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Effect of biochemical characters on Dhakki dates by using solar dryer techniques

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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 deteriorate rapidly in quality after harvest due to poor or non-existent processing and storage facilities. The drying is the most important in dates. So, different techniques had been used for better drying of this delicious fruit. Therefore, the objective was to evaluate the performance of Solar dryer and Hybrid dryer to investigate the drying conditions for date fruit. Two factor complete randomized design (CRD) were applied and comparison of mean was prepared by using Tukey's test at 5% level of significance. In our research total soluble salts (10.38 %) were more in 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 process dates differs significantly in these dryers as solar dryer and hybrid dryer had 3.68 % and 8.51 % vitamin C respectively. Reducing sugars (18.58 %) were more in hybrid dryer as compared to solar dryer (18.30%). In the same way, total sugars were more in hybrid dryers (31.48 %) and less in solar dryer (30.98 %). As for as the non-reducing sugars are concerned, these were more (12.88 %) in hybrid dryers as compared to the solar dryer (12.69 %). It is concluded that good quality dates cab prepared by adopting hybrid dryers as compared to sun drying techniques.

Keywords: Date palm, Arecaceae, Solar dryer, Hybrid dryer, total soluble salts, quality

1. Introduction
Most of the developing nations can't deliver enough nutrition to meet their expanding populations (Garrity *et al*., 2010; Shiferaw *et al*., 2011) [1, 2]. An impressive level of products delivered in a portion of these territories crumble quickly in quality after gathering because of poor or non-existent preparing store rooms. Field damages are high in light of the fact that the yields are normally left to dry gradually in the fields under overwhelming assault by pests, rodents, and dirt.

Foods drying has been applied for ancient times, is the oldest protection method (Atalay *et al*., 2017) [3]. It is very important because it is inexpensive, calmest and the most common method of preserving and storing of perishable agricultural commodities. Dried items are exceptionally substitute to accessing markets than the naturally fresh items due to numerous increases in populations (Basunia *et al*., 2010) [4]. Sun drying is the oldest drying procedures to reserve different cultivated commodities for at least one year but sun drying is unhygienic technique to preserve agricultural commodities because of dirt.

The drying procedure is a standout amongst the most widely recognized uses of sun oriented energy in unclouded nations. In a large portion of these territories, the universal practice is to utilize regular sun dehydrating for sifted or shelled yields. In this technique, the harvests are spread on an uncovered floor or by the sides of the street for drying. Numerous substitute energy fonts can be utilized rather than petroleum products. The selection of what sort of energy fonts ought to be utilized must, for each situation, be made based on monetary, ecological as well as security inspections.

Dehydration also decreases enzyme activity within the product. When drying a product, there are three important inter-related factors that influence the capacity of air to remove water and this is: the amount of moisture is already present in the air, the temperature of the air and the amount of air passing around the food (Fellows, 2000) [5].

Basically a higher air temperature will get a faster drying rate, but higher temperature will give more undesired effects as degradation of vitamins, and changes in color and taste. Too high temperature could also dry out the surface to quick, and moisture are getting trapped inside the product, so the last stage of the drying process will be more slowly (Togrul and Pehlivan, 2002) [6].

Other important factors to think of when drying fruits, are the composition and structure of the product tissue. The orientation of fibers in the fruit allows more rapid movement of moisture along the fibers than across them. Cell rapture by blanching may also increase the drying rate, when the cell membranes are punctured, and water are more easily available for moisture movement. High content of solutes as sugars, starches or salts increase the viscosity inside the products, and slowdown the evaporation of the water, but the water is in those cases bound, so the water activity will be lower (Fellows, 2000) [5].

