Effect of Different Drying Methods on Quality Characteristics of Persimmon Slices

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ABSTRACT

Tow different drying methods (conventional sun drying and oven dehydration at 60 °C, 70 °C and 90 °C) were investigated to evaluate their performance and effect on quality attributes of persimmon slices. No significant ($p \leq 0.05$) differences could be traced regarding dehydration and rehydration ratios of persimmon slices dried by the two methods was found. Furthermore some chemical components (sugars, total acidity, ascorbic acid, sulphur dioxide, total carotenoids and total phenolic compounds) of the persimmon slices were lost due to drying process. High destruction of vitamin C was observed. Total phenolic compound in fresh persimmon was higher than that of dried fruits. The significantly ($p \leq 0.05$) highest scores were recorded by panelists for persimmon slices dehydrated at 90°C. Microbial analysis exhibited the highest bacteria, yeasts and mould count (CFU/ g) for persimmon preserved by sun drying among the other dehydrated samples (at 60, 70 and 90°C).

Key words: sun drying, dehydration, persimmon, carotenoid, total *phenols, sensory evaluation*

INTRODUCTION

Persimmon (*Diospyros kaki*) is a good source of natural antioxidants, vitamins and dietary fibers which are probably help to reduce some risk of human diseases (Steinmetz and Potter, 1996 ; Boileau *et al.*, 1999).

Although there are more than 400 species of persimmon found in different shape and color, they could be classified into two groups depending on the degree of astringency at the mature stage (astringent and non- astringent) (Matsuo, 1998). When an astringent persimmon fruit is eaten, the tannins cells in the flesh are crushed and soluble tannins are released giving a strong astringent sensation, which diminishes during the natural ripening process (Taira, 1996; Telis *et al.*, 2000) .

The persimmon is mainly eaten fresh but it could be also frozen, canned or dried and stored up to 6 months in controlled atmosphere. During dehydration of whole fruits, the skin acts as a semi permeable membrane that controls the water transfer rate from the fruit to external medium (Telis *et al.*, 2000). Although persimmon peel is generally regarded as waste, Gorinstein *et al.*, (1994) reported that the concentrations of carotenoids and polyphenols are higher in the peel than that of pulp. Therefore, persimmon peel has obviously effect as hypochlestromic and antioxidative in rats diet.

However, fresh persimmon is not available over the year , thus fruits are generally dried under the sun (solar) and artificial dryer (Marder and Schomaker, 1995). A combination of solar and artificial drying has been used to provide high quality products (Kitagawa and Glucina, 1984). Astringent varieties are suitable for drying but non-astringent cultivars become brown and tough . Since traditionally dried fruits do not have a long shelf life, the fruits were treated with SO_2 prior to drying (combination of solar and artificial drying) to provide high quality products (Fu-Ming and Yeung-Chung, 1995).

Marder and Schoemaker (1995) stated the best method to obtained good solar dried persimmon, ripe fresh fruits must be (slightly green in color but turning almost fully yellow and still very firm). The fruits must be washed, peeled, sleized laterally in half and pre-treated with metabisulphite before drying to maintain the attractive color of fruits, high temperatures during convection drying lead to degradation of tannin and sugars crystallization in fresh fruit. As a result, sweet, tasteful and non astringent dried product was obtained. Kim *et al.,* (2006) concluded that heat treatment like drying increases the total phenolic and antioxidative compounds and antigenotoxic activities of the ethanol and water extracts of persimmon peel.

The present study was carried out to investigate physical, chemical, microbiological and sensory properties of dried persimmon fruit slices prepared by two different drying methods.

MATERIALS AND METHODS

Materials:

Seedless persimmon *(Diospyros kaki)* fruits in 2007 under ripeness condition were obtained from the Horticulture Research Institute, Agriculture Research Center, Giza. The fruits were washed, sorted, then sliced to 5mm thickness using adjustable electrical slicer. The slices were immersed in 0.5% sodium metabisulphite solution for 5min prior to drying processes.

The persimmon slices were divided into four portions. The first one was served as sun drying under normal atmosphere conditions where one layer of persimmon slices were put on stainless steel trays, exposed to direct sun for 6 hours/ day for 7 days at 28-30°C (Asgar *et al.,*2003). The second portion was spread on the stainless steel trays in one layer and subjected to 60 °C in a cabinet dryer for 8-12 hours to reach moisture content of about 14-16% (Akyidiz *et al.*, 2004).Third and fourth portions were treated at the same conditions but their drying temperature were 70 and 90°C, respectively (Akyidiz *et al.*, 2004). After drying the product was subjected to physical, chemical, microbiological and sensory analyses.

