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Effect of Solar Drying Techniques on Biochemical Characteristics of Dhakki Dates

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Abstract: Date palm (*Phoenix dactylifera* L.) relates to the family Arecaceae. Most developing countries cannot produce enough food to meet their increasing populations. A considerable percentage of crop items produced in some of these areas reported rapid deterioration of postharvest quality, mainly due to inadequate or non-existent processing and storage facilities. Drying is the most critical process in dates. So, different techniques have been used for better drying of this delicious fruit. Therefore, the trial was conducted to evaluate the performance of solar and hybrid dryers to investigate the drying conditions for date fruit. Two-factor completely randomized design (CRD) was applied, and comparison of mean was made by using Tukey's test at 5% level of significance. In our research, total soluble solids (10.38%) were more in the solar dryer as compared to the hybrid dryer (9.51%). Hybrid dryer (0.808%) achieved more acidity as compared to the solar dryer (0.717%). Vitamin C content of processed dates differed significantly in these dryers as solar dryer, and hybrid dryer showed 3.68% and 8.51% vitamin C, respectively. The higher amount of reducing sugars (18.58%) was recorded in date fruits processed in the hybrid dryer as compared to the solar dryer (18.30%). Consequently, values of total sugars were also significantly higher for date fruits dried in the hybrid dryer (31.48%) as compared to the solar dryer (30.98%). As for as the non-reducing sugars are concerned, they were more (12.88%) in the hybrid dryer as compared to the solar dryer (12.69 %). Thus, it can be concluded that good quality dates can be prepared by adopting hybrid dryers as compared to solar drying techniques.

Keywords: Date palm, Arecaceae, solar dryer, hybrid dryer, total soluble solids, quality, postharvest.

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1. Introduction

Domestication of date palm (*Phoenix dactylifera* L.) is recorded ~7,000 years before present, in Dalma Island, Abu Dhabi or Iraq, therefore among the fruits trees, date palm is considered among the earliest domesticated (Chao, and Krueger, 2007; Fuller, 2018; Zohary et al., 2012). Nowadays, the date is a vital fruit plant of hot arid habitats, ranging from a desert oasis to irrigated farms (Flowers et al., 2019; Gros-Balthazard et al., 2017). Countries of Arabian Peninsula and North Africa constitute traditional areas of date cultivation, which further extended to South Asia including Pakistan (Chaluvadi et al., 2019l; Johnson et al., 2013; Lim, 2012).

Developing nations are facing challenges to meet their nutritional requirements of expanding populations (Garrity et al., 2010; Shiferaw et al., 2011). Dates are widespread across the world and are economic source of amino acids, proteins, carbohydrates, dietary fibre and minerals (Benmeziane-Derradji, 2019; Hamad et al., 2015; Hamzah et al., 2019). Due to presence of various nutritional compounds like anthocyanins, carotenoids, flavonols, flavones, phenolic acids, polyphenols, volatile compounds dates are also excellent antioxidants (Al-Farsi and Lee, 2008; Hussain et al., 2020; Metoui et al., 2019). Dates and its products are used in the nutraceutical, pharmaceutical industries and for the development of natural compounds of diversified usage (Al-Alawi et al., 2017; Djaoudene et

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al., 2019; Ghori et al., 2018). Therefore dates have the potential for valuable contribution to long-term food security.

Date colour, flavour, fruit intactness, moisture and nutrients levels are among the essential quality characteristics of dates (Lobo et al., 2013; Yahia and Kader, 2011). During its development date fruit (date) passes through internal and external and modifications in colour, chemical composition, taste, and texture (Al-Alawi et al., 2017). These changes are dependent on the stage of fruit development, preharvest management (Awad, 2007). Moreover, postharvest management also has a significant impact on the quality and shelf life of agricultural products. Mediocre handling of agricultural commodities, including dates, after harvesting and during storage deteriorated the quality and marketing value (Hasan et al., 2019; Kitinoja et al., 2018).

