QUALITY PROPERTIES OF SOLAR DRIED PERSIMMON (DIOSPYROS KAKI)

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Abstract

The aim of this paper is to determine the quality properties of solar dried persimmon (Diospyros kaki), pre-treated with different antioxidants such as: citric acid, vitamin C and potassium metabisulfite.

The persimmons were prepared in two ways: with direct pre-treatment and with freezing before pre-treatment. Drying of persimmons was done in solar drier.

To obtain dried products with good quality properties it is important to have raw material with appropriate chemical composition. Estimation of quality properties of fresh and dried persimmon was performed by chemical analysis of: total dry matter, vitamin C, sugars, total acids and ash. The content of total dry matters is in relation with total sugars and is important for determination of quality. The ratio of total sugars and the content of total acids (as malic acid) and vitamin C, determine the sensorial properties.

According to results of quality properties it was concluded that, frozen persimmons were better for drying, because of loss of astringency taste due the process of freezing. From the various antioxidants, it was noticed that in pre-treatment of fresh and frozen persimmons by potassium metabisulfite were produced dried product with the best sensorial properties. This product had the highest content of total dry matter (88.40%), glucose (10.12%), fructose (8.74%) and vitamin C (398.87 mg/100g).

Key words: Persimmon, Quality properties, Solar drier.

1. Introduction

Solar drying of food is one of the oldest ways of food preservation. Although people in the ancient times did not know about basic laws of physics, chemistry and biochemistry, they noticed that dried food can be kept longer.

Drying, as a preservation method, was known to ancient Egyptians and other civilisations [1]. The fundamentals of the modern, industrial drying were founded by the French, and the first industrial dryer was built in the year of 1850 [2].

Persimmon (Diospyros kaki) known as “Japanese apple” or “Asian’s apple” in South America, is worldwide grown species of underclass Diospyros. The persimmon has a sweet fruit. This kind of fruit, which is wide grown in China, is deciduous tree with broad and firm leaves. Growing of the persimmons started in some parts of East Asia and latter, in the XIX century, was brought in California, North Europe and Brazil. According form, the fruit is round to oval, with a weight of 500 g. The surface of the fruit is smooth, shinning with thin shell, colored from yellow to red-orange. Persimmons fruit consists of two groups of cultivars with different degrees of astringency [10]. Generally, persimmon is classified as a climactric fruit [5]. Climactric fruits could be ripe after harvest even if harvesting fruits at early maturity stage and unripe [11 and 12].

With the concurrence between European and world green markets, the main commitment is the production of dried fruits which have good and stable quality. For this purpose it is necessary to use a raw material with good quality, which is appropriately selected, prepared and properly dried in solar drier without any pollution, where quality of fresh and dried fruit will be constantly controlled [3].

The persimmon is a highly nutritional fruit [6] containing carotenoids, vitamin C, tannins, pectic substances and high levels of sugars. According to Testoni [13], the main sugars are fructose and glucose (90% of the total) and with a ratio 1 to 1. Sucrose (that normally disappears at full maturity), galactose and arabinose are present as minor components. The total amount of pectic substances range from 0.7 to 1% fresh weight. The tannins are present as soluble in amount of ranges from 0 to 4% fresh weight in dependance from the cultivar, and ripening stage. The total amount of carotenoids ranges between 5 and 6 mg/100 g fresh weight, while
in the peel of mature fruit the amount is 10 times higher. Persimmon is a good source of ascorbic acid - there is about 50 mg/100 g in the fresh pulp. The immature fruit and peel contain considerably more ascorbic acid than the pulp of mature fruit. It is generally observed that, if ascorbic acid is well retained, the other nutrients are also well retained [23]. Ascorbic acid is usually considered as an index of nutrient quality during processing and storage of foods [14]. Ascorbic acid is known to be a vitamin sensible to a number of factors, including: pH, moisture content, oxygen, temperature and light.

Climate and soil conditions in the Republic of Macedonia are very good for production of quality persimmons for fresh consumption and for processing. The good conditions for growing persimmons with characteristic color, smell, taste and appearance are low relative humidity of the air and warmth intensity of the sun.

The astringency sensation of persimmon comes from the presence of soluble tannins. During the ripening process (softening) or during astringency removal treatments, soluble tannins coagulate and become insoluble and they are not noticed anymore [15]. There are many methods for astringency removal, and among them are: alcohol treatment, freezing, CO₂ treatment, ripening and softening [12].

