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Research Article
Impact of Pretreatments and Drying Temperatures on Quality of Siwi and Sakkoti Dates

[1]Amira Sh. Shawky, [1]Mohamed S. Abbas, [2]S.M.H. Rabie, [3]M.T.M. Assous and [2]M.A. Mostafa Zeinab

[1]Department of Natural Resources, Faculty of African Postgraduate Studies, Cairo University, Egypt
[2]Food Technology Research Institute, Agricultural Research Center, Egypt
[3]Central Laboratory for Research and Development of Date Palm, Agricultural Research Center, Egypt

Abstract

Background and Objective: Drying of date helps in preserving it to be consumed outside the harvest season and removes some moisture from dates and also slows down the action of date endogenous enzymes. This study was carried out to investigate pretreatments and drying temperature on the physical and chemical properties of 2 date varieties (Siwi and Sakkoti) at the khalal stage. **Materials and Methods:** The date fruits at khalal stage were dipped in ascorbic acid solution, sodium metabisulfite solution and sulfur dioxide before cut into pieces, halves and as whole. Then dates were dried at 50, 55, 60 and 65°C, respectively till ~20% moisture content and examined the physical and chemical properties of dried dates. **Results:** Moisture content of Siwi and Sakkoti at the khalal stage was 56.90 and 51.72%, respectively, while total sugars were 79.76 and 75.74%, respectively on dry weight bases. The color of dates Hunter (L and b) were the highest of treated with meta-bisulfate solution or sulfur dioxide and the lowest of color date observed (Hunter, a) comparing with control and ascorbic acid. **Conclusion:** The pretreatments indicated that the dipping dates in sodium meta-bisulfate solution or sulfur dioxide then, dried at 60°C produce high quality parameters of semi-dry dates comparing control and ascorbic acid.

Key words: Date palm, Sakkoti, Siwi, ascorbic acid solution, sodium metabisulfite solution, sulfur dioxide, endogenous enzymes

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Corresponding Author: M.T.M. Assous, Central Laboratory for Research and Development of Date Palm, Agricultural Research Center, Egypt

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Date palm (*Phoenix dactylifera* L.), a tropical and subtropical tree, belonging to family Palmae (Arecaceae) is one among man kind's oldest cultivated plants and- in the Arabian Peninsula. Date fruits have rich content of essential nutrients which include carbohydrates, minerals, dietary fibers, vitamins and small amounts of fat and protein. Egypt is ranked the first internationally concerning the amount of production of different dates, however, very little amounts are directed for export due to lack in awareness, technology and facilities for post-harvest treatments, processing and packaging. Dates have played an important role in the daily life of the people for last 7000 years[1]. World production of dates has increased significantly and steadily over the last 30 years. Arab countries produce about 74.5% of world total production. Egypt is the largest world's top ten producers of dates[2]. Egypt produces 1.68 million tons of date fruits, which represents 15.1% of the total production of Egyptian fruits (11.15 M tons). Only 16.5% of total date fruit production (278000 tons) was directed for food processing[3]. Date fruits have great importance in human nutrition owing to their rich content of essential nutrients which include carbohydrates, minerals, dietary fibers, vitamins and small amounts of fat and protein[4]. Dates are good source of rapid energy (carbohydrate content, 70-80%) and provide 274-300 k.cal of energy from 100 g of the flesh date. Most of the carbohydrates in dates are in the reducing sugars form of (fructose and glucose)[5]. Fresh soft date has easily eaten. Thus, for these qualities, dates are being used for breakfast during the holy month of Ramadan all over the Muslim world[6]. Dates are also used as component in food preparation such as sweets, snakes, confectionery, baking products, institutional feeding and health foods[7]. Drying of date helps in preserving it to be consumed outside the harvest season. Drying removes some moisture from dates so that bacteria, yeast and mold cannot grow and spoil the dried dates and also slow down the action of date endogenous enzymes[8]. However, a disadvantage of hot air drying causes serious damage to quality attributes of the products such as flavor, color, texture and valuable nutrients[9]. This investigation aimed to, evaluate the effects of pre-treatments and dying temperature on some quality attributes of Siwi and Sakkoti dates so that improving product quality and preserving the nutritional value.