Generally, the loss from preparation and pretreatment exceeds those from the actual drying stage of the process. Ascorbic acid is water soluble, and when the water evaporates from the products, it could react with other solutes at higher rate. It is also sensitive for heat and oxidation, so low drying temperature and fast drying is important to prevent too much degradation. Low oxygen and moisture content during storage are also factors that prevent further degradation during storage. The fat soluble vitamins are mostly contained within the dry material of the product. Heavy metal catalyst occurring in the water products gets more reactive when the moisture content decreases and oxidation accelerates. The peroxides from oxidation react with the fat-soluble vitamins and the vitamins are degraded. Low oxygen levels, low temperature and protection against light, reduces the loss during storage. The proteins of the vegetables are not affected substantially, regarding biological value (Fellows, 2000) [5].

The effectiveness of a sun powered dryer relies upon its kind and model and also on the rate of warmth losses through activity (Timoumi et al., 2004) [7]. Trials directed in numerous nations have plainly demonstrated that sun oriented vitality can successfully be utilized to dry horticultural products (Sarsavadia, 2007) [8]. Utilizing sun powered vitality as a warmth font for products drying has gotten impressive consideration in few passed years because of the quick heightening of petroleum products cost and the likelihood of scarcity. Approaches to catch and utilize sun based vitality have for the most part included coupling air warming frameworks that utilize solar collector to grain-drying frameworks (Sharma et al., 2009) [9].

A standout amongst the most vital potential uses of sun based vitality is the sunlight based drying of agricultural items (grapes, dates, apricots, bananas, tomatoes, onions, and green beans). Brilliant vitality from the sun can be utilized as a part of two different ways: either to warm the encompassing air in a sun based air warmer and utilize that air to dry the agricultural items or to warm the items specifically through the ingestion of sun based radiation by the wet item. The second strategy is more sparing and simpler in light of the fact that no warmth exchange losses happen. In any case, vegetables containing high measures of vitamin A and other therapeutic and natural items must not be presented to sunlight directly (Mustayen et al., 2014) [10].

In case of solar dryer, its glasses cover products from dirt and other harmful materials. Sunlight based edibles preparing is an eminent innovation that gives great quality food at low or no extra fuel cost. Various sun powered dryers, accumulators and concentrators are right now being utilized for different steps in diet preparing and value/worth addition (Poonia et al., 2017) [11]. Solar radiation and temperature have a great influence on fruit sugar accumulation. The results regarding sugar contents were significantly affected by sun-drying techniques (Hussain et al., 2015) [12]. Fruit sugar content is a variable mutagenic trait which is greatly affected under varied environmental conditions. 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, and increased transpiration. Postharvest practices such as timing of harvest, handling techniques and storage conditions can alter the fruit sugar profiling. In solar dryer tray for 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 (Hussain *et al*., 2015) [12].

Objectives

To evaluate and compare the performance of hybrid solar dryer and glass glazed solar dryer.

To investigate the optimum drying conditions for date fruit in dryers.

2. Materials and Methods

Fruits to be evaluated were collected from date palm research sub-station Jhang punjab. Fruits were harvested at Khalal stage. Thirty-two-kilogram fruits were brought and sixteen kilo gram fruit were used in each dryer i.e. hybrid solar dryer and glass glazed solar dryer were utilized. Dhakki dates were dried3in the workshop of Department of Farm Machinery and Power, Faculty of3Agriculture Engineering and3Technology, University of Agriculture Faisalabad. Morphological and chemical analysis was conducted3at Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan. All the samples were carefully handled and then transferred to the dryers. After drying, samples were morphologically as well as biochemically assessed.