Persimmons are interesting to industry, because it can be frozen, canned or dried. In oriental countries, consumption of dried persimmons is already a tradition. Dried persimmons present good sensory attributes and could be a valuable source of vitamin A and ascorbic acid [23]. The most interesting industrial application for persimmons processing is drying technique. In fact, traditionally the Japanese and Chinese have always peeled, cut and sun dried persimmons [12]. Dried persimmons obtained by solar drying have a great nutritional and healthy value. The process of sun drying has been updated in California and in Italy, where Testoni and Maltini [16] proposed the ideal parameters for drying (hot air at 45 °C for about 18 h) in relation to the ripening stage and thickness of slices of 'Kaki Tipo' persimmon. If the fruit is quartered and peeled the usable temperature is about 65 °C. The final step is reached when the weight loss is about 75 - 85% of initial weight, obtaining a high-energy intermediate moisture product, ready to eat. The relatively high temperatures common applied during convective drying also lead to tannin degradation, whereas sugars present in the fruit exude to the surface where they crystallize. The result is a sweet, tasteful and non-astringent dried product [17 and 18].

2. Materials and Methods

Generally, there are very few research results in the Republic of Macedonia about this fruit. In this research were used persimmon fruits, originating from the Vardar region, Republic of Macedonia. The fruits were harvested at full physiological maturity, when the selected fruits of persimmons had uniform orange color, a uniformed form, regular size and intermediate degree of firmness.

Harvested persimmons were separated and prepared in two ways: with direct pre-treatment and with freezing before pre-treatment. The process of freezing was performed in order to reduce astringency taste of the physiologically ripe fruit, as one of the recommended methods, which according Testoni [13] is reducing the content of tannins. One of the separated parts of persimmons fruits were frozen for 24 hours, and afterwards were thawed at room temperature. Then from these persimmons fruits handles were removed and together with the other parts of persimmons were washed in fresh water, hand peeled and cut in round sheets. The pre-treatment includes treatments with different antioxidants. The treatments with antioxidants were made on both separated and prepared persimmon fruit sheets, each in three variants: with 5% solution of citric acid for 5 minutes, 3% solution of potassium metabisulfite for 5 minutes, and with 2% solution of ascorbic acid for 5 minutes. The process of persimmons drying was done in solar dryer, under controlled conditions. Drying was performed at temperatures within the range of 45 °C during nights, to 65 °C during days. The process of drying lasted about 52 hours, due to the reason that the drying period was at the end of November.

The analyses on chemical composition were made to control the quality of the raw materials and of all variants of solar dried persimmon fruit sheets prepared in different ways. For that purpose the following parameters were determined in each of the samples, with three repetitions:

- Content of total dry matters was determined by drying the material in dryer on the temperature of 105 °C;
- Moisture content was obtained by calculation (when from 100% will be deducted % of total dry matters);
- Total acidity content by the method of neutralization with 0.1 M NaOH solution in the presence of 1% solution of phenolphthalein indicator;
- Content of sugars, as glucose and fructose were determined by HPLC method;
- Content of vitamin C by method of Thilmans, which is based on the redox reaction between L-ascorbic acid and organic color 2,6-dichlorophenolindophenol;
- Content of total ash was examined by removing moisture from the prepared material in drier on the temperature of 105 °C. Then the rest was burned in electric oven with gradually increasing the temperature to 550 °C. Burning was done until ashes become grey or white.
Results were statisticaly evaluated by F-test.

The sensory analysis was performed on dried persimmon fruit sheets to evaluate their taste, color and odor.

3. Results and Discussion

Fresh and dried persimmons are important nutritional product, which have high content of sugars, as glucose and fructose as a source of energy.

The important parameters for determination the quality of fresh and dried persimmons are content of total dry matter and moisture content respectively. It is worth to mention that, the total solids have importance in the dehydration process [7]. Most of the dry matter goes to simple sugars, glucose and fructose, as the most represented in persimmon fruits. According to Fennema [14], ascorbic acid is considered as an index of nutrient quality during processing and storage of foods, and that’s why we examined the content of vitamin C in fresh, frozen-fresh and in all variant of pre-treated dried persimmon sheets.