MATERIALS AND METHODS

Date palm fruits (*Phoenix dactylifera* L.) Siwi and Sakkoti date varieties at the end khalal stage were obtained from Bahria Oases and Aswan Governorate, respectively in September 2018, Egypt. Sodium metabisulfite, sulfur and ascorbic acid were purchased from El-gomhoria Company, Egypt. The study was carried out at the department of Food Engineering and Packaging, Food Technology Research Institute, Agricultural Research Center, from September 2018-August 2019.

Processing methods

Preparation for dates before pretreatments: The date fruits were exposed to steam for 3 min at atmospheric pressure to inactivate enzymes and soften the texture of date fruits, then cooled in tap water according to Degefa *et al.*[10].

Pretreatments for dates before drying: The dates from each cultivar were divided into 4 groups, then treated as follows: The first group of dates was dipped in ascorbic acid solution (0.5%) for15 min. The second group of dates was dipped in sodium meta-bisulfate solution (0.5%) for 15 min. The third group of dates was treated with sulfur dioxide in an enclosed room and the concentration of sulfur used to burn was 29 g m^{-3} for 12 h. The fourth dates a control without previous treatments.

After pretreatments the fourth treatment was divided into 3 groups follows, the 1st group was dried as the whole date after treated with above treatment, the 2nd group was dried as half date after treated with the above treatment and the 3rd group was dried as pieces' date after treated with above treatment.

Drying process: The treated date with different pretreatments and control as whole fruits, halves and pieces were dried at 50, 55, 60 and 65°C, respectively till ~20% moisture content.

Color measurement: International color measurement L, a and b values of fresh date fruits as well as the dried date samples was measured using Minolta Chroma Meter, model CR-200. Calibration was done by a white plate before use. Color changes were quantified for L, a and b which refers to yellow tonality as was described by Barbagallo *et al.*[11]. Color measurement of whole date fruits were measured in terms of (CIE) Hunter L, a, b, H and C values where L-value measures the degree of lightness ranging from black, a-value measures the greenness to redness and b-value measures the blueness to yellowness. H-value is the hue angle which may be defined as the angle between the hypotenuse and 0 on the (bluish-green/red-purple) axis, H-value is calculated from the arctangent of b/a. H-value should remain positive between (0 and 360) of the color wheel and C-value is calculated from

a and b. It represents the hypotenuse of a right triangle created by joining (0,0), (a, b) and on index somewhat analogous to color saturation or intensity as was described by Hunter[12] and Little[13].

Chemical analysis of fresh and dried dates: Total soluble solids (TSS) were determined by Abbe refractometer at 20°C and the pH value was measured using a Beckman pH meter. Moisture content, acidity, fiber, ash, protein, reducing, non-reducing and total sugars, were determined according to AOAC[14]. Tannins content was determined according to Makkar *et al.*[15]. Total phenols were determined calorimetrically using the Folin-Ciocalteu reagent as was described by Wolfe *et al.*[16], using a UV-1601 spectrophotometer (Shimadzu, Kyoto, Japan). The concentrations are expressed as milligrams of gallic acid equivalents per 100 g of date.

Statistical analysis: The results of color measurements of fresh dates and dried dates were statistically analyzed using SPSS statistical package[17].

RESULTS

The moisture content, total soluble solids, pH value, acidity, total phenols, tannins, ash, crude proteins, crude fiber, total sugars, reducing sugars and non-reducing sugars and color measurements L, a, b, C and H values of Siwi and Sakkoti cultivars at khalal stage in Table 1.

Effect of pretreatments and drying temperature on the moisture content of dried date products: The moisture content decreased with increasing drying temperatures. So, the highest moisture content value 21.63% in control whole fruits at 50°C and the lowest value 19.21% for pieces of date fruits pretreated with sulfur dioxide and then dried at 65°C (Table 2). Also, the moisture content of dried Sakkoti date products was listed in Table 3. The highest moisture content value 20.53% was recorded for whole date fruits pretreated with sodium meta-bisulfate and dried at 50°C and the lowest value was 17.45% for pieces of date fruits treated with ascorbic acid at 65°C.

