EFFECT OF MODIFIED SUN DRYING TECHNIQUES ON FRUIT QUALITY CHARACTERS OF DATES HARVESTED AT RUTAB STAGE

Imtiaz Hussain, Saeed Ahmad, Muhammad Amjad* and Rashid Ahmed**

ABSTRACT

A study was conducted at University of Agriculture, Faisalabad, Pakistan during 2012 to optimize the best sun drying technique for improving the quality of processed dates (cv. Hillawi). The fruits were collected at rutab/dong stage from 15-25 years old plants and subjected to various sun drying techniques for 6 to 8 days depending upon daily weather conditions. Physicochemical changes related to quality were analyzed and found that the fruits dried under direct sun light during the day time, removed and covered during night showed higher moisture (24.13%), minimum weight loss (18.73%), higher TSS (11.09 °Brix), total sugar (69.39%) and higher reducing sugar (51.47%) with lower acidity (0.130%) in fruits when reached at tamr stage (dried). Higher phytonutrients such as total phenolics (224.28 mg GAE/100 g), total flavonoids (34.31 mg CEQ/100 g) and total antioxidants (72.20% DPPH inhibition) with lower tannins (0.143%) were also found in these fruits. It is concluded that good quality dried dates can be prepared successfully by adopting the modification in conventional sun drying technique that could improve the economic status of farmers.

KEYWORDS: Phoenix dactylifera; Sun-drying techniques; Hillawi; dates; fruit quality; rutab stage; physico-chemical characteristics; phytonutritional composition; Pakistan.

INTRODUCTION

Date palm (Phoenix dactylifera L.) is a major cultivated fruit crop in arid and semi-arid regions of Western Asia and North Africa (31). It is one of the oldest mankind’s cultivated fruit crops on earth (30) and well known as “tree of life” due to its long life span (5). The name of date palm is mentioned in the blessed books like Qur’an, Torah and Buddha, due to its prized value and historic importance (5, 11). The biochemical composition of date fruit is variable due to various factors such as variety, region, climate, fertilizer

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application and type of cultural practices (2). Pakistan is the fifth largest date producing country in the world with an annual production of 735280 tons from an area of 90.1 thousand hectares, contributing 10 percent share in global production (3). Date palm is third major fruit crop of the country having more than 325 well known cultivars (16).

In Pakistan, monsoon rainfalls coincide with the ripening period of dates which cause the rottening of ripened fruit. Hillawi being the important cultivar and commercially grown in Punjab, Pakistan, ripens during mid July to August which is a peak monsoon period. The fruit of Hillawi is completely harvested and consumed at khalal stage with less economic value. There is no trend to process or cure the fruit due to occurrence of monsoon rains. However, if the fruit is harvested at rutab stage and properly processed/cured by using proper sun drying techniques, it can be saved for future consumption with good economic value.

Drying technique is an ancient process of food preservation which removes water from the food and inhibits enzymatic degradation and limits microbial growth. It is the most wide spread and energy-consuming food preservation process (24). Different methods of drying have been developed for food and each method has its own advantages. Sun-drying is a low cost technology which minimizes the post-harvest losses in developing countries. Drying of fresh dates is necessary because high moisture (about 60%) limits its shelf life. In sun-drying water is usually removed by evaporation. Matured date fruits are allowed to partially dry on the trees before these are harvested and fruit is further dried in sun-quality and storage. However, problems associated with sun-drying are well documented (8, 9, 14). During dehydration, irreversible burst and discoloration occur to the exposed commodity which results in loss of integrity due to capillaries shrinkage with less hydrophilic properties (20). Sun-drying allows flavors to concentrate, prevents the loss of volatile compounds and unwanted caramelization of natural sugars against other drying methods (29). Sun-drying enhances better initial colour, texture, as well as translucency and sheen (22).

The objective of present study was to evaluate different sun-drying techniques for improving physico-chemical properties for dates harvested at rutab stage.

**MATERIALS AND METHODS**

This study was conducted at Post Graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad, Pakistan (Latitude 31°-26’ N, Longitude 73°-06’ E and Altitude 184.4 m) during the year 2012. Fruits of
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Dates (cv. Hilawi) were harvested at rutab stage and dried under direct sunlight exposure (DSE) by adopting following drying techniques (SDTs). Experiment was laid out in complete randomized design (CRD).