Taking into account the fact that product quality pre-requisit is raw material, before start of drying process we made analysis, in three replicatons, of the raw material that was previously prepared by freezing and without freezing. In this research was found that the persimmon fruits which were fresh-frozen and then thawed shows higher contents total dry matters, due to which is the higher content of sugars, glucose and fructose. The moisture content was proportional to the total dry matter content and was lower in the fresh-frozen persimmon fruits compared to fresh ones. In the Figure 1 are shown results of three repetitions for total dry matters and sugars, as glucose and fructose in fresh and fresh-frozen persimmons.

In Table 1 are given results from our research of the chemical analysis of fresh and fresh-frozen persimmons, as the mean value of three repetitions, with standard deviation for examined parameters.

The aim of this study was to reveal the effect of different pre-treatments on dried persimmon sheets on their nutritional value and on their sensory properties. The different pre-drying treatments were such as immersing in sodium metabisulfite solution (3%) for 5 minutes, immersing in ascorbic acid solution (2%) for 5 minutes and immersing in citric acid solution (5%) for 5 minutes. Salama [19] recorded that all pre-treated samples of persimmon fruits have slight decrease in the drying ration as compared to untreated ones.

Tannins are present on higher level as tannic acid in fresh persimmons fruits, which according to Ozen et al. [21], disappears when the fruit becomes very ripe. We have used persimmons in physiological maturity, not very rape and therefore these pre-treatments were also in terms to reduce the astringent taste in dried sheets of persimmons. The astringent taste is not desirable for most of consumers.

After different pre-treatments of fresh and fresh-frozen persimmon fruits sheets, and process of drying in a solar dryer, we made analysis on chemical compositions in all dried variants, in three repetitions. Then we calculate the mean values and standard deviation of ob-

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Table 1. Chemical analysis of fresh and fresh-frozen fruit of persimmons

<table>
<thead>
<tr>
<th>Analyzed parameters</th>
<th>Fresh fruit</th>
<th>Fresh-frozen fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dry matters (%)</td>
<td>18.74 ± 0.184</td>
<td>20.51 ± 0.147</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>81.26 ± 0.184</td>
<td>79.49 ± 0.147</td>
</tr>
<tr>
<td>Glucose (%)</td>
<td>2.69 ± 0.217</td>
<td>4.95 ± 0.106</td>
</tr>
<tr>
<td>Fructose (%)</td>
<td>2.09 ± 0.196</td>
<td>4.49 ± 0.161</td>
</tr>
<tr>
<td>Total solids (%)</td>
<td>0.16 ± 0.011</td>
<td>0.117 ± 0.008</td>
</tr>
<tr>
<td>Vitamin C (mg/100g)</td>
<td>94.23 ± 8.426</td>
<td>110.98 ± 2.404</td>
</tr>
</tbody>
</table>

The content of total acidity (as malic acid) in fresh persimmon fruit was in the range on 0.152 - 0.173% and in fresh-frozen in range on 0.109 - 0.124%. When we calculated these values on dry weight, the total acidity (as malic acid) was in the range 0.818 - 0.926% in fresh persimmon and 0.535 - 0.576% in fresh-frozen persimmons. Salama [19], stated that total acidity is 0.87 ± 0.230% on dry weight basis. The content of vitamin C in fresh persimmon fruit was in the range on 85.63 - 102.47 mg/100 g or 460.872 - 541.24 mg/100 g on dry weight basis. In fresh-frozen persimmon fruit the content of vitamin C was in the range on 103.78 - 112.68 mg/100 g or 509.225 - 545.137 mg/100 g on dry weight basis. Generally, persimmon fruit is a good source of ascorbic acid (vitamin C) and also for carotene (pro-vitamin A) sugar, crude fiber and minerals, especially potassium [20].
tained results. In Table 2 and Table 3 are presented results from chemical analysis of all variants of pre-treated dried persimmon fruit sheets, obtained from fresh and from fresh-frozen persimmons.