Effect of pretreatments and drying temperatures on pH value and acidity of dates: The effects of pretreatments and drying temperatures on pH value and acidity of Siwi are clearly shown in the Table 4. The pH value increased with increasing drying temperature which reported pH at 50°C less than that at 65°C but the size of the date fruits had no effect on pH value. The measurement of acidity (expressed as malic acid) of Siwi dried products indicated increasing acidity by the pretreatments and decreasing by increasing drying temperature.

The pretreatments and drying temperatures effect on Sakkoti dried products in Table 5. The highest pH value 6.53 was recorded for control whole date fruits at 65°C and the lowest value, 5.38 for whole date fruits pretreated with sulfur dioxide and dried at 50°C.

Table 1: Physical-chemical properties of date fruits varieties at khalal stage (on dry weight bases)

	Date fruit varieties	
Parameters	Siwi	Sakkoti
Moisture (%)	56.90	51.72
Total soluble solids (TSS) (%)	36.50	40.50
pH value	6.49	6.50
Acidity (%)	0.419	0.352
Total phenols (%)	0.57	0.843
Tannins (mg/100 g)	16.31	15.48
Ash (%)	1.41	1.33
Proteins (%)	2.11	1.92
Crude fiber (%)	5.10	5.18
Total sugars (%)	79.76	75.34
Reducing sugars (%)	70.28	23.67
Non-reducing sugars (%)	9.48	51.67
Color measurements		
L	39.50	44.96
a	4.66	5.54
B	35.89	38.98
C	36.21	39.36
H	82.80	81.86

L-value measures the degree of lightness ranging from black, a-value measures the greenness to redness and B-value measures the blueness to yellowness, H-value is the hue angle which may be defined as the angle between the hypotenuse and 0 on the (bluish -green /red -purple) axis, H-value is calculated from the arctangent of b/a, H-value should remain positive between (0 and 360) of the color wheel, C-value is calculated from a and b, It represents the hypotenuse of a right triangle created by joining (0,0), (a, b) and on index somewhat analogous to color saturation or intensity

Table 2: Effect of pretreatments and drying temperature on moisture content (%) of siwi date

		Temperature (°C)			
Drying size	Pre-treatments	50	55	60	65
Whole dates	Control	21.63	21.52	21.38	20.24
	Ascorbic acid	21.52	21.36	21.18	20.13
	Sodium metabisulfite	21.43	21.13	20.84	20.23
	Sulfur dioxide	21.42	21.15	20.87	20.30
Date halves	Control	20.74	20.53	20.75	19.83
	Ascorbic acid	20.57	20.12	19.63	19.24
	Sodium metabisulfite	20.42	20.00	19.65	19.22
	Sulfur dioxide	20.36	20.12	19.92	19.43
Date pieces	Control	20.63	20.47	20.23	19.67
	Ascorbic acid	20.22	20.05	19.74	19.33
	Sodium metabisulfite	20.26	19.82	19.53	19.18
	Sulfur dioxide	20.14	19.93	19.45	19.21

Table 3: Effect of pretreatments and drying temperature on moisture content (%) of Sakkoti date

		Temperature (°C)			
Drying size	Pre-treatments	50	55	60	65
Whole dates	Control	20.50	20.33	20.22	19.73
	Ascorbic acid	20.44	20.28	20.18	19.98
	Sodium metabisulfite	20.53	20.42	20.15	19.86
	Sulfur dioxide	20.30	20.11	19.83	19.75
Date halves	Control	18.46	18.24	18.12	17.75
	Ascorbic acid	18.58	18.14	18.03	17.76
	Sodium metabisulfite	18.43	18.26	18.09	17.72
	Sulfur dioxide	18.26	18.05	17.93	17.69
Date pieces	Control	18.30	18.17	18.09	17.56
	Ascorbic acid	18.36	18.19	17.98	17.45
	Sodium metabisulfite	18.16	18.02	17.85	17.63
	Sulfur dioxide	18.10	18.02	17.87	17.63

Table 4: Effect of pretreatments and drying temperature on pH value and acidity as malic acid (%) of siwi date (Dry weight bases)