Table 1: Biochemical Parameters to be assessed

Sr. No.	Parameters	Methodology
1	TSS	Refractometer (Abbas et al.,2011)
2	TA	Acidity meter (Abbas et al.,2011)
3	Vitamin C	Determined by the oxidation of ascorbic acid with 2,6-dichlorophenol endophenol dye (Ghojageet al., 2011)
4	Non- reducing sugars	Determined by AOAC method as described by (Hussain et al., 2014)
5	Reducing sugars	Determined by AOAC method as described by (Hussain et al.,2014)
6	Total sugars	Determined by AOAC method as described by (Hussain et al.,2014)

Explanation of biochemical parameters

2.1 Total soluble solid

The total soluble solid content were measured by a digital refractometer (ATAGO, RX 5000 Japan) in mature fruit. Hardware was first standardized with refined water by achieving perusing at ≤ zero. A drop of juice was set on the tip focal point of refractometer and its top was secured. The perusing was recorded each time by squeezing beginning catch than was the focal point of refractometer with refined water and dried with tissue paper before another date fruit juice (DFJ) test was stacked.

2.2 Titratable acidity

The measurement of titratable acidity technique was described by (AOAC, 2000). (10 mL) Filtered fresh extracted homogenized DFJ was put in 100 mL conical bottle and distilled water to make volume to 50 mL.(2-3) drops Phenolphthalein were added in solution in indicator diluted (1:4) with distilled water and titrated against N/10 NaOH solution shake in the flask till color pink end point was achieved . The results were expressed as % citric acid mathematically total titratable acidity in below formulation.

2.3 Vitamin C (mg/100 g)

Ruck (1961) estimate the ascorbic acid in (DFJ) juice. Added 10 ml of juice in 100 ml volumetric base flagon, then volume was made up by including 0.4% oxalic acid.5 ml aliquot was taken out into measuring glass. Put 2, 6-dichlorophenol indophenol till light pink color and endured for 10-16seconds. Put 42 mg preparing pop ($NaHCO_3$) and 52 mg 2, 6-dichlorophenol indophenol into 200 ml volumetric jar and made up volume also checked by including refined water to arrange dye color. Vitamin C was figured scientifically, to utilize by following equation:

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

D1= ml color utilized as a part of titration of aliquot
D= ml of color 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

Sugars

The Natural product of sugars content are represented as total of reducing & non-reducing sugars by utilizing strategy depicted by (AOAC, 1998) for estimate of sugars. Following arrangements were set up for the amount of lessening and non-decreasing sugars contents.

a) Filtrate the fruit juice
b) Arrangement of Invert sugars
c) Fehling’s solution arrangement

a) Preparation of juice filtered

Taken of 10 ml juice and 90 ml lead sub acetic acid to make 100 ml volume dropped into 250 ml flagon.25 ml lead sub acetic acid derivation arrangements (430g of lead acetic acid derivation/1000ml) and take up 10 ml of 20% potassium natural oxalate $C_2K_2O_4$ arrangement are include. The arrangement are separate, subsequently the filtrate material are utilize for the assessment of reducing & non-reducing sugars.

b) The standard transform preparation and arrangement

The impartial and antacid arrangements of sugars should not be preserved for more extended timeframe and ought to be readied when required (Ronald and Sawyer, 1981); accordingly, standard sugar arrangement was newly arranged. For the arrangement of standard modify arrangement, 23.75 g immaculate sucrose (investigative review) was broken up in around 120ml water in a 250 ml volumetric cup, 9 ml conc. HCl was included and the arrangement was kept for eight days at room temperature for reversal of sugar substance. On fulfillment of reversal, volume was made up to the stamp with refined water. The arrangement of 200ml volume was moved into a 2 liter volumetric glasses jar.200 ml of distal water was added and (71.4 ml) volume of NaOH sodium hydroxide preparation of to 40 g/L containing (4 g) benzoic acid are include alongside ceaseless shaking. At that point 1 liter of refined water was included, blended, pH was balanced at 3 and volume was made up to the stamp. Thusly, a (1% m/v) stable stock arrangement sugars are got, then weakened to mark (0.25%) average arrangement and utilizing of 1 N NaOH.

c) Fehling’s Solution preparation

Fehling's volume breaks down gradually thus crisp Fehling's solution are made adequate or happen quick necessity as it were. For the planning of Fehling's solution, measure up to amounts of arrangement A & arrangement B are exchange to a dry volumetric jar than mixed altogether. Fehling's A and Fehling’s B are set up in below methods.