Methods:

Physical methods:

Drying and dehydration ratios were carried out as described by Gouda (1974). The method described by Lewis (1984) was used for the determination of Color index.

Analytical methods:

Moisture content was determined by drying at 70°C according to Tripathi and Nath (1989), total solids (TS)(100- moisture %), crude fiber, ash, crude protein (N×6.25) and crude ether extract were determined according to the AOAC(1996). Sugars were determined as total sugars following phenol sulfuric method according to the method of (Dubois *et al.*, 1956). Total reducing sugars was determined according to Lane- Eynon method as outlined by Egan *et al.*, (1981). Vitamin C was determined using 2,6 dichlorophenol indophenols and total acidity (% as malic acid) of persimmon were determined according to the AOAC (1996). Total carotenoids was determined by the method of Pott *et al.*, (2003). Sulfur dioxide was determined in the presence of sulfuric acid (1+3) and 0.5g sodium bicarbonate by titration with 0.02 N iodine solution using starch solution as an indicator according to the method of AOAC (1996).

Extraction and determination of total phenolic compounds:

About 10g of the persimmon was homogenized with 125 ml of 95% ethanol for 1 min and then gently boiled for 30 min, cooled and filtered using Whatman No.1. The filtrate was evaporated under vacuum at 60° C to reach 10 ml. Total polyphenols was determined by Folin- Ciocalteu method (Gorinstein *et al.*, 1994) and measured at 675 nm. The results were given in mg/100g as gallic acid.

Determination of antioxidant activity:

Antioxidant activity of persimmon ethanolic extract was determined by DPPH (1,1- diphenyl 1-2 picryl hyolrazyl) according to Singh *et al.*, (2002).

Microbiological evaluation:

Total plate cout, yeast& mould, Coliform and pathogenic bacteria including *E.coli, Staphylococcus aureus* and *Salmonella spp.* were determined according to Oxoid (1992).

Sensory evaluation:

Organoleptic properties of dried persimmon were carried out by 10 trained panelists to evaluate the quality of the final product according to the methods of Kramer and Twigg (1962).

Statistical analysis:

The data obtaind were subjected to analysis of variance according to SPSS, (1997). Significant differences among individual means were analyzed by Duncan`s multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Physical properties of dried persimmon slices:

Physical characteristics of dried persimmon slices are considered to be very important properties. Table (1) shows dehydration ratios of persimmon slices dried by two different methods and at different temperatures. The results revealed that no significant ($p \leq 0.05$) differences were recorded between dehydration and rehydration ratio due to either the drying method or temperature of dehydration. Moreover, no significant ($p \leq 0.05$) differences were noted in the dried samples related to the drying temperature. Contrary, color index of sun drying persimmon was higher than that of oven dehydrated persimmon. It is well known that foods that dried under optimum conditions suffer less damage, rapidly rehydrate and have extent shilf life than that poorly dried (Morton and Waston, 1988). Referring to Table (1), it could be noticed that samples dried by sun drying had higher color intense as compared to the other dried ones. The increase in optical density (O.D) of dried fruits is an quality index and as real indication of deterioration of color and development of browning reactions (Aguilera *et al.*,1987; Avila and Silva,1999).

Table (1): Dehydration and rehydration ratios of persimmon slices dried by two different methods

Properties	Drying methods			
	Sun drying	Dehydration		
		60°C	70°C	90°C
Dehydration ratio	3.89±0.12 [a]	3.68±0.34 [a]	3.37±0.31 [a]	3.08±0.87 [a]
Rehydration ratio	1: 3.43±0.55[a]	1: 3.59±0.32[a]	1 : 3.63±0.94[a]	1: 3.44±0.38[a]
Color index	0.499±0.29[b]	0.365±0.33[a]	0.348±0.71[a]	0.341±[0.95a]

M± SD = means and standard deviation of triplicate trails
Within the row, values having the same superscript letters are not significantly different at 5% level

Chemical composition of fresh and dried persimmon slices:

Results in Table (2) indicate that fresh persimmon fruits contained 72.81% moisture, 27.19% total solids, 59.51% total sugars (dry matter) 32.12% reducing sugars (dry matter), 27.39% non- reducing sugars, 2.78% crude fiber, 1.89% ether extract, 2.83% protein and 2.23% ash. The total acidity of the fresh fruit was 0.92%, 3018 mg/100g total carotenoids (as β-carotenes) , 5.50 pH value and 55.22 mg/100g ascorbic acid. These findings agreed with Herrmann (1994) and Abd El- Hady (2002).