		Temperature (°C)							
		pH-value				Acidity (%)			
Drying size	Pre-treatments	50	55	60	65	50	55	60	65
Whole dates	Control	6.44	6.55	6.46	6.46	0.438	0.467	0.435	0.432
	Ascorbic acid	6.36	6.37	6.4	6.43	0.442	0.438	0.435	0.431
	Sodium metabisulfite	6.29	6.31	6.32	6.35	0.462	0.459	0.457	0.451
	Sulfur dioxide	5.68	5.70	5.73	5.74	0.523	0.52	0.518	0.517
Date halves	Control	6.47	6.48	6.48	6.49	0.427	0.426	0.423	0.420
	Ascorbic acid	6.37	6.38	6.42	6.41	0.439	0.438	0.436	0.432
	Sodium metabisulfite	6.32	6.33	6.36	6.37	0.46	0.458	0.454	0.453
	Sulfur dioxide	5.70	5.72	5.74	5.75	0.519	0.516	0.515	0.512
Date pieces	Control	6.47	6.47	6.48	6.48	0.423	0.422	0.422	0.420
	Ascorbic acid	6.38	6.38	6.41	6.39	0.44	0.439	0.437	0.434
	Sodium metabisulfite	6.33	6.36	6.38	6.41	0.457	0.455	0.454	0.452
	Sulfur dioxide	5.71	5.75	5.75	5.77	0.517	0.514	0.512	0.510

Effect of pretreatments and drying temperatures on total phenols content of dried date products: Regarding dried Siwi date products, data of total phenols in Table 6. Total phenols ranged from the lowest value 0.428% for control whole date fruits dried at 50°C to the highest value 0.507% for date pieces pretreated with sulfur dioxide and dried at 65°C. Total phenols of Sakkoti dried products were ranged from the lowest value 0.648% for control whole date fruits dried at 50°C to highest value 0.715% for pieces' date fruits pretreated with sulfur dioxide (Table 7).

Effect of pretreatments and drying temperatures on sugar contents of dates: The total, reducing and non-reducing sugars contents of Siwi and Sakkoti date fruits (Table 8 and 9).

Table 5: Effect of pretreatments and drying temperature on pH value and acidity as malic acid (%) of Sakkoti date (dry weight bases)

		Temperature (°C)							
		pH-value				Acidity (%)			
Drying size	Pre-treatments	50	55	60	65	50	55	60	65
Whole dates	Control	6.45	6.47	6.51	6.53	0.342	0.323	0.312	0.300
	Ascorbic acid	6.39	6.45	6.47	6.48	0.365	0.361	0.359	0.356
	Sodium metabisulfite	6.27	6.28	6.30	6.31	0.381	0.379	0.375	0.373
	Sulfur dioxide	5.38	5.41	5.43	5.44	0.443	0.441	0.437	0.435
Date halves	Control	6.47	6.50	6.49	6.52	0.325	0.314	0.310	0.300
	Ascorbic acid	6.41	6.43	6.44	6.44	0.363	0.360	0.358	0.355
	Sodium metabisulfite	6.27	6.30	6.32	6.33	0.380	0.377	0.374	0.372
	Sulfur dioxide	5.50	5.52	5.56	5.57	0.428	0.429	0.431	0.432
Date pieces	Control	6.49	6.49	6.48	6.5	0.320	0.319	0.317	0.314
	Ascorbic acid	6.43	6.43	6.45	6.46	0.360	0.359	0.357	0.356
	Sodium metabisulfite	6.30	6.33	6.34	6.35	0.374	0.373	0.371	0.370
	Sulfur dioxide	5.51	55.6	5.57	5.58	0.430	0.427	0.425	0.424

Table 6: Effect of pretreatments and drying temperature on phenol content (%) of Siwi date (dry weight bases)