Fehling’s A: disintegrate (69.3 g) cupric sulfate pentahydrates in refine water to make 1liter volume.

Fehling’s B: break up (345 g) sodium potassium nitrate and 100g Caustic soda (NaOH) in distilled water to make 1Liter solution.

2.4. Total sugars

The estimation of total sugars content to make 25 ml volume of aliquot solution effectively. Arranged up to 100 ml volume in volumetric flask for reducing sugars, then add 5 ml conic and 20 ml refined water. HCl made up volume should be kept for 24-48 hours to change over to non-reducing sugars or retreating sugars. NaOH arrangement and made up 100 ml volume with refined water. The readied volume made up to burette and titrated against constant heating up put 2-3 drops of methylene blue tri hydrate into (10 ml) Fehling's volume to block red color. Add up to sugars were ascertained by utilizing the accompanying equation:

Total sugars (%) = $25 \times (A/C)$

A= ml of standard sugar arrangement utilized against 10 ml Fehling's solution.
C= ml of test aliquot utilized against 10 ml Fehling's solution.

2.5. Reducing sugars

This strategy depicted by Hortwiz (1960). The filtrate juice was taken in burette and titrated against 10 ml Fehling's solution utilizing 2-3 drops of methylene blue tri hydrate as a marker with consistent bubbling till block red end point showed up. Reducing sugars was ascertained by utilizing following recipe:

Reducing sugars (%) = $6.25 \times (A/B)$

A= ml of arrangement sugar arrangement utilized against 10 ml Fehling's solution.
B= ml of test aliquot utilized against 10 ml Fehling's solution.

2.6. Non-reducing sugars
For non-reducing sugar are examining by the equation (Hortwitz, 1960) as following:

Non-reducing sugars (%) = 0.95× (Total invert sugars % - reducing sugars %)

3. Statistical analysis
Two factor completely0randomized design (CRD) was applied and comparison of means0was prepared by using Tukey's test0at 5% level of significance. All0the exploration was executed in "SPSS 21" software. Graphs were drawn in MS Excel.

4. Results and Discussion
Two dryers were utilized for this purpose whose temperatures were noted all day sequentially and are depicted in tables.

Table 2: Efficiency of 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
1:00	37	63	26	750	0.30	45.50
12:00	39	64	25	790	0.30	48.80
1:00	40	67	27	820	0.30	50.50
2:00	38	62	24	765	0.14	46.50
3:00	37	61	24	710	0.14	41.50

Table 3: Drying rate of dryers

Time	T_{db} (°C)	T_{wb} (°C)	T_{am} (°C)	V_{in} m/s	I_t W/m^2	Drying Rate Kg/hr
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
01:00	76	50	45	0.80	845	9.50
02:00	72	58	44	0.70	810	4.50
03:00	66	53	42	0.70	800	1.70

After drying in both dryers with different trays temperature, the characters mentioned below were assessed carefully. All results are depicted below.

Total soluble salts in solar dryer
In solar dryer, the temperature of tray was optimum for total soluble salts as it acquired highest that was 12.13±0.09 %. Tray 3 and 4 had almost the same percentage of it. The minimum was by tray 4 (9.37±0.03 %). The four trays cumulatively gave 10.38±0.37 % of total soluble salts and it was more than the hybrid dryer.

Total soluble salts in hybrid dryer
In case of hybrid dryer, when measured the total soluble salts highest percentage was in tray 4. There was no significant difference in remaining trays as results had the similarity up to more extent. And minimum (8.83±0.22 %) was in tray 3.As for overall highest mean of total soluble salts it was highest (10.62±0.68 %) in tray 1. And the least (8.97±0.12 %) was noted in tray 3. Clear view is represented in the graph 4.6. Manaa *et al*. (2013) reported to dry dates, the traditional ways were not keeping the quality well as compared to the modern ones like solar and hybrid dryers.

