EFFECTS OF FREEZING AND DRYING ON PHYSICOCHEMICAL PROPERTIES OF *DIOSPYROS KAKI* FRUITS

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Abstract
The research purpose was to determine the quality characteristics of persimmon fruits subject to two conservation methods such as: drying and freezing. Drying of persimmon was done at 60° C for 24 hours and freezing at -18° C. The physicochemical parameters analyzed were: antioxidant capacity, vitamin C content, total soluble substance, titratable acidity, mineral substances, dry matter and water content. Antioxidant activity determination was performed by the spectrophotometric method with the DPPH reagent (2,2- diphenyl-1-picrylhydrazyl). Vitamin C concentrations were determined by HPLC. Initially all the studied parameters were measured in fresh fruits in order to compare the results with the data obtained after the conservation of fruits. The findings of the study have indicated that conservation methods are good for some nutrient retention depending on the temperature level applied. The research results demonstrated that temperature has an influence on the antioxidant properties of the fruit. The highest antioxidant capacity was obtained in the case of fresh fruits, followed by the ones subjected to freezing and drying. Regarding persimmon consumer acceptability moisture and dry matter have a high influence. The lowest level of moisture was obtained in the fresh fruits followed by frozen ones. The highest content of vitamin C was obtained in the case of dried persimmon fruits.

Keywords: persimmon, freezing, drying, physicochemical parameters, vitamin C, antioxidant activity.

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1. INTRODUCTION

Diets rich in fruits are recommended due to their health promoting properties (Slavin et al. 2012). Fruits contain essential vitamins, fiber, mineral and other bioactive compounds that are associated with lower risk of chronic diseases (Blanck et al. 2008).Persimmon (*Diospyros kaki*) fruits are rich in nutritive compounds compared to other fruits and have a protective action due to the presence of vitamins, ascorbic acid and β-carotene (Chen et al. 2008).Except for carotenoids, *Diospyros kaki* contain a large amount of natural antioxidants (Kim et al. 2006). Antioxidants are chemical substances involved in the oxidation delay of lipids through the inhibition of the beginning or propagation of oxidative chain reactions (Prisacaru, 2016).Persimmon is a good source of ascorbic acid, about 50 mg/100 g fresh pulp. In general if the ascorbic acid is well retained the other compounds are also retained (Nicoleti et al. 2004).Generally ascorbic acid is considered as an index of nutrient quality during processing of foods (Fennema, 1977). Ascorbic acid is a sensible vitamin to numerous factors: moisture content, temperature and light.

In the past years an increasing attention has been paid to the role of natural active ingredients in human health. Due to this fact the preservation of bioactive compound from fruit is an important aspect of fruit preservation. Fruits are essential foods as they play an important role in the diet of humans. Fresh fruits are highly perishable because they contain high moisture. Due to this fact and because persimmons are not available all year around the purpose of the research was to analyze the influence of two conservation methods on the physicochemical properties of *Diospyros kaki* fruits. In this study persimmon was preserved by two different procedures: freezing at -18º C and dehydration at 60º C for 24 hours. Antioxidant capacity, vitamin C content, total soluble substance, titratable

acidity, mineral substances, dry matter and water content were evaluated in order to find a substitute for fresh fruits.

2. MATERIALS AND METHODS

Plant material:
Mature fruits samples (*Diospyros kaki* L., var. Rojo Brillante) were purchased from a local market. The fruits were randomly divided into three groups: one used as fresh, second as dried fruits and third as frozen. Kaki fruits were rinsed under running tap water and dried with paper tissue. Each fruit was peeled and portioned in slices of 10 mm thickness. The second group was dried 60º C for 24 hours in a drying oven by putting the slices on trays, until constant mass. The third group were frozen in a freezer at -18º C until analysis.

Chemicals:
All reagents used for analysis were purchased from Sigma Merck and Aldrich. Deionizer water was used.

Chemical analyses:
Moisture content was analyzed by the drying process at the temperature 103° C (European Standard EN ISO 665/2000).
Vitamin C content was determined using acid extracts of fruit samples (4 gram of fruit was extracted with 12 ml of Perchloric acid and o-Phosphoric acid 1% solution). Repeated extractions of the obtained residue with the acidified solution were performed until the extraction samples remained colorless. Vitamin C content was analyses using a HPLC SHMADZU system coupled with UV–VIS detector. Calibration curve was done using dilutions Sigma 99% standard L ascorbic acid in bidistilled water.
Total soluble solids (TSS) were analyzed using an Abbe refractometer (SR ISO 2173:2008).
Ash content was determined according to SR ISO 763:2008 method (5 g of sample was calcinated at 600 ° C for 4 hours).
Total acids were determined by the method of neutralization with 0.1 n NaOH solution in the presence of 1% solution of phenolphthalein indicator (SR ISO 750:2008)
Antioxidant activity was analyzed by the method that is based on the scavenging activity of 2,2-Di (4-tert-octylphenyl)-1-pycrilhydrazyl (DPPH) radicals. The absorbance was measured at 515 nm using a spectrophotometer. IC50 was calculated using a calibration curve with different quantities of DPPH. Inhibition percent of free radicals (I%) was calculated with the relation (1):

$$I\% = \frac{Astandard - Asample}{Astandard} \times 100 \qquad (1)$$

where,
I% - inhibition percentage of radicals;
$A_{Standard}$ - absorbance of the standard sample;
A_{sample} - absorbance of the analyzed sample.
Statistics:
Samples were analyzed in triplicate and the results are given as averages ± standard deviation.