		Temperature (°C)			
Drying size	Pre-treatments	50	55	60	65
Whole dates	Control	0.428	0.432	0.436	0.443
	Ascorbic acid	0.432	0.437	0.446	0.453
	Sodium metabisulfite	0.431	0.436	0.442	0.453
	Sulfur dioxide	0.476	0.483	0.491	0.500
Date halves	Control	0.441	0.447	0.452	0.456
	Ascorbic acid	0.444	0.451	0.458	0.465
	Sodium metabisulfite	0.465	0.477	0.483	0.490
	Sulfur dioxide	0.485	0.492	0.497	0.505
Date pieces	Control	0.445	0.453	0.458	0.464
	Ascorbic acid	0.446	0.445	0.463	0.472
	Sodium metabisulfite	0.474	0.482	0.487	0.493
	Sulfur dioxide	0.487	0.498	0.503	0.507

Table 7: Effect of pretreatments and drying temperature on phenol content (%) of Sakkoti date (dry weight bases)

		Temperature (°C)			
Drying size	Pre-treatments	50	55	60	65
Whole dates	Control	0.648	0.652	0.654	0.658
	Ascorbic acid	0.662	0.669	0.671	0.675
	Sodium metabisulfite	0.681	0.685	0.690	0.694
	Sulfur dioxide	0.689	0.693	0.697	0.708
Date halves	Control	0.657	0.660	0.663	0.667
	Ascorbic acid	0.675	0.681	0.684	0.687
	Sodium metabisulfite	0.687	0.690	0.692	0.697
	Sulfur dioxide	0.694	0.698	0.704	0.711
Date pieces	Control	0.659	0.662	0.667	0.669
	Ascorbic acid	0.676	0.683	0.687	0.689
	Sodium metabisulfite	0.690	0.696	0.700	0.705
	Sulfur dioxide	0.702	0.706	0.712	0.7.15

From these results, total sugars and non-reducing sugars decreased with increasing drying temperature while reducing sugars increased by increasing drying temperature.

Effect of pretreatments and drying temperature on the color of whole dates: Color measurements of pretreated whole date fruits dried at different temperatures in Table 10 in terms of Hunter L, a, b, H and C values.

For each date cultivar, means in a row (comparisons among pre-treatments means within each drying temperature) sharing same upper case letter(s) are not significantly different at $p \leq 0.05$, means in a column (comparisons among pretreatments means within each drying temperature) sharing same lower case letter(s) are not significantly different at $p \leq 0.05$.

Table 8: Effect of drying temperature on sugar contents (%) of Siwi date (dry weight bases)

		Temperature (°C)											
		50			55			60			65		
Drying size	Pre-treatments	RS	NRS	TS	RS	NRS	TS	RS	NRS	TS	RS	NRS	TS
Whole dates	Control	70.12	8.45	78.77	70.43	8.22	78.65	70.54	7.96	78.5	70.62	7.76	78.38
	Ascorbic acid	70.02	8.70	78.72	70.12	8.44	78.56	70.25	8.23	78.48	70.38	7.97	78.35
	Sodium metabisulfite	70.00	8.60	78.60	70.12	8.32	78.44	70.22	7.88	78.10	70.34	7.58	77.92
	Sulfur dioxide	70.06	8.62	78.68	70.16	8.18	78.54	70.28	8.16	78.44	70.36	7.96	78.32
Date halves	Control	70.10	8.53	78.63	70.18	8.36	78.54	70.33	8.10	78.43	70.45	7.85	78.30
	Ascorbic acid	70.17	8.55	78.60	70.23	8.06	78.45	70.33	8.01	78.34	70.42	8.02	78.26
	Sodium metabisulfite	70.12	8.36	78.48	70.17	8.15	78.32	70.30	7.98	78.28	70.44	7.67	78.11
	Sulfur dioxide	70.07	8.53	78.60	70.17	8.26	78.43	70.25	8.10	78.35	70.37	7.92	78.29
Date pieces	Control	70.09	8.42	78.51	70.14	8.33	78.47	70.24	8.12	78.36	70.36	7.86	78.22
	Ascorbic acid	70.07	8.40	78.47	70.10	8.22	78.32	70.19	7.88	78.20	70.25	7.82	78.07
	Sodium metabisulfite	70.11	8.24	78.35	70.22	8.04	78.26	70.35	7.93	78.14	70.46	7.89	78.04
	Sulfur dioxide	70.13	8.38	78.51	70.22	8.14	78.36	70.30	7.93	78.23	70.41	7.74	78.15