SDT₁ = Control (DSE without covering and removal during night)
SDT₂ = DSE on mat and covered with polythene sheet during night
SDT₃ = DSE on mat and removal in baskets during night
SDT₄ = SE on mat with removal in baskets and covered during night
SDT₅ = DSE on mat and removal with mats during night

Data on physical (fruit weight loss and moisture contents), biochemical (total soluble solids, acidity, reducing sugar and total sugar) and phytonutritional (total phenolic contents, total flavonoids, total antioxidants and total tannins) parameters were obtained.

The sun-drying practices were performed continuously for 6 to 8 days (depending on daily temperature) until moisture less than 25%. The samples were brought to the Pomology Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad for performing the required analysis.

One hundred tamar fruits were selected for data collection from each treatment. After removal of seeds, 25g sample of date fruit pulp was mixed with 100 ml of distilled water in a small food blender and then filtered through a filter paper. The obtained filtrate was used for analysis of total soluble solids (TSS), total sugars, reducing sugars and acidity. TSS were measured with a digital refractometer (ATAGO, RX 5000; Atago Inc., Tokyo, Japan) and expressed in °Brix. Acidity was determined by titrating the samples against 0.1N sodium hydroxide (NaOH) by using 2-3 drops of phenolphthalein as an indicator with pink colour as an end point and was expressed as percent citric acid. Ascorbic acid was determined according to the method described by Ruck (25). Sugars were estimated according to the methods described by Hortwitz (15) and Lane and Eynon (19). From each sample, 5 ml of juice was taken in 250 ml volumetric flask with 100ml distilled water, 25 ml lead acetate solution (430 g/l) and 10 ml of 20 percent potassium oxalate solution was added. Then volume was made upto the mark with distilled water and filtered, and filtrate was used to estimate sugar contents. Estimation of total tannins was performed by titration method with standard potassium permanganate (KMnO₄) solution by using indigo carmine as an indicator (1). Total phenolic contents were determined by using Folin-Ciocalteu (FC) reagent method as described by Singleton and Rossi (26). Total flavonoids contents were determined by the method of Kim et al. (18). Total antioxidants activity was
determined by scavenging of radical 2, 2-diphenyl-1-picrylhydrazyl (DPPH) as described earlier. Moisture content was determined by an automatic electronic computer operated moisture tester (Brabender® MT-C, made by GmbH & Co. KG, Germany). For determining the fruit weight loss, fruits were weighed before imposing the treatments which served as initial fruit weight. The loss in weight was recorded at the final day of observation which served as the final fruit weight. The loss in weight was determined by following formula and expressed as percentage.

\[
\text{Fruit weight loss} = \frac{\text{Initial fruit weight} - \text{Fruit weight at final observation}}{\text{Initial fruit weight}} \times 100
\]

**Statistical analysis:** The collected data were analyzed statistically by employing Fisher analysis of variance technique (22) using computer software MSTAT-C (12) and treatment means were compared by applying least significance difference (LSD) test at 5 percent probability level.

**RESULTS AND DISCUSSION**

**Fruit weight loss and moisture content (%)**

The results (Table 1) indicate that fruit weight loss and moisture contents were affected by various sun drying techniques. Maximum weight loss (47.80%) was recorded in control (DSE without covering and removal during night) against minimum weight loss (18.73%) in SDT₄ (DSE with removal in baskets and covered during night) which was at par with SDT₃. Minimum moisture reduction (13.91%) was noted in control against maximum (24.13%) in SDT₄ followed by SDT₃ and SDT₅.

Weight loss from fresh food commodity depends upon transpiration and respiration. In transpiration, water loss occurs due to differences in water vapor pressure in the atmosphere and transpiring surface. Respiration results in weight reduction because a carbon atom is lost from the fruit each time a carbon-dioxide molecule is produced from an absorbed oxygen molecule and evolved into the atmosphere (7). Fruit weight loss of fresh product can influence the economic returns. It was observed that continuous open sun-drying caused excessive weight loss with poor quality fruit as compared to other modified sun-drying techniques. In developing countries, one of the main purpose of sun-drying is to reduce the post-harvest losses by lowering the internal water contents to an optimum level (23).
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Table 1. Effect of sun drying techniques on weight loss and moisture contents of date palm at tamr stage (cv Hillawi).