Table (2): Chemical characteristics of dried persimmon slices (on dry weight basis)

Constituents	Fresh fruits	Drying methods			
		Sun drying	Dehydration		
			60° C	70°C	90° C
Moisture (%)	72.81 ± 0.11^{a}	16.32 ± 0.21^{b}	15.22 ± 0.11^{c}	15.33 ± 0.23^{c}	14.89 ± 0.43^{d}
Total solids (%)	27.19 ± 0.02^{d}	83.68 ± 0.11^{c}	84.78 ± 0.42^{b}	84.7 ± 0.86^{b}	85.11 ± 0.33^{a}
Total sugars (%)	59.51 ± 0.43^{a}	57.87 ± 0.11^{b}	57.60 ± 0.23^{c}	57.56 ± 0.11^{c}	56.72 ± 0.23^{d}
Reducing sugars (%)	32.12 ± 0.78^{d}	37.89 ± 0.31^{b}	37.44 ± 0.33^{c}	37.88 ± 0.23^{b}	38.11 ± 0.89^{a}
Non reducing sugars(%)	27.39 ± 0.11^{a}	19.98 ± 0.23^{c}	20.16 ± 0.52^{b}	19.68 ± 0.12^{c}	18.61 ± 0.45^{d}
•Total acidity (%)	0.92 ± 0.21^{a}	0.789 ± 0.83^{d}	0.816 ± 0.93^{c}	0.841 ± 0.14^{c}	0.86 ± 0.16^{b}
pH - value	5.5 ± 0.33^{a}	4.72 ± 0.12^{c}	4.90 ± 0.45^{c}	5.03 ± 0.22^{b}	5.15 ± 0.23^{b}
Ascorbic acid (mg/100g)	55.22 ± 0.43^{a}	39.42 ± 0.32^{d}	46.18 ± 0.26^{b}	45.87 ± 0.11^{c}	45.14 ± 0.57^{c}
Sulphur dioxide (ppm)	-	1389 ± 0.11^{c}	1400 ± 0.13^{b}	1406 ± 0.10^{a}	1403 ± 0.23^{b}
••Total carotenoids (mg/100g)	1685 ± 0.11^{a}	1366 ± 0.61^{c}	1516 ± 0.62^{d}	1568 ± 0.33^{c}	1583 ± 0.44^{b}

•as malic acid ••as β- carotene

M±SD = means and standard deviation of triplicate trails

In a row, values having the same superscript letters are not significantly different at 5% level

The moisture content is considered the most important factor to regulate the deterioration of quality attributes in dried fruits. The main purpose of drying is to reduce the moisture content in order to prevent growth of microorganisms and food spoilage (Twifek, 2001). The results in Table (2) indicated that moisture content of fresh persimmon slices was 72.81% which significantly ($p \leq 0.05$) higher than those of dried ones. It is clear, also, that moisture content of sun dried slices was significantly ($p \leq 0.05$) higher than that dehydrated with oven dryer. On the other hand, no significantly ($p \leq 0.05$) differences were recorded among the dehydrated slices due to the variation of drying temperature (from 60 - 90 °C). Total and reducing sugars of persimmon slices did not exhibit any significant ($p \leq 0.05$) differences as a result of drying by different methods, while fresh slices had higher value than that of dried ones. The total sugars of fresh persimmon slices decreased slightly by drying process (Table,2). The decrease in sugars content may be due to the formation of furfural as reported by Galal *et al.,* (1989). The tabulated data showed that drying process led to increased in reducing sugars and decreased in non reducing sugars. Mattuk *et al.*, (1997) reported that dehydration process of guava slices had a clear effect on sugars content, while an obvious decrease occurred in the non-reducing sugars. A simultaneous increase was observed in the reducing ones, this may be due to the fact that under acidic conditions and drying temperature the non-reducing sugars are inverted to reducing ones.

A significantly ($p \leq 0.05$) decrease in total acidity after drying process of persimmon slices was noticed. This may be attributed to the loss of organic acids that could be consumed in the hydrolysis of polycarbohydrates (Nezam El- Din, 1978). Also, ascorbic acid was destroyed as a result of drying process. The decrease in ascorbic acid could be caused by the oxidization of ascorbic acid during drying as reported by Galal *et al.,* (1989). Notwithstanding, it was obvious that ascorbic acid content of persimmon slices samples dried by oven were significantly higher than those dried by sun. These results are in agreement with Eheart and Oldland (1972) who reported that vitamin C of dried fruits was destroyed by heat.

Drying processes had a great effect on sulfur dioxide content, whereas, large quantity of SO_2 was lost during sun drying (Table,2). Nezam El- Din (1978) demonstrated that 86-90% SO_2 added to apricot juice was lost by drying, while Mattuk *et al.,* (1997) recorded 40-60% loss in SO_2 in the dried guava powder.