### Table 2. Chemical analysis of all variants of pre-treated dried persimmons fruit sheets, obtained from fresh persimmons

<table>
<thead>
<tr>
<th>Analyzed parameters</th>
<th>K$_2$S$_2$O$_5$</th>
<th>Citric acid</th>
<th>Ascorbic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dry matters (%)</td>
<td>83.08 ± 0.332</td>
<td>84.14 ± 0.325</td>
<td>82.95 ± 0.210</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>16.92 ± 0.332</td>
<td>15.86 ± 0.325</td>
<td>17.05 ± 0.210</td>
</tr>
<tr>
<td>Glucose (%)</td>
<td>9.13 ± 0.348</td>
<td>9.76 ± 0.142</td>
<td>9.31 ± 0.176</td>
</tr>
<tr>
<td>Fructose (%)</td>
<td>8.29 ± 0.156</td>
<td>8.85 ± 0.244</td>
<td>8.52 ± 0.160</td>
</tr>
<tr>
<td>Total acids (%)</td>
<td>0.498 ± 0.024</td>
<td>0.824 ± 0.007</td>
<td>0.312 ± 0.016</td>
</tr>
<tr>
<td>Vitamin C (mg/100g)</td>
<td>364.23 ± 19.406</td>
<td>283.6 ± 3.994</td>
<td>337.45 ± 7.548</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>3.05 ± 0.096</td>
<td>2.99 ± 0.137</td>
<td>2.42 ± 0.088</td>
</tr>
</tbody>
</table>

### Table 3. Chemical analysis of all variants of pre-treated dried persimmons fruit sheets, obtained from fresh-frozen persimmons

<table>
<thead>
<tr>
<th>Analyzed parameters</th>
<th>K$_2$S$_2$O$_5$</th>
<th>Citric acid</th>
<th>Ascorbic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dry matters (%)</td>
<td>88.40 ± 0.195</td>
<td>86.54 ± 0.815</td>
<td>83.36 ± 0.919</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>11.60 ± 0.195</td>
<td>13.46 ± 0.815</td>
<td>16.64 ± 0.191</td>
</tr>
<tr>
<td>Glucose (%)</td>
<td>10.12 ± 0.176</td>
<td>9.43 ± 0.082</td>
<td>9.16 ± 0.100</td>
</tr>
<tr>
<td>Fructose (%)</td>
<td>8.74 ± 0.153</td>
<td>8.25 ± 0.096</td>
<td>8.33 ± 0.068</td>
</tr>
<tr>
<td>Total acids (%)</td>
<td>0.716 ± 0.026</td>
<td>1.135 ± 0.064</td>
<td>0.384 ± 0.206</td>
</tr>
<tr>
<td>Vitamin C (mg/100g)</td>
<td>398.87 ± 20.003</td>
<td>223.01 ± 10.531</td>
<td>246.06 ± 10.196</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2.98 ± 0.135</td>
<td>1.97 ± 0.121</td>
<td>1.98 ± 0.145</td>
</tr>
</tbody>
</table>

The moisture content is one of the important parameters of quality for dried fruits. From the presented results in the Table 2 and Table 3 it can be seen that the highest moisture content had the dried persimmon sheets processed from fresh persimmon, pre-treated with ascorbic acid and the lowest content had dried persimmon sheets processed from fresh-frozen persimmon, pre-treated with K$_2$S$_2$O$_5$. Accordingly to this, the content of total dry matters was highest in dried persimmon sheets, processed from fresh-frozen persimmon, pre-treated with K$_2$S$_2$O$_5$ where the results were in the range 88.21 - 88.60% and the lowest content of total dry matters had dried persimmon sheet, processed fresh persimmon, pre-treated with ascorbic acids, where the results were in the range 82.75 - 83.17%.

Due to process of preparation and pre-treatment of the persimmon fruit sheets, as a result of the degradation of polysaccharides coming up to increasing the content of monosaccharides: the content of glucose in fresh persimmon was in range 2.46 - 2.89% and of fructose was in range 1.87 - 2.25%. With the different pre-treatments and process of drying, mostly was increased content of glucose and fructose in persimmon fruit sheets, pre-treated with citric acids, where the results were in the range 9.63 - 9.91% and 8.57 - 9.03% respectively. According to data from www.usda.com, the content of monosaccharides in different varieties of the fruits of persimmons in full maturity is between 9.34% and 13%. The content of glucose in fresh-frozen persimmons was in range 4.85 - 5.06% and of fructose was in range 4.31 - 4.62%. After different pre-treatments the content of glucose and fructose mostly increased in persimmon fruit sheets pre-treated with K$_2$S$_2$O$_5$ where the results were in the range 9.93 - 10.28% and 8.61 - 8.91% respectively.

