Molecular press dehydration of plant tissues using soluble high molecular weight dehydrating

agent. *Korean Patent* 10-04748861.
18. Lee HS, Coates GA. 1999. Vitamin C in frozen, fresh squeezed, unpasteurized, polyethylene-bottled orange juice: A storage study. *Food Chem* 65: 165-168.
19. Singh GD, Sharm R, Bawa AS, Saxena DC. 2008. Drying and rehydration characteristics of water chestnut (*Trapa natans*) as a function of drying air temperature. *J Food Eng* 87: 213-221.
20. Witrowa-Rajchert D, Lewicki PP. 2006. Rehydration properties of dried plant tissues. *Int J Food Sci Tech* 41: 1040-1046.
21. Lewicki PP, Wickzkowska J. 2006. Rehydration of apple dried by different methods. *Int J Food Properties* 9: 217-226.
22. Patras A, Brunton NP, Pieve SD, Butler F. 2009. Impact of high pressure processing on total antioxidant activity, phenolic, ascorbic acid, anthocyanin content and colour of strawberry and blackberry purees. *Innov Food Sci Eng Tech* 10: 308-313.
23. Planchon V, Lateur M, Dupont P, Lognay G. 2004. Ascorbic acid level of Belgian apple genetic resources. *Sci Hortic* 100: 51-61.
24. Kondo S, Yoshikawa H, Katayama R. 2004. Antioxidant activity in astringent and non-astringent persimmons. *J Hort Sci Biotech* 79: 390-394.
25. Krokida MK, Maroulis ZB, Saravacos GD. 2001. The effect of the method of drying on the colour of dehydrated products. *Int J Food Sci Tech* 36: 53-59.
26. Litvin S, Mannheim C, Milta J. 1998. Dehydration of carrots by a combination of freeze drying microwave heating and air or vacuum drying. *J Food Eng* 36: 103-111.
27. Karathanos VT, Kanellopoulos NK, Belessiotis VG. 1996. Development of porous structure during air drying of agriculture plant products. *J Food Eng* 29: 167-183.
28. Tiwari G, Wang S, Birla SL, Tang J. 2008. Effect of water-assisted radio frequency heat treatment on the quality of ‘Fuyu’ persimmons. *Biosystems Eng* 100: 227-234.
29. Besada C, Arnal L, Salvador A. 2008. Improving storability of persimmon cv. Rojo Brillante by combined use of preharvest and postharvest treatments. *Postharvest Biol Technol* 50: 169-175.

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