RS: Reducing sugars, NRS: Non-reducing sugars, TS: Total sugars

Table 9: Effect of drying temperature on sugar contents (%) of Siwi date (dry weight bases)

		Temperature (°C)											
		50			55			60			65		
Drying size	Pre-treatments	RS	NRS	TS	RS	NRS	TS	RS	NRS	TS	RS	NRS	TS
Whole dates	Control	23.2	51.43	74.63	23.31	51.12	74.43	23.43	50.72	74.15	23.53	50.13	73.66
	Ascorbic acid	23.14	51.36	74.50	23.23	51.19	74.32	23.39	50.66	74.05	23.46	50.32	73.78
	Sodium metabisulfite	23.05	51.38	74.43	23.17	51.09	74.26	23.32	50.68	74.00	23.39	50.48	73.87
	Sulfur dioxide	23.46	51.30	74.85	23.59	50.91	74.50	23.72	50.52	74.24	23.79	50.30	74.09
Date halves	Control	23.35	51.34	74.89	23.46	51.15	74.61	23.54	50.82	74.36	23.63	50.30	73.93
	Ascorbic acid	23.51	51.25	74.76	23.58	50.82	74.40	23.69	50.44	74.13	23.83	50.01	73.84
	Sodium metabisulfite	23.30	51.26	74.56	23.35	51.00	74.35	23.48	50.66	74.14	23.53	50.43	73.96
	Sulfur dioxide	23.58	51.27	74.90	23.65	51.02	74.67	23.70	50.73	74.43	23.78	50.43	74.21
Date pieces	Control	23.25	51.17	74.42	23.34	50.78	74.12	23.46	50.43	73.89	23.57	50.07	73.64
	Ascorbic acid	23.28	51.14	74.42	23.39	50.95	74.14	23.41	50.42	73.83	23.51	50.04	73.55
	Sodium metabisulfite	23.36	51.31	74.76	23.42	51.00	74.42	23.53	50.65	74.18	23.61	50.65	74.03
	Sulfur dioxide	23.52	51.38	74.70	23.63	51.10	74.73	23.69	50.87	74.56	23.72	50.76	74.48

DISCUSSION

The chemical composition of Siwi and Sakkoti date fruits this results in agreement with Al-Farsi *et al.*[6] who reported that moisture content of fresh date was 42.49% and Zaitoon *et al.*[18] reported moisture content in khalal stage 67.22%, crude fiber 3.71%, crude protein 2.11%, ash 0.86%. Data were also in agreement with Nezam El-Din and Abd El-Hameed[19] who reported that total acidity, total sugars, reducing sugars, total phenols were 0.45%, 72.6%, 63.1%, an d 0.66%, respectively. The results of tannins were similar to that of Al-Hooti *et al.*[20] who reported 0.4% for tannins value and in agreement with Al-Farsi and Lee[21] who reported TSS of date fruits 30-45 Brix at khalal stage. Also, Mohamed *et al.*[22] reported total phenols content of 35.82 and 99.34 mg/100 g for two Sudanese date palms. chemical properties of dates vary depending on various factors such as cultivars, region, climate and fertilizer[20]. The color measurement of Siwi and Sakkoti date fruits these results agreed with those found by Mohamed *et al.*[22] and Hasnaoui *et al.*[23] who reported that L value ranged from 12.12 to 38.93, a value in the range of +1.35 to+15.29 and b value in the range of +0.86 to +35.12. Measuring the color of date fruits is useful in comparing different dates. Overall, the difference in color is mainly due to genetic variability[24]. The values of H and C indicated the yellow color of date fruits[12,13].