In the Table 2 and Table 3 are presented results for the content of total acids (expressed as malic acid), in dried persimmons sheets processed from fresh and fresh-frozen persimmon fruit, where the highest content had dried persimmons sheets, processed from fresh-frozen persimmon, pre-treated with citric acid, and the lowest content of total acids (expressed as malic acid) had the dried persimmons sheets processed from fresh persimmons, pre-treated with ascorbic acid. The content of vitamin C (ascorbic acids) was highest in dried persimmons processed from fresh-frozen persimmon, pre-treated with K$_2$S$_2$O$_5$, and lowest in dried persimmons processed from fresh-frozen persimmons, pre-treated with citric acid. In terms of ash content there were no significant differences between variants with different treatments. Namely, the content of ash was among the range 1.88 - 2.11% in dried persimmons sheets processed from fresh-frozen persimmon, pre-treated with citric acid and 2.95 - 3.14% in dried persimmons sheets processed from fresh persimmon, pre-treated with K$_2$S$_2$O$_5$.

The obtained results were statistically evaluated, by F-test and it was found that there is significant differences in the content of total dry matter, sugars and vitamin C in dried persimmon sheets, processed from
fresh-frozen persimmon, where was used as pre-treatment potassium metabisulfite (K₂S₂O₅).

Sensory evaluation of the dried persimmon sheets is considered as one of the important factors that affect, to a large extent, their acceptability for consumer. Therefore, the prepared dried samples were evaluated sensory properties for color, taste and odor of dried persimmons. It was determined that the odor were inherent, typical for dried fruit processed from fresh and fresh-frozen fruits in all treatments. The taste of dried fruits processed from fresh frozen fruit was more pleasant, because of the reduced presence of astringency, resulting in decreased content of tannin matters. The color was typical (orange) only in dried fruit obtained from fresh and fresh-frozen fruits of persimmons treated with potassium metabisulfite (K₂S₂O₅), and in the other 4 samples dried fruits were with untypical (brown) color. This is in accordance to statement of Salama [19] that sulfating induced a light color of the dried products. This may be due to prevention of both types of browning inactivating irreversibly enzyme systems and blocking the reducing group of sugars by SO₂ as reported by Somogyi and Luch [8] and Akyidiz [22]. Also, Salama [19] noted that the dried sheet samples treated with sodium metabisulfite had the highest scores, following by samples treated with citric acid. These results are in accordance with those obtained by Hassan [4]. Thus, sulphiting pre-treatment seems to prevent the color deterioration during dehydration, as it retards both enzymatic and non-enzymatic browning reactions [9].

4. Conclusions

Based on the results of chemical analysis of fresh, fresh-frozen and solar dried persimmons and also, from their sensorial estimation we can make following conclusions:

- The contents of all analyzed parameters were higher in fresh-frozen fruit compared to fresh persimmon fruits.

- Mostly of analyzed parameters were found that had higher content in dried persimmon fruit sheets that were processed from fresh-frozen fruit.

- The content of total dry matters was highest in dried persimmon sheets obtained from fresh-frozen persimmon, pre-treated with K₂S₂O₅, where the results were in the range 88.21 - 88.60%.

- After different pre-treatments the content of glucose and fructose mostly increased in persimmon fruit sheets pre-treated with K₂S₂O₅ where the results were in the range 9.93 - 10.28% and 8.61 - 8.91% respectively.

- The content of total acids was the highest in dried persimmons sheets, processed from fresh-frozen persimmon, and pre-treated with citric acid.

- The highest content of vitamin C was in processed variant treated with K₂S₂O₅ and it was 364.23 mg/100 g in dried fruits processed from fresh persimmon fruits and 578.87 mg/100 g in dried fruits processed from fresh-frozen persimmon fruit.

- According to the results of chemical analysis, which were statistically evaluated, we can recommend before drying process of persimmon fruit to use previously freezing and thawing of fruits, and as pre-treatment we suggest using of K₂S₂O₅.

- The odor as a sensorial characteristic was typical for dried fruit obtained from fresh and fresh-frozen fruits in all treatments.

- The taste of dried fruits processed from fresh-frozen fruit was more pleasant due to reduced presence of astringency.

- The color as a sensorial characteristic was evaluated in the dried persimmon fruit sheets processed from fresh and fresh-frozen fruits of persimmon treated with K₂S₂O₅.

- The Republic of Macedonia has good agro climatic conditions for quality production of fresh and also of solar dried persimmons.

5. References