Globally Pakistan is among the top producers and exporters of date fruit (FAO, 2018; Nadeem et al., 2019; Naqvi et al., 2015). Harvested dates usually are left to dry gradually in the open air, for 5-6 days, making it vulnerable to rainfall, pests, diseases, rodents and dirt (Abul-Soad et al., 2015). Therefore, a significant portion of the date harvest loses its market and/or nutritional value due to poor handling and storage.

Fruit dehydration is done to obtain complete desired maturity by reducing moisture content (Sagar and Kumar, 2010). Although dates naturally dry on the trees, however fruits are dehydrated to increase its shelf life, especially in case of soft and semidry cultivars. Moreover, fruit dehydration is necessary for areas with higher relative humidity and where monsoon coincides with the date maturity period (Abul-Soad et al., 2015). Foods drying has been applied for ancient times, is the oldest protection method (Atalay et al., 2017).

Solar drying is inexpensive and the most common method of dehydration to preserve and storage of perishable agricultural products (Basunia et al., 2010). Higher air temperature ensures faster drying. However, it can lead to undesired effects, including degradation of vitamins, colour modifications and taste deterioration. Too high temperature could cause rapid drying and damage the external surface. Moreover, higher temperature induces drying the outer surfaces only, and moisture may be trapped in the inner layers of fruit, avoiding complete and desirable drying (Togrul and Pehlivan, 2002).

Solar dryers can be effectively utilized for dehydrating agricultural and horticultural products (Eltawil et al., 2012; Lingayat et al., 2020; Sangamithra et al., 2014) either to warm the circulating air in a solar dryer or to warm the items specifically through harnessing solar radiation by the wet item. The second strategy is more sparing and simpler because no warmth exchange losses happen. In the case of the solar dryer, its glass cover protects agricultural products from pests, dirt and other harmful materials (Hussain et al., 2015; Poonia et al., 2017). The effectiveness of a solar-powered dryer relies upon its kind and model, and also on the rate of heat losses through activity (Timoumi et al., 2004). Recently the application of solar dryers has significantly increased due to various factors, including increasing cost of petroleum energy, and also environmental concerns and awareness. The efficiency of solar dryers has increased by coupling air warming frameworks that utilize solar collector to grain-drying structures (Sharma et al., 2009). With the increase in technology drying of agricultural products (grapes, dates, apricots, bananas, tomatoes, onions, and green beans) through solar gadgets is rapidly increasing.

Although, date nutrient profile and sugar content are under strict genetic control, however, these characteristics significantly influenced by environmental and management conditions. Open sun-drying caused a substantial loss of sugar contents as compared to those fruits which were harvested during night time. The higher temperature increased total sugars due to changes in carbohydrate biosynthetic enzymes activity and increased transpiration. Postharvest practices such as the harvest timing, handling techniques and storage conditions can alter the fruit sugar profiling (Hussain et al., 2015). In any case, vegetables containing a higher quantity of vitamin A and other therapeutic and natural items must not be presented to sunlight directly (Mustayen et al., 2014).

Postharvest date physiology combined with the adoption of good agricultural practices is essential research aspects to ensure maximum date yields without compromising chemical, physical, and sensory attributes. The fundamental objective of this research was to compare the performance of hybrid solar dryer and glass glazed solar dryer and their impact on nutritional contents of dates. Moreover, to investigate the optimum drying conditions for date fruit in dryers.

2. Materials and Methods

Dhakki date fruits (32 kg) of were harvested, at Khalal stage, from Date Palm Research Sub-station Jhang Punjab, Pakistan. Harvested dates were carefully handled, divided into two equal sub-samples and subsequently transferred to the dryers, i.e. hybrid solar dryer and glass glazed solar dryer. Dhakki dates were transferred to the workshop of Department of Farm Machinery and Power, University of Agriculture, Faisalabad (UAF), Pakistan for drying and subsequently morphological and biochemical analysis were conducted Laboratory of Institute of Horticultural Sciences, UAF, Pakistan.

Total soluble solids content were measured by a digital refractometer (ATAGO, RX 5000 Japan) in mature fruit (Shafique et al., 2011). Reading was recorded each time by squeezing beginning catch than was the focal point of refractometer with filtered water and dried with tissue paper before another date fruit juice (DFJ) test was stacked.