Table 4: Means for Total Soluble Salts

Tray	Dryer		Total
	Solar Dryer	Hybrid Dryer	
Tray 1	12.13±0.09a	9.10±0.06c	10.62±0.68a
Tray 2	10.90±0.12b	9.20±0.15c	10.05±0.39b
Tray 3	9.10±0.10c	8.83±0.22c	8.97±0.12c
Tray 4	9.37±0.03c	10.90±0.17b	10.13±0.35b
Total	10.38±0.37a	9.51±0.26b	

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Total acidity in solar dryer
Tray 2 (0.867±0.028 %) and 3 (0.833±0.044 %) had almost the same value of total acidity, highest was in tray 2 (0.867±0.028 %). The minimum (0.567±0.02 %) was in tray 1. Overall in four trays, the total acidity was 0.717±0.043 %.

Total acidity in hybrid dryer
Total acidity was maximum in tray 2 (0.867±0.033 %). Tray 1, 2 and 3 had alike values, 0.800±0.058 %, 0.867±0.033 % and 0.833±0.044 % respectively and were statistically non-significant. Hybrid dryer attained more total acidity as compared to solar dryer in all trays cumulatively.
If noted overall in case of trays only, tray 2 (0.867±0.020 %) got higher total acidity as compared to other trays. Izli (2017) did the experiment, after drying it was revealed that microwave drying was efficient as compared to the freeze drying.

Table 5: Means for Total Acidity

Tray	Dryer		Total
	Solar Dryer	Hybrid Dryer	
Tray 1	0.567±0.024b	0.800±0.058a	0.683±0.059b
Tray 2	0.867±0.028a	0.867±0.033a	0.867±0.020a
Tray 3	0.833±0.044a	0.833±0.044a	0.833±0.028a
Tray 4	0.600±0.029b	0.733±0.033ab	0.667±0.036b
Total	0.717±0.043b	0.808±0.024a	

Vitamin C in solar dryer
In solar dryer, tray 4 got the higher percentage of vitamin C (5.27±0.19 %). Minimum was attained by tray 2 that was 2.33±0.12 %. In all four trays the overall mean in this dryer was 3.68±0.33 %.

Vitamin C in hybrid dryer
In tray 4, the mean value of vitamin C was maximum (10.63±0.26 %). The minimum (6.50±0.25 %) was in tray 1. The overall in all trays, it was 8.51±0.47 % which was much more than in solar dryer.
The overall assessment told that the tray 4 temperature was excellent for the vitamin C contents. The graph 4.8 is expressing the details of the results. Basunia *et al*. (2010) [4] concluded that the faster drying was achieved by solar tunnel dryer as compared to other methods. Bechoff *et al*. (2009) also reported the loss of vitamins and minerals in

drying which reduced their contents.

Table 6: Means for Vitamin C

Tray	Dryer		Total
	Solar Dryer	**Hybrid Dryer**	
Tray 1	3.33±0.09f	6.50±0.25d	4.92±0.72c
Tray 2	2.33±0.12g	7.80±0.17c	5.07±1.23c
Tray 3	3.80±0.21f	9.10±0.23b	6.45±1.19b
Tray 4	5.27±0.19e	10.63±0.26a	7.95±1.21a
Total	3.68±0.33b	8.51±0.47a	

Reducing sugars in solar dryer
There existed great variability as the four trays had diversified percentage of reducing sugars. Tray 1, 2 3, and 4 had 17.03±0.13 %, 18.57±0.18 %, 18.57±0.15 % and 19.02±0.17 % respectively. Highest (19.02±0.17 %) was achieved by tray 4. The cumulative of all four trays obtained was 18.30±0.24 %.