Almost all food-processing techniques and particularly fruits drying involve the use or the modification of water in food. The control of water activity in foods is an important tool for extending their shelf life. It protects the quality of foods by controlling microbial, chemical and physical changes. The moisture contents of Siwi and Sakkoti date fruits were agreement with Hussain *et al.*[25] who found minimum moisture reduction (13.91%) and maximum moisture reduction (24. 13%). The results were in agreement with Ashraf *et al.*[26] who reported that the increase in drying temperature and decrease in sample thickness significantly reduced drying

Table 10: Mean values of color whole dried Siwi and Sakkoti dates

	Sakkoti date cultivar				Siwi date cultivar			
Dates treatment	50°C	55°C	60°C	65°C	50°C	55°C	60°C	65°C
L-value								
Control	32.14^{bAB}	33.92^{bA}	30.76^{bAB}	26.97^{cB}	34.43^{bA}	31.20^{bA}	35.66^{bA}	35.43^{abA}
Ascorbic acid	33.99^{bA}	35.75^{bA}	30.14^{bA}	31.76^{bcA}	36.56^{abA}	32.77^{bAB}	26.93^{cB}	34.58^{bA}
Sodium metabisulfite	34.25^{bC}	42.97^{aAB}	37.86^{aBC}	46.70^{aA}	36.84^{abA}	33.40^{bA}	33.80^{bA}	33.85^{bA}
Sulfur dioxide	51.32^{aA}	42.75^{aB}	42.54^{aB}	37.73^{aB}	41.66^{aA}	43.17^{aA}	43.48^{aA}	41.70^{aA}
$LSD_{0.05}$	6.278							
a-value								
Control	13.43^{aA}	13.81^{aA}	10.37^{aB}	13.80^{aA}	7.75^{aB}	10.40^{aAB}	10.87^{aA}	12.69^{aA}
Ascorbic acid	11.04^{aA}	11.60^{abA}	11.84^{aA}	12.16^{abA}	7.52^{aB}	9.62^{aB}	9.50^{aB}	13.72^{aA}
Sodium metabisulfite	11.47^{aA}	11.00^{abA}	10.77^{aA}	10.30^{bA}	8.87^{aA}	10.16^{aA}	11.32^{aA}	11.48^{aA}
Sulfur dioxide	7.23^{bB}	8.81^{bAB}	9.15^{aAB}	10.53^{bA}	6.93^{aB}	8.01^{aB}	11.55^{aA}	13.75^{aA}
$LSD_{0.05}$	3.301							
b-value								
Control	21.42^{bAB}	27.4^{b-A}	19.73^{cAB}	16.00^{bB}	15.76^{bA}	15.40^{bA}	20.05^{bA}	20.57^{bA}
Ascorbic acid	23.21^{bA}	21.24^{cA}	21.60^{cA}	20.76^{bA}	16.65^{bA}	14.42^{bA}	10.59^{bA}	16.71^{bA}
Sodium metabisulfite	25.47^{bC}	29.91^{bBC}	34.12^{bAB}	41.84^{aA}	20.19^{bA}	17.27^{bA}	19.09^{cA}	15.27^{bA}
Sulfur dioxide	43.30^{aA}	43.87^{aA}	43.34^{aA}	34.22^{aB}	29.29^{aA}	32.02^{aA}	33.78^{aA}	31.75^{aA}
$LSD_{0.05}$	8.35							
Chroma value								
Control	25.28^{bAB}	30.75^{bA}	22.31^{cB}	21.13^{bB}	17.58^{bA}	18.57^{bA}	22.83^{bA}	24.23^{bA}
Ascorbic acid	25.70^{bA}	24.21^{bA}	24.70^{cA}	24.08^{bA}	18.32^{bA}	17.55^{bA}	14.23^{cA}	21.69^{bA}
Sodium metabisulfite	27.95^{bB}	31.91^{bB}	35.83^{bAB}	43.09^{aA}	22.09^{bA}	20.11^{bA}	22.29^{bcA}	19.14^{bA}
Sulfur dioxide	43.90^{aAB}	44.74^{aA}	44.30^{aA}	35.81^{aB}	30.34^{aA}	33.16^{aA}	36.01^{aA}	34.65^{aA}
$LSD_{0.05}$	8.14							
Hue value								
Control	57.80^{bA}	63.00^{bA}	61.40^{bA}	49.30^{cB}	63.80^{bA}	56.20^{bA}	61.20^{bA}	57.80^{bA}
Ascorbic acid	64.50^{bA}	61.30^{bA}	58.60^{bA}	59.00^{bA}	64.60^{bA}	54.60^{bB}	47.90^{cB}	50.70^{bB}
Sodium metabisulfite	65.40^{bB}	69.40^{bAB}	72.00^{aAB}	76.20^{aA}	66.40^{bA}	59.50^{bAB}	57.60^{bB}	53.00^{bB}
Sulfur dioxide	80.60^{aA}	78.70^{aA}	78.20^{aA}	72.50^{aA}	75.90^{aA}	75.50^{aA}	70.00^{aAB}	66.20^{aB}
$LSD_{0.05}$	8.149							