Measurement of titratable acidity was done according to the method of AOAC (2000). Filtered fresh extracted (10ml) was homogenized DFJ and transferred to a 100 ml conical flask and distilled water was added to make volume up to 50 mL. 2-3 Drops phenolphthalein (2-3) were added in solution indicator which diluted (1:4) with distilled water and titrated against N/10 NaOH solution shake in the flask till colour pink endpoint was achieved. Results were expressed as % citric acid.

Ruck (1963) described the method of ascorbic acid determination in juice. Juice (10ml) added in 100 ml volumetric flask, filled with oxalic acid (0.4%) 5 ml aliquot. 6-dichlorophenol indophenol was added till the appearance of a light pink colour and undergone for 10-16 s. Moreover, $NaHCO_3$ (42 mg) and 2, 6-dichlorophenol indophenol (52 mg) were mixed in a 200 ml volumetric jar and made up volume also checked by including distilled water to arrange dye colour. Vitamin C was determined using the equation given below:

Ascorbic acid = (mg/100g juice) = $((D1 \times V \times 100)/(D \times A \times B))$

D1= ml colour utilized as a part of titration of aliquot, D= ml of colour utilized as a part of one ml titration for standard vitamin C arrangement and include 1.5 ml of 0.4% oxalic corrosive + 1 ml of 0.1% ascorbic acid. A= ml utilized extract of fruit; V= 0.4% oxalic acid added aliquot solution; B= ml of consumed juice for titration.

Lane and Eynon method (No. 935.64) of AOAC (2000), was followed for the determination of total, non-reducing and reducing sugars, as described earlier (Hussain et al.,2015).

Table 1. Biochemical parameters to be assessed

Parameters	Methodology
Total soluble solids (TSS)	Refractometer (Shafique et al., 2011)
Titratable acidity (TA)	Acidity meter (Shafique et al., 2011)
Ascorbic acid (Vitamin C)	Determined by the oxidation of ascorbic acid with 2,6-dichlorophenol indophenol dye (Shafique et al., 2011)
Non- reducing, reducing and total sugars	Determined by AOAC method as described by (Hussain et al., 2015)

Two-factor completely randomized design (CRD) was applied, and comparison of means was made by using Tukey's test at 5% level of significance. All the exploration was executed in "SPSS 21" software. Graphs were drawn in MS Excel.

3. Results and Discussion

Two dryers were utilized for this purpose whose temperatures were noted all day sequentially and are depicted in tables. After drying in both dryers with different trays temperature, the characters mentioned below were assessed carefully.

Table 2. Efficiency of Solar dryers

Time	T_1 (°C)	T_2 (°C)	T_2-T_1 (°C)	I_t (w/m^2)	Air velocity (m/s)	Efficiency(%)
9:00	36	60	24	670	0.20	40.50
10:00	36.5	61	24.5	740	0.20	43.40
11:00	37	63	26	750	0.30	45.50
12:00	39	64	25	790	0.30	48.80
01:00	40	67	27	820	0.30	50.50
02:00	38	62	24	765	0.14	46.50
03:00	37	61	24	710	0.14	41.50

Table 3. Drying rate of hybrid dryers

Time	T_{db} (°C)	T_{wb} (°C)	T_{amb} (°C)	V_{in} (m/s)	I_t (W/m^2)	Drying Rate (kg h^{-1})
9:00	44	34	35	0.70	710	6.72
10:00	54	36	36	0.70	770	7.31
11:00	59	39	41	0.80	780	7.90
12:00	67	44	43	0.80	835	8.60
13:00	76	50	45	0.80	845	9.50
14:00	72	58	44	0.70	810	4.50
15:00	66	53	42	0.70	800	1.70

T_{db}= dry bulb; T_{wb}= wet bulb; V_{in} = Inside velocity; I_t = Intensity of temperature; T_{amb}=ambient temperature.

3. Results and Discussion

Fruits storage and shelf life require adequate moistures contents. Drying is an erratic or continuous process linked with the transfer of mass and heat. It has a significant impact on appearance, nutritional contents, structure, shape, taste and various features of agricultural products (Azouma et al., 2019; Hasan et al., 2019) determines maintained for proper processing, quality maintenance and preservation (Lingayat et al., 2020; Wang et al., 2018).

