J. of Soil Sciences and Agricultural Engineering, Vol.1 (4):323-337, 2010

THIN LAYER DRYING OF HAYANI DATE USING A PORTABLE DRYER

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ABSTRACT

A study was carried out to test and evaluate a portable mechanical date dryer using butane – gas as heat energy source. The temperature of drying air was adjusted to be approximately constant during the experiment of period at 40 , 50 , 60 and 70°C and air velocity of 1 ,1.5 and 2 m/s. Two empirical models (Exponential and Page) were examined to describe the drying behaviour of date**.** The change in date moisture content during the drying process, thermal efficiency of the drying process and the total and reducing sugars of the dried date were also determined. The obtained results showed that, both of the examined models could satisfactory describe the change in date moisture content during the drying process. While the Page's model could predict the change in moisture content of date more adequately than the simple model. The dryer thermal efficiency increased with the increase of drying air temperature and air velocity, and it ranged from 32.23 to 69.84 % for the un-peeled date, from 33.82 to 71.63% for the un-peeled treated date and from 35.42 to 75.13% for the peeled date. Also, the total and reducing sugars percentages decreased with the decrease of drying air temperature and air velocity and the reducing sugar ranged from 44.85 to 51.38 % while the total soluble sugar ranged from 55.95 to 65.14 % .

INTRODUCTION

Date**s** are considered among the most important crops cover a large area of Arabic and Islamic world, where date palm expand in north Africa from the far west in Morocco to Egypt.

Date palm grown in Egypt spreaded in several zones and expanded approximately 1500 km from north to south, this area locates under different climatic condition**s** which led to produce different varieties of date. Thus soft varieties (Hayani, Amhat, Semany, Saglol, Bentesha) expanded in north zone of Egypt and rank the highest percentage of total production (approximately 52.1%) Semi dried varieties (Alamry, Alagalany, Alsewy) cover middle Egypt and oasis and rank the second position in production (approximately 33.8%), while dried varieties (Alyacoty, Alprtmoda, Almlcapy, Algandila, Algargoda, Aldgna, Alshamea) grown in upper Egypt especially in Aswan governorate and rank (approximately 14.1%) of the total yearly production (M.O.A 2003).

Under this condition farmers harvest soft varieties date before complete ripening stage or (rutab stage) and they are whether start marketing their product as fresh date in cheap price, or dry the product under sunshine (traditional method) by spreading them on mats in the open air being directly exposed to the solar radiation. This method is obviously not satisfactory as dust, dirt, rodents and insects can not be eliminated. On the other hands even this method has the advantage of non energy consumption, the total cost become high because of slow drying rate, long drying period and the need for large number of workers for frequent turning up the bed of date during the drying process and covering it during night time... etc.

The present study aims to test and evaluate a portable mechanical dryer for drying high moisture date (Hayani var.). Two different drying models (simple exponential and Page) were examined for describing the drying behaviour of date. Thermal efficiency and final quality of the dried date were also estimated.

THEORETICAL CONSIDERATIONS

In this study two different drying models (simple exponential and Page) were examined for describing the thin layer drying of date palm under four different levels of air temperature (40, 50, 60 and 70°C) and three different levels of air velocity (1, 1.5 and 2 m/s) .

The value of moisture content after drying time (t) predicted by any drying equation depends mainly on the drying parameters (drying constant and the equilibrium moisture content) of this equation. In this study, the final moisture content (M_f) was used as an approximate value for the dynamic equilibrium moisture content, taking into account that the drying runs turned off when the reduction in the sample weight was almost ceased, as previously mentioned by Matouk *et al.,* (2002) and El-sahrigi et.al.,(2006). The two examined models are presented as follows:

1-The simple exponential model:

$$MR = \exp\ (-k_s\ t)$$

$$MR = \frac{M - M_f}{M_o - M_f} = \exp(-k_s t) \quad \ldots\ldots\ldots\ldots (1)$$

1- Page model

$$MR = \exp\ (-k_p\ t^u)$$

$$MR = \frac{M - M_f}{M_o - M_f} = \exp(-k_p\ t) \quad \ldots\ldots\ldots\ldots (2)$$

Where:

MR : Moisture ratio , dimensionless

M : Average moisture content at time t, (d.b) kg water / kg dry solid.

M_f : Final moisture content. (d.b) kg water / kg dry solid.

t : Time ,min.

k_s , k_p : Drying constant, min $^{-1}$

u : Experimental constant , dimensionless

To calculate the drying constants, the two models were linearized as follows:

1-The simple exponential model**:**

$$Ln(MR) = -k_s t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

2-The page model:

$$Ln(-LnMR) = Ln(k_p) + u.Ln(t) \ldots\ldots\ldots\ldots (4)$$

The drying constant (k_s) of the simple exponential model (Eq.3) was obtained by applying linear regression analysis to the values of Ln (MR) and the elapsed drying time (t). The slope of the best fit straight line represents the drying constant (k_s).

On the other hand the values of the drying constants of Pag's model (k_p and u), were obtained by applying linear regression analysis to the values of Ln [-Ln (MR)] and the corresponding drying time (Eq 4). The slope of the fitted line represents the constant (u) while the value of the anti log of the intercept represents the constant (k_p).