Total carotenoids of persimmon slices was significantly (≤ 0.05) decreased by drying process. The significantly ($p \leq 0.05$) highest decrease (18.93%) in total carotenoids was occurred in persimmon slices dried by sun. This decrement may be due to some oxidation reactions that developed during drying as reported by Morton and Waston (1988). The carotenoids content of dehydrated persimmon slices at different temperature (60, 70 and 90 °C) ranged between 1516- 1584 mg/100g. The percentage of carotenoides decreases were 10.02, 6.94 and 6.05%, respectively. Karabulya and Liberman (1983) found that the loss of total carotenoids after drying process reached to 85% of the initial amount of dried persimmon fruits.

Total phenolics content and antioxidant activity (AA%) of the phytocompounds in fresh and dried persimmon slices:

Total phenolic content of fresh persimmon slices was 1122.66 mg/100g (on dry weight basis) which was dramatically decreased by drying process. Since, total phenolic content of persimmon slices dried by sun and dehydrated at 60, 70 and 90°C were 588.96, 614.23, 709.65 and 1099.48 mg/100g, respectively. These results were in agreement with Kim *et al.*, (2006) who showed that total phenol content of grape seed extract was significantly increased by heat treatment. They suggested that heat could be liberated phenolic compounds from the fruit tissue The DPPH is a free radical compound and has been widely used to test the free radical-scavenging ability of various natural antioxidants (Shimoji *et al.*, 2002). Antioxidant activity (AA%) of persimmon slices dried by sun drying and dehydrated at 60, 70 and 90 °C were 68.41, 70.19, 72.33 and 75.66 %, respectively. The data of this investigation indicate that sun drying was more effective than dehydration to reduce antioxidant activity of the fruit. The outer layers of the plant such as peel, shell and hull, generally, contain large amounts of polyphenolic compounds to protect the inner materials. A number of phenolic acids are linked to various cell- wall components such as arabinoxylans and proteins (Harris and Hartley, 1976). Park *et al.*, (2006) reported that the persimmon without astringent component had lower antioxidant activity, because the amount of soluble persimmon tannins was low. Condensed tannins persent in persimmon fruits are responsible for the astringent taste (Wu and Hwang, 2002).

Table (3): Total polyphenols content of dried persimmon slices and antioxidant activity (AA%) of their ethanolic extracts.

Treatment	Total polyphenols content (mg / 100g DW)	AA%
Fresh fruits(control)	1122.66±0.33[a]	76.31±0.88[a]
Sun drying	588.96 ±0.45	68.41±0.11
Dehydration :		
at 60° C	614.23±0.72[d]	70.19±0.27[d]
at 70° C	709.65±0.51[c]	72.33±0.51[c]
at 90° C	1099.48±0.33[b]	75.66±0.42[b]

M±SD = means and standard deviation of triplicate trails
Within the column values having the same superscript letters are not significantly different at 5% level
DW= dry weight basis

Microbiological properties:

The changes in microbial counts (Total bacterial, yeast & mould and Coliforms) as well as the detection of some pathogenic bacteria such as *E.coli*, *Staphylococcus aureus* and *Salmonella spp.* of persimmon slices as affected by drying process were studied and the obtained results were given in Table (4). Data revealed that persimmon slices dried by sun drying had the significantly ($p\leq 0.05$) highest count of bacteria than those dried by oven. The significantly ($p\leq 0.05$) lower count of bacteria for the persimmon slices dried by oven could be attributed to the high temperature that employed during drying process. Whitfield (2000) reported that temperature ranging between 37.2°C to 71°C was found to be effectively kill bacteria. Drying process caused a dramatic decrease in the microbial load of the dried persimmon samples. Also, yeast and mould counts of dried persimmon at high temperature (at 70 and 90°C) had lower counts of yeasts and mould. This may be attributed to the low moisture content as found by Scalin (1997) reported that reducing moisture content of food to the range between 10 and 20% prevent foods from yeast and mould contaminations. But, the significantly ($p\leq 0.05$) highest count of yeasts and moulds of sun dried samples could be attributed to the low temperatures along with long period of drying (Kendall and Allen, 1998). No pathogenic bacteria such as *E. coli*, *Staphylococcus aureus* and *Salmonella spp*. were detected in fresh or in dried persimmon slices. Nezam El- Din (1978) found that dried apricot sheets had a very few total count (10 – 50 cell/ g) which may be due to the effect of acidity, heat, pH, SO_2 or sucrose concentration.