Two drying methods, i.e., solar and hybrid drying, were utilized, in this study, for processing of date fruits. Temporal variations in temperature were recorded (Table 2, 3) to assess the drying efficiency of both drying methods. In case of solar dryers, drying efficiency or temperature gain is dependent on the prevailing weather conditions, including sunshine hours, clear sky, wind speed and relative humidity. (Lingayat et al., 2017). Therefore, the reliability of such drying methods weather and season dependent. However, alternate drying techniques, like hybrid drying, has reduced limitations of solar drying (Amer et al., 2018; Reyes et al., 2013).

3.1. Total soluble solids

In the solar dryer, the temperature of the tray was optimum for total soluble sugar, which ranged from 9.37 to 12.13%, which was higher than the values obtained in the hybrid dryer (8.83 to 10.62%). Quality of dates significantly influenced by the method of drying. Dates traditionally had poor quality as compared to solar and hybrid dryers (Seerangurayar et al., 2019).

3.2. Total acidity

Average acidity of dates dried in the solar dryer was lower (0.567% to 0.867%) as compared to those dried in the hybrid dryer (0.800 to 0.867%). Izli (2017) reported significant differences in total acidity of fruits dried by different methods and revealed that microwave drying was efficient as compared to the freeze-drying.

3.3. Vitamin C

Vitamin C concentration in date fruits ranged from 3.68 to 8.51% (Table 4). Date fruits dried in solar driers had substantially lower values of vitamin C, as compared to the hybrid dryers. Basunia et al. (2010) reported that the faster drying achieved by solar tunnel dryer could reduce vitamin C contents. Bechoff et al. (2009) also reported the loss of vitamins and minerals in drying.

3.4. Sugar contents

High variability in reducing sugars (17.03±0.13 % to 19.02±0.17 %) was observed in date fruits processed under the solar dryer. However, when averaged across the drying methods, dates processed in hybrid drying had slightly higher amounts of reducing sugars, than that of solar drying. A similar trend was observed in the case of non-reducing sugars contents. Dates dried in solar dryers had lower reducing sugars than the dates processed in hybrid dryers. Almuhanna (2012) used solar greenhouse as a solar dryer and reported variations in sugar contents. Gallali et al. (2000) reported that solar drying of fruits resulted in lowered nutritional values.

Different methods of drying resulted in a similar trend in total sugar contents, as observed in reducing and non-reducing sugars. Maximum values of total sugars were recorded in the dates dried in hybrid dryers, as compared to solar dryers.

Different degrees of warmings achieved during various methods of drying resulted in shrinkage of fruits (Prado et al., 2000) and variations in microstructure (Seerangurayar et al., 2019) and potentially can result in differences in bio-active ingredients (Tham et al., 2018), likely by triggering amino acids and sugar reactions (Hatami et al., 2017).

Table 4. Effect of different drying method on biochemical characteristics of date palm cv. Dhakki fruits

	Total Souble Solids	Total Acidity	Vitamin C	Reducing Sugar (%)	Non-reducing Sugar (%)	Total Sugar (%)
Solar Dryer	10.38±0.37a	0.717±0.043b	3.68±0.33b	18.30±0.24b	12.69±0.14b	30.98±0.21b
Hybrid Dryer	9.51±0.26b	0.808±0.024a	8.51±0.47a	18.58±0.17a	12.88±0.15a	31.48±0.19a
Mean	9.945	0.762	6.095	18.44	12.785	31.23

TSS, total soluble solids; RS, reducing sugar; NRS, non-reducing sugar.

4. Conclusion

The best results were observed in the hybrid dryer, but if the weight is the only concern, then the solar dryers had been successful than the hybrid dryers. Total soluble solids, total acidity, vitamin C, reducing sugars, non-reducing sugars were more in the hybrid dryer as compared to the solar dryer.

List of Abbreviations: BAP: Benzyl amino purine; DFJ, date fruit juice; TA, titratable acidity; TSS, total soluble solids.

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