<table>
<thead>
<tr>
<th>Sun drying techniques</th>
<th>Weight loss (%)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT₁ = Control (DSE without covering and removal during night)</td>
<td>47.80±1.78a</td>
<td>13.91±2.56d</td>
</tr>
<tr>
<td>SDT₂ = DSE and covering with polythene sheet during night</td>
<td>28.17±2.14b</td>
<td>17.17±1.97c</td>
</tr>
<tr>
<td>SDT₃ = DSE and removal in baskets during night</td>
<td>22.66±1.71bc</td>
<td>21.06±0.66ab</td>
</tr>
<tr>
<td>SDT₄ = DSE with removal in baskets and covered during night</td>
<td>18.73±2.34c</td>
<td>24.13±1.51a</td>
</tr>
<tr>
<td>SDT₅ = DSE and removal with mats during night</td>
<td>27.47±2.07b</td>
<td>19.00±1.44bc</td>
</tr>
</tbody>
</table>

Total soluble solids (°Brix), total sugar and reducing sugar (%)

Sun drying techniques also significantly affected the total soluble solids in date fruit. Minimum TSS (6.21°Brix) was noted in control while higher value (11.09°Brix) was recorded in SDT₄ (Table 2). The data further showed that higher fruit acidity (0.263%) was recorded in control against lower acidity level (0.130%) in SDT₄ followed by SDT₃. Higher value of total sugar (69.39%) was recorded in SDT₄ followed by SDT₃ (62.10%) and SDT₅ (55.80%) while minimum total sugar contents (32.88%) (Table 3) were noted in control. Maximum reducing sugar content (51.47%) was noted in SDT₄ followed by SDT₃ (47.24) and SDT₅ (44.21) whereas minimum value was recorded in control (26.46%).

Table 2. Effects of sun drying techniques on total soluble solids and acidity of date palm at tamr stage (cv. Hillawi).

<table>
<thead>
<tr>
<th>Sun drying techniques</th>
<th>TSS (°Brix)</th>
<th>Acidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT₁ = Control (DSE without covering and removal during night)</td>
<td>6.21±0.41d</td>
<td>0.263±0.025a</td>
</tr>
<tr>
<td>SDT₂ = DSE and covering with polythene sheet during night</td>
<td>7.28±0.73cd</td>
<td>0.223±0.015b</td>
</tr>
<tr>
<td>SDT₃ = DSE and removal in baskets during night</td>
<td>9.39±0.65b</td>
<td>0.173±0.015c</td>
</tr>
<tr>
<td>SDT₄ = DSE with removal in baskets and covered during night</td>
<td>11.09±1.06a</td>
<td>0.130±0.010d</td>
</tr>
<tr>
<td>SDT₅ = DSE and removal with mats during night</td>
<td>8.43±0.47bc</td>
<td>0.196±0.005bc</td>
</tr>
</tbody>
</table>

Table 3. Effects of sun drying techniques on total sugar and reducing sugar contents of date palm at tamr stage (cv Hillawi).

<table>
<thead>
<tr>
<th>Sun drying techniques</th>
<th>Total sugar (%)</th>
<th>Reducing sugar (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT₁ = Control (DSE without covering and removal during night)</td>
<td>32.88±1.27e</td>
<td>26.46±1.00e</td>
</tr>
<tr>
<td>SDT₂ = DSE and covering with polythene sheet during night</td>
<td>51.39±1.60d</td>
<td>41.61±0.62d</td>
</tr>
<tr>
<td>SDT₃ = DSE and removal in baskets during night</td>
<td>62.10±2.52b</td>
<td>47.24±0.94b</td>
</tr>
<tr>
<td>SDT₄ = DSE with removal in baskets and covered during night</td>
<td>69.39±1.95a</td>
<td>51.47±2.02a</td>
</tr>
<tr>
<td>SDT₅ = DSE and removal with mats during night</td>
<td>55.80±1.34c</td>
<td>44.21±0.66c</td>
</tr>
</tbody>
</table>

Solar radiation and temperature have a great influence on fruit sugar accumulation. The results regarding sugar contents were significantly affected by sun-drying techniques. Fruit sugar content is a variable multigenic trait which is greatly affected under varied environmental conditions (17). The open sun-drying caused a heavy loss of sugar contents as compared to...
those fruits which were removed during night time. High temperature increased TSS due to changes in carbohydrate biosynthetic enzymes activity (30), and increased transpiration (13). Post-harvest practices such as timing of harvest, handling techniques and storage conditions can alter the fruit sugar profiling (17). In SDT4, improvement in fruit quality might be due to presence of all day’s heat which reduces the excessive fruit weight loss by maintaining the internal fruit water contents, color and other quality related characters.