3. RESULTS AND DISCUSSION

Fresh, dried and frozen persimmons are nutritional products for which important parameters in the quality determination are the content of total dry matter and moisture content. The total solids have importance in the dehydration and freezing process (Kordylas, 1991). According to recent studies ascorbic acid is considered an important parameter for quality during processing and that's why we examined the content of vitamin C in fresh, frozen and dried samples (Fennema, 1977)
Due to the fact that quality of products are directly influences by the raw material quality, before applying the processes of drying and freezing, fresh fruit of persimmon was analyzed, in three replication. According to recent studies in the determination of fresh, frozen and dried persimmon quality, total dry matter and moisture are important parameters (Butt et al. 2015).
Data from table 1 represent the results from our research of the chemical analysis of fresh, frozen and dried persimmon as mean value of

three repetitions and standard deviation. From the data obtained we can observe that dried persimmon fruit showed a higher dry matter content (82.68%), followed by 23.20% which was recorded in the case of frozen fruits (Table 1). The moisture content was proportional with the total dry matter content having a value of 86.96% in fresh fruits, 76.80% in frozen ones and 17.32% at dried persimmon.

Table 1: Chemical analysis of fresh, frozen and dried persimmon fruits

	Mean values ± SD of samples		
Analyzed parameters	Fresh	Frozen	Dried
Total soluble substances (° Brix)	2.49 ± 0.04	2.71 ± 0.03	1.13 ± 0.11
Total dry matters (%)	13.04 ± 0.04	23.20 ± 0.03	82.68 ± 0.11
Moisture (%)	86.96 ± 0.19	76.80 ± 0.37	17.32 ± 0.31
Ash (%)	0.689 ± 0.003	0.250 ± 0.002	6.086 ± 0.13
Total acids (%)	0.11 ± 0.01	0.10 ± 0.001	0.12 ± 0.005

The total acidity in fresh persimmon fruits ranged between 0.10% and 0.11%, in fresh frozen in range on 0.102% and 0.103% and in dried persimmon between 0.120% and 0.125%. From the data obtained on the total acidity we can say that persimmon can be classified as a low- acid fruit. Results on total acids are in concordance with the results of other studies (Karakasova et al. 2013; Salama, 2008).

The total soluble solid content ranged between 1.13° Brix in dried persimmon and 2.71° Brix in fresh frozen fruits (Table 1). The content of sugars and inorganic acids that are linked to the amount of soluble solids presents in the fruits are an important factor for the fruits that are sold and eaten fresh because consumers prefer fruits that are sweeter (Silva et al. 2002). The values obtained for the total soluble substances are below the range found in previous studies (Curi et al. 2017; Karakasova et al. 2013).

The content of vitamin C in fresh *Diospyros kaki* fruit was in range of 52.23 - 52.99 mg/100 g or 211.53 - 214.61 mg/100 g on dry weight basis, from 30.85 - 31.02 mg/100 g or 41.03 - 41.26 mg/100 g on dry weight basis in the frozen fruits and 81.90 - 82.77 mg/100 g or 81.08 - 81.94 mg/100 g on dry weight basis in dried persimmon (Figure 1). Persimmon fruits are, in generally, a good source of vitamin C, similar results being obtained in other studies (Karakasova et al. 2013)

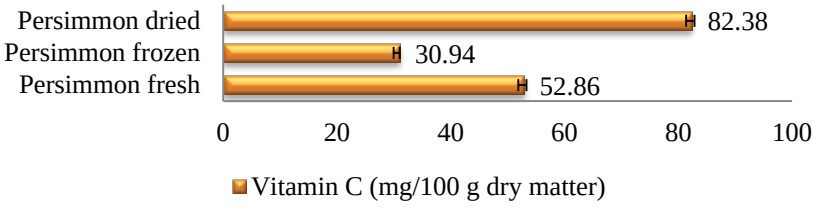

Figure 1: Vitamin C content of fresh, frozen and dried persimmon fruits

Antioxidant activity of persimmon fruits depending on the conservation method applied is presented in figure 2.

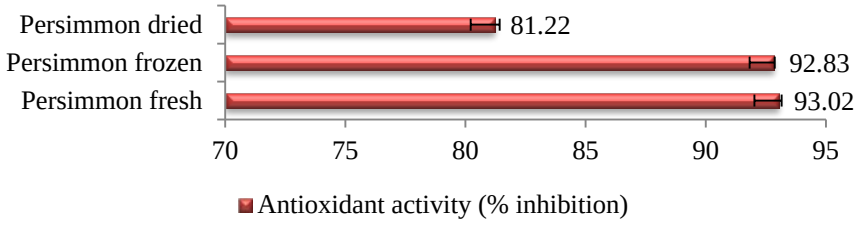

Figure 2: Antioxidant activity of fresh, frozen and dried persimmon fruits

From the data obtained we can mention that fresh persimmon has the higher scavenging activity (93.02 %), value that was greater than an inhibition of 81.22 % obtained in dried fruits. Antioxidant activity in analyzed samples has decreased in the same order (fresh fruits > frozen fruits > dried fruits) as mention in other studies (Semenov et al. 2015; Park et al. 2006).

4. CONCLUSION

In this study the influence of conservation through freezing and drying on different physicochemical parameters of persimmon fruits in comparison with the fresh fruit was analyzed. Antioxidant capacity values ranged between the limits mention by other studies and had the highest value in fresh fruits. The highest vitamin C content on dry matter basis, an important antioxidant, was obtained in fresh fruits, followed by dried fruits, suggesting that from the point of view of this parameter drying is the best method to conserve persimmon. From the data analyses we can conclude that the conservation by freezing is the most adequate methods regarding the inhibition percent of free radicals, total soluble substances and acidity.

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