Reducing sugars in hybrid dryer
The most elevated percentage (19.07±0.15 %) of reducing sugars was in tray 3. Tray 2 and tray 4 had significant relationship between them statistically having 18.40±0.18 % and 17.87±0.09 % respectively. The average of all four trays was 18.58±0.17 %, which was higher than the solar dryers. Almuhana (2012) used solar greenhouse as a solar dryer.
In general assessment, if we see the trays, tray 3, on both dryers, got higher percentage of reducing sugars as compared to other trays and hybrid dryer remained dominant over the Solar dryer in case of reducing sugars.

Table 7: Means for Reducing Sugars

Tray	Dryer		Total
	Solar Dryer	**Hybrid Dryer**	
Tray 1	17.03±0.13c	18.97±0.29a	18.00±0.46b
Tray 2	18.57±0.18ab	18.40±0.18ab	18.48±0.12ab
Tray 3	18.57±0.15ab	19.07±0.15a	18.82±0.15a
Tray 4	19.02±0.17a	17.87±0.09bc	18.44±0.27ab
Total	18.30±0.24b	18.58±0.17a	

Total sugars in solar dryer
In this assessment, tray 3 got higher percentage of total sugars (31.63±0.19 %) and minimum (30.00±0.17 %) was in tray 1. Tray 2 and tray 4 were non-significantly different from each other having (31.33±0.41 %) and (30.93±0.07 %) respectively.

Total sugars in hybrid dryer
It was supreme in tray 1 which had 31.93±0.32 % total sugars and lowest in 30.93±0.33 %. The trays average percentage of total sugars was 31.48±0.19 % which was extra than the solar dryer.
In only trays experiment, all were statistically non-significant having 30.97±0.46 %, 31.13±0.25 %, 31.55±0.21 %, 31.27±0.22 % for four trays respectively. But the most elevated percentage was by tray 3. Prado *et al*. (2000) in their experiment applied different temperatures for checking the shrinkage of dates. Also assessed the diameter and the brix values of grapes after solar dryer drying.

Table 8: Means for total sugars

Tray	Dryer		Total
	Solar Dryer	**Hybrid Dryer**	
Tray 1	30.00±0.17b	31.93±0.32a	30.97±0.46a
Tray 2	31.33±0.41ab	30.93±0.33ab	31.13±0.25a
Tray 3	31.63±0.19a	31.47±0.43ab	31.55±0.21a
Tray 4	30.93±0.07ab	31.60±0.36a	31.27±0.22a
Total	30.98±0.21b	31.48±0.19a	

Non-reducing sugars in solar dryer
The solar dryer gave its maximum value (13.07±0.12 %) of non-reducing sugars in tray 3. And the average of all four trays was 12.69±0.14 % that was less than the hybrid dryer.

Non-reducing sugars in hybrid dryer
13.63±0.09 % was the highest non-reducing sugars in tray 4. And the tiniest (12.40±0.12 %) was achieved by tray 3. The average in all trays was 12.88±0.15 %. It was more than the average of all trays in solar dryer.
The tray wise non-reducing sugars were maximum in tray 1 (12.98±0.05 %). The perfect view is in the graph 4.11. Gallali *et al*. (2000) gave results of chemical characters which decreased during drying by solar dryers of different fruits and vegetables.

Table 9: Means for non-reducing sugars

Tray	Dryer		Total
	Solar Dryer	**Hybrid Dryer**	
Tray 1	13.00±0.10bc	12.97±0.07bc	12.98±0.05a
Tray 2	12.77±0.09bcd	12.53±0.13cd	12.65±0.09b
Tray 3	13.07±0.12b	12.40±0.12de	12.73±0.17ab
Tray 4	11.93±0.13e	13.63±0.09a	12.78±0.39ab
Total	12.69±0.14b	12.88±0.15a	

Conclusion
The best results were observed in hybrid dryer, but if weight in concerned only, then the solar dryers had been successful than the hybrid dryers. TSS, TA, Vit. C, Reducing sugars, Non-reducing sugars were more in hybrid dryer as compared to solar dryer.

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