Phytonutritional composition

**Total phenolics and total antioxidants:** Different sun drying techniques significantly affected the phytonutritional composition of date fruit. Higher total phenolic contents (224.28 mg GAE/100g) were measured in SDT4 followed by SDT3 (189.88 mg GAE/100g) Minimum total phenolic compounds (166.80 mg GAE/100g) were recorded in control (Table 3). Higher antioxidant activity (72.20% DPPH inhibition) was recorded in SDT4 followed by SDT3 (61.21% DPPH inhibition) and SDT5 (51.31% DPPH inhibition). Minimum antioxidant activity was observed in control (32.35% DPPH inhibition) (Table 4).

### Table 4. Effects of sun drying techniques on total phenolics and total antioxidant activity of Hillawi date palm at tamar stage.

<table>
<thead>
<tr>
<th>Sun drying techniques</th>
<th>Total phenolics (mg GAE/100 g)</th>
<th>Total antioxidants (% DPPH inhibition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT1 = Control (DSE without covering and removal during night)</td>
<td>166.80±2.44d</td>
<td>32.35±1.54d</td>
</tr>
<tr>
<td>SDT2 = DSE and covering with polythene sheet during night</td>
<td>179.78±1.54c</td>
<td>47.76±2.90c</td>
</tr>
<tr>
<td>SDT3 = DSE and removal in baskets during night</td>
<td>189.88±2.68b</td>
<td>61.21±2.42b</td>
</tr>
<tr>
<td>SDT4 = DSE with removal in baskets and covered during night</td>
<td>224.28±5.03a</td>
<td>72.20±1.57a</td>
</tr>
<tr>
<td>SDT5 = DSE and removal with mats during night</td>
<td>181.50±0.89c</td>
<td>51.31±4.43bc</td>
</tr>
</tbody>
</table>

### Table 5. Effects of sun drying techniques on total flavonoids and total tannins contents of Hillawidate palm at tamar stage.

<table>
<thead>
<tr>
<th>Sun drying techniques</th>
<th>Total flavonoids (mg CEQ/100 g)</th>
<th>Total tannins (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDT1 = Control (DSE without covering and removal during night)</td>
<td>22.54±1.05d</td>
<td>0.323±0.015a</td>
</tr>
<tr>
<td>SDT2 = DSE and covering with polythene sheet during night</td>
<td>26.39±0.65c</td>
<td>0.273±0.015b</td>
</tr>
<tr>
<td>SDT3 = DSE and removal in baskets during night</td>
<td>29.86±0.32b</td>
<td>0.210±0.010d</td>
</tr>
<tr>
<td>SDT4 = DSE with removal in baskets and covered during night</td>
<td>34.31±1.56a</td>
<td>0.143±0.015e</td>
</tr>
<tr>
<td>SDT5 = DSE and removal with mats during night</td>
<td>27.28±0.45c</td>
<td>0.246±0.015c</td>
</tr>
</tbody>
</table>
Total flavonoids and total tannins (%): Maximum total flavonoids contents were recorded in SDT₄ (34.31 mg CEQ/100g) followed by SDT₃ (29.86 mg CEQ/100 g). Minimum total flavonoids (22.54 mg CEQ/100g) was observed in control (Table 5). Higher level of total tannin contents (0.323%) was noted in control against minimum in SDT₄ (0.143%) followed by SDT₃ (0.210%) and SDT₅ (0.246%). These results are in line with findings of Walker and Ho (29) who reported that appropriate sun-drying methods allows food flavors to concentrate, preventing the loss of volatile compounds and unwanted caramelization of natural sugars and prevents the undesirable browning color. These results also agree to those of Mrak et al. (22) who revealed that sun-drying enhances the good initial color and texture, as well as translucency and sheen of the tested food commodity. In present study phenolic compounds were also significantly affected by various sun-drying techniques. These results are also supported by Al Farsi et al. (1).

CONCLUSION

It is concluded that sun-drying techniques significantly affected fruit physical and quality characters in ‘Hillawi’ date palm. Among all tested sun-drying techniques, SDT₄ (DSE with removal in baskets and covered during night) performed better excessive fruit weight loss by maintaining the fruit moisture content to an optimum level. This technique also mentioned desirable composition as TSS, acidity, total sugar, reducing sugar, total phenolics, total antioxidant activity, total flavonoids and total tannin contents.

REFERENCES


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