Table (4): Microbiological evaluation of fresh and dried persimmon slices

Microbial characteristics	Fresh slices	Sun drying	Dehydration		
			60°C	70°C	90°C
Total bacterial count (×10 CFU/g)	$30\times10^{5\,a}$	18×10^{3b}	9×10^{2c}	6×10^{2c}	3×10^{2d}
Yeasts & Moulds (×10 CFU/g)	9×10^{6a}	6×10^{3b}	3×10^{2c}	3×10^{2c}	2×10^{2d}
Coliform group	-	-	-	-	-
E. coli	-	-	-	-	-
Staphylococcus aureus	-	-	-	-	-
Salmonella spp.	-	-	-	-	-

Within the column, values having the same superscript letters are not significantly different at 5% level

Organoleptic characteristics of dried persimmon slices:

Table (7) shows the obtained data of the organoleptic properties of persimmon slices dried by two drying methods under investigation. It is obvious that organoleptic properties (appearance, taste, color, texture, aroma and overall acceptability) were significantly ($p\leq 0.05$) influenced by the drying method.The significantly ($p\leq 0.05$) lowest scores of all characteristics were given for sun drying persimmon slices. As mentioned by Atkinson and Strachan (1962), a part from improving sensory qualities, sulphites minimize the loss of ascorbic acid and carotenoids in dried fruits (Atkinson and Strachan, 1962). Oliveira and Oliveira (1999) reported that the best overall quality of dried foods is obtained at a constant temperatures of about 60° C during drying. Also, they showed that pigments degrade above 60° C and stability to thermal degradation increases as pH decreases. Therefore, the best sensory quality of the dried persimmon slices was found by drying the fresh fruits with oven dryer at 90 °C.

Table(5): Sensory evalution of dried persimmon slices

Attributes	Sun drying	Dehydration		
		60°C	70°C	90°C
Appearance	6.52^{c}	7.42^{b}	8.74^{a}	8.89^{a}
Taste	5.83^{c}	7.33^{b}	7.92^{b}	9.23^{a}
Color	6.46^{d}	7.01^{c}	7.36^{b}	8.62^{a}
Texture	6.74^{c}	7.72^{c}	8.54^{a}	8.71^{a}
Aroma	6.54^{c}	7.32^{b}	7.53^{b}	8.32^{a}
Overall acceplitiy	6.42^{c}	7.36^{b}	8.02^{a}	8.75^{a}

In a row, means followed by the same superscript letters are not significantly different at
5% level.

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الملخص العربى

تأثير طرق التجفيف المختلفة على خصائص جودة شرائح الكاكى المجففة

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أجريت هذه الدراسة بغرض المقارنة بين طريقتان للتجفيف (التجفيف الشمسى بالطريقة التقليدية والتجفيف الصناعى فى أفران حرارية بالهواء الساخن على درجات حرارة مختلفة ٦٠°م ، ٧٠ °م ، ٩٠°م) وذلك لمعرفة تأثير طرق التجفيف على جودة شرائح ثمار الكاكى المنزرعة فى مصر لمعرفة مدى امكانية أستهلاكها فى مواسم عدم توفر ثمار الكاكى الطازجة. قد أوضحت النتائج عدم وجود فروق معنوية على مستوى ٥ ٪ بين معاملى التجفيف والتشرب لشرائح الكاكى المجففة سواء كانت بالتجفيف الشمسى أو فى الافران. كما لوحظ عدم وجود فروق معنوية فى نسبة الفقد فى المكونات الكيماوية (سكريات، حموضة ، ثانى أكسيد الكبريت) الا أنه سواء كان التجفيف شمسى أم التجفيف فى الفرن حدث فقد معنوى فى محتوى فيتامين ج فى الشرائح المجففة بفعل حرارة التجفيف فى كل العينات المجففة. أوضح التحليل الميكروبيولوجى أرتفاع الاعداد الميكروبية معنويا فى شرائح الكاكى المجففة تجفيف شمسى مقارنة بالعينات المجففة فى الافران. وقد تبين من النتائج الاختبارات الحسية أن العينات المجففة على ٩٠ °م (لمدة ٨ ساعات) حصلت على أعلى درجات من المحكمين بعد أسترجاع الشرائح المجففة من حيث اللون - الطعم - القوام - الرائحة ودرجة القبول الكلى مقارنة بالعينات الاخرى (سواء المجففة على ٦٠°م أو ٧٠ °م) أما العينات المجففة شمسيا فكان لونها برتقالى باهت وذلك نتيجة لطول فترة تعرض العينات للشمس أثناء عملية التجفيف .