time. Moisture content and drying rate were influenced by the drying temperature and sample size. The results shown moisture content was affected by temperatures and fruit surface transpiration. The effects of pretreatments and drying temperatures on pH value and acidity of Siwi and Sakkoti date fruits were in agreement with Nezam El-Din and Abd El-Hameed[19] and Anet and Reynolds[27] who reported a little decrease in pH value in sulfur treated date which may be resulted from the effect of sulfur dioxide on inhibition of non-enzymatic browning reaction. Total acidity of all treatments were more than that of the control date fruits which related to browning reaction Nezam El-Din[28] and Mortazavi *et al.*[29] who showed that reduction in acidity level by heating can be due to the conversion of part of organic acids into sugars, the relationship between the enzymatic acidity in date fruits and the pH value and color[30]. The total phenols of Siwi and Sakkoti date fruits shown were in agreement with those of Mansouri *et al.*[31] who reported that phenols increased by drying. The significant increase in phenolic content on drying possibly due to degradation of tannins and maturation of degradative enzymes at a higher temperature, all treatments showed higher values of phenols content than the control[32]. Health benefit is an important attribute which enhance the quality of dried products. These results agreed with Mechlouch *et al.*[33]. Total sugars and non-reducing sugars decreased with increasing drying temperature and whereas reducing sugars increased by increasing drying temperature[26]. The reducing sugars represented 95.08% of the total sugars at tamer stage; this could be due to the effect of the inverses activity on the non-reducing sugars during ripening[34].

Measuring color of whole date fruits is useful for the comparison among different pretreatments and the effects of drying temperature on the quality of dried dates. The high (L) value shows high degree of lightness of color. Statistical analysis showed significant differences ($p<0.05$) among means of color values of Siwi and Sakkoti cultivars the higher (L and b) values for the pretreatment with sulfur dioxide or sodium metabisulfite solution regardless increasing temperature. While, the color value of date observed in Siwi and Sakkoti cultivars, the lowest (a) values of the pretreatment with sulfur dioxide or sodium metabisulfite solution regardless increasing temperature. Color of pretreated were in agreement with Hasnaoui *et al.*[23] and Biglari *et al.*[24] evaluated the fruit color of date palm cultivars from Moroccan oases at

tamer stage . The high color of (C) showed that near to yellow of dates. Hunter color (C) value was shown the intensity of color, Siwi and Sakkoti cultivars showed the highest (C) value 36.01 and 44.74 for pretreatment with sulfur dioxide dried at 60°C. Color (H) value of Siwi date was no significant sulfur dioxide or sodium metabisulfite solution at same temperature. On the other hand, the color (H) of pretreatments with sulfur dioxide or sodium metabisulfite solution were high score compared other treatments. In general, the difference in color mainly due to the pretreatments, drying temperature and the best treatments were sulfur dioxide or sodium metabisulfite solution with 60°C. The study recommends pretreated with sodium metabisulfite solution or sulfur dioxide before drying to improve color dried date products.

CONCLUSION

Date varieties (Siwi and Sakkoti) at the khalal stage of maturity can be successfully dried to produce high quality of semi-dry date products (whole, halves or pieces fruits) with pretreatments sodium metabisulfite solution or sulfur dioxide, then dried at 60°C.

SIGNIFICANCE STATEMENT

This study discovers the effect of pretreatments and different temperatures of date fruits Siwi and Sakkoti that can be beneficial for manufacturers to apply it on large scale. This study will help the researcher to cover the critical areas of the best pretreatment and temperature to obtain the best quality of date fruits that many researchers were not able to explore. Thus a new theory on these pretreatments materials and possibly other drying temperatures may be used in date industries.

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