MATERIALS AND METHODS

Materials:

Fresh, ripe hand harvested samples of date palm (Hayani) were used in this study. It was obtained from a local date producing farm in Demiatta governorate. The initial moisture content of the freshly harvested date ranged from (97.36 to 118.45 % d.b.) and the total sugar content ranged from (44.58 to 65.14 % d.b.).

Preparation of the samples:

The main sample was divided into three sup samples as follows:-

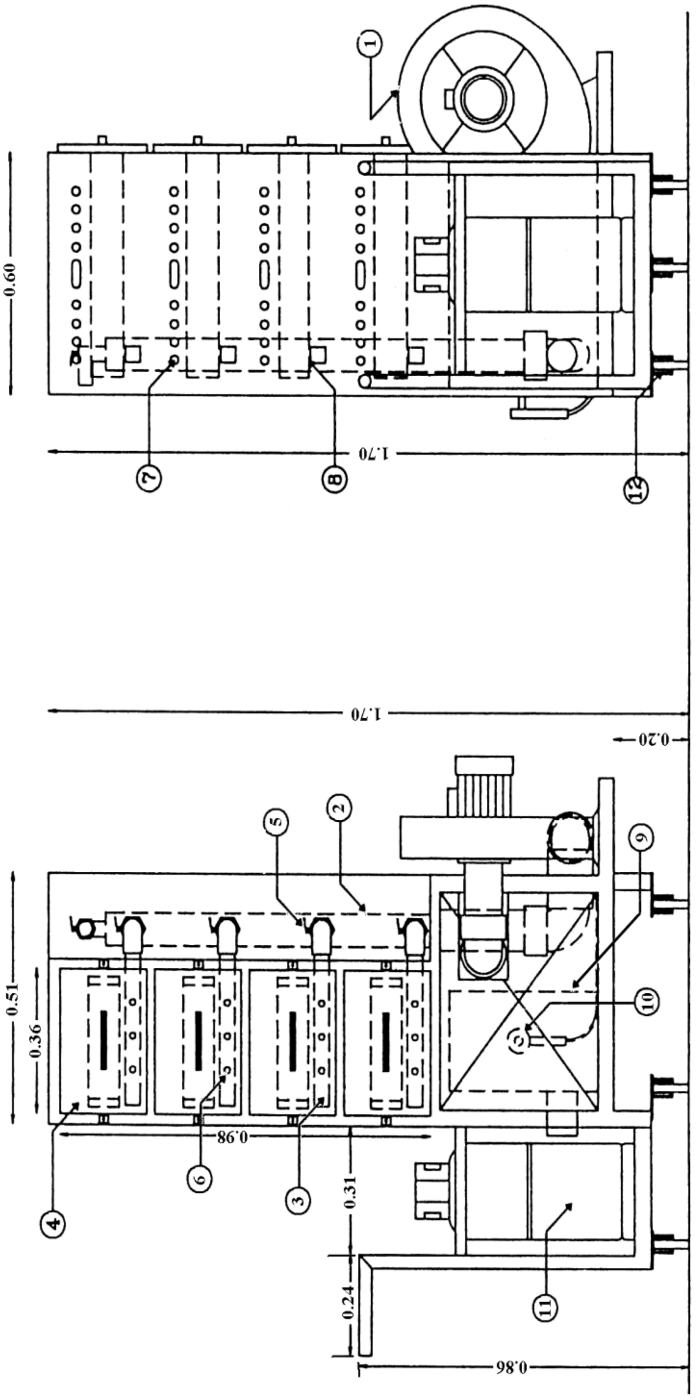
- The first sup sample was un-peeled date and coded as (T_1).
- The second sup sample was un-peeled date blanched by dipping in a solution containing 1.5% potassium meta-bisulphite as recommended by Inayatullah *et al.,* (1989) and coded as (T_2) .
- The third sup sample was peeled date without pretreatment and coded as (T_3).

After pre-treatment, date samples were stored in plastic bags and kept inside a freezer at (-18°C) until used. Before any experimental run, the date sample taken out of the freezer and kept under the environmental conditions of laboratory to attain room temperature

Equipment

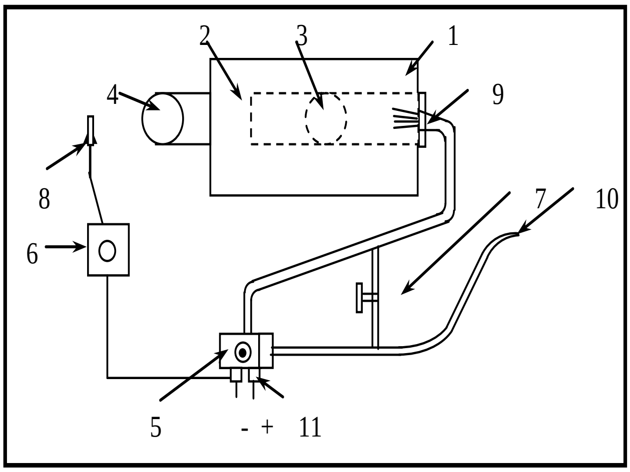
The portable dryer:

- The portable dryer used in this study was designed and fabricated by El-Sahrigi, *et al.* 2007. It consisted of a main frame of 60 cm long, 60 cm wide, and 175 cm high, a drying bed of four trays supported inside the dryer body in vertical sequence forming a plenum chambers of 60×7×31.5 cm (L×W×H), between the trays. A 0.5 kW centrifugal fan was used to supply an equal amount of drying air to each tray, and a butane gas heating circuit with temperature control system was used for heating the drying air. Fig (1) illustrates elevation and side view of the portable dryer used during the experimental period, and Fig. (2) shows a schematic diagram for the temperature control system. Detail descriptions of the dryer and main parts are given by El-Sahrigi, *et al.*, 2007.



(1) Centrifugal fan (2) Main air duct (3) Air duct branch (4) Drying trays
(5) Air valve (6) Air entrance holes (7) Air discharge holes (8) Plenum chamber
(9) Air heating unit (10) Gas nozzle (11) Gas pump (12) Wheels

Fig.(1): Schematic diagram for the protable dryer.



1- Heating unit 2-Heating cylinder 3- Air inlet 4- Air outlet
5- Solenoid valve 6- Thermostat 7- Control valve 8- Sensor
9- Nozzle 10- Gas source 11- Electric source

Fig. 2: Schematic diagram for the temperature control system

Experimental measurements:

Date Moisture content:

The moisture content of date was determined according to (AOAC 1990). It was determined by drying samples of dates (10 g, in duplicate) in electric oven at 70 °C until reaching a constant weight (48 h was sufficient).

Air velocity:

The velocity of drying air under the trays was measured using a digital air velocity instrument connected with a velocity probe with measuring range of (0.1 to 10 m/sec) and accuracy of (± 0.1 m/s).

Air temperature:

Air temperature meter was used for measuring the drying air temperature during the experimental work. The measuring range of the meter was from (-40 to 104.4 °C) with an accuracy of (±0.2 °C).

Thermal Efficiency:

The thermal efficiency was calculated at date final moisture content of 15% d.b. as the proper moisture content for date storage using the following relationship (Reys and Jindal ,1986).

$$\eta_{th} = (W_w \times \frac{Lh}{Q}) \times 100 \qquad \text{................ (5)}$$

Where

η_{th} : Thermal efficiency,%

W_w : Water evaporated from date, kg
Lh : Latent heat of evaporation of water, kJ/kg
Q : Total energy consumption, kJ

Total energy consumption was calculated according to the following formula:

$$Q = C.V \times gc \qquad \text{………………. (6)}$$

Where:
C.V: Calorific value, kJ/kg
gc : Gas consumption , kg

The latent heat of water vaporization was taken to be 2406.8, 2382.8 , 2358.5 and 2333.8 kJ/kg at 40 , 50 , 60 and 70°C, respectively . Also the calorific value and density of butane gas were taken as 45600 kJ/kg and 2.7 kg/m^3 , respectively according to El-Kholy (1998).

Total and reducing sugars:

Total and reducing sugars were determined according to Somogi (1952).

Experimental procedure:

The temperature of drying air was adjusted to be approximately constant at selective levels of 40 , 50 , 60 and 70°C and air velocity of 1 ,1.5 and 2 m/s. The centrifugal fan was adjusted to force the hot air from the heating chamber by an equal amounts through the four drying chambers. Before each run, the dryer was adjusted at the required levels of drying air temperature and air velocity. To grantee dryer stability during the experimental runs all the dryer trays were loaded with a dummy samples and the dryer was operated for at least one hour. After making sure that the dryer working at stable condition, the dryer trays were again loaded with another date sample which were distributed uniformly in a single layer. The first and third trays were employed for measuring the change in date moisture content at time intervals of 30 min at the beginning of the drying process up to 120 min during the last drying stage. While the second and fourth trays were used for measuring the initial and final moisture content of date. Drying air temperature and air velocity were also measured at different points under each tray at adjacent time intervals of measuring the moisture content. The drying process was kept running until the weight loss almost ceased to approach the final moisture content.

RESULTS AND DISCUSSION

Date moisture content:

Fig. (3) illustrate**s** the change in date moisture content as related to drying time for the un-peeled date treatment (T_1). The results indicated similar trends of the other two treatments (T_2 and T_3) in which the reduction rate of moisture content increased with the increase of air temperature and velocity and it was higher for the un-peeled date (T_1) followed by the un-peeled treated date (T_2) and the peeled date (T_3)**.** On the other hand, the drying time of date samples decreased with the increase of drying air temperature and air velocity. The results also indicated that, at an average final moisture content of about 15 % ±1 d.b., the recorded drying times at the maximum drying air temperature of 70 ^oC and air velocity of 2 m/sec were 450, 420, and 360 min for the un-peeled date (T_1), the un-peeled treated date (T_2), and the peeled date(T_3) respectively. This means that, the chemical _re-treatment of the unpeeled date decreased the drying time by about 6.73 %, while the peeling process decreased the drying time by about 14.3 % as compared with the un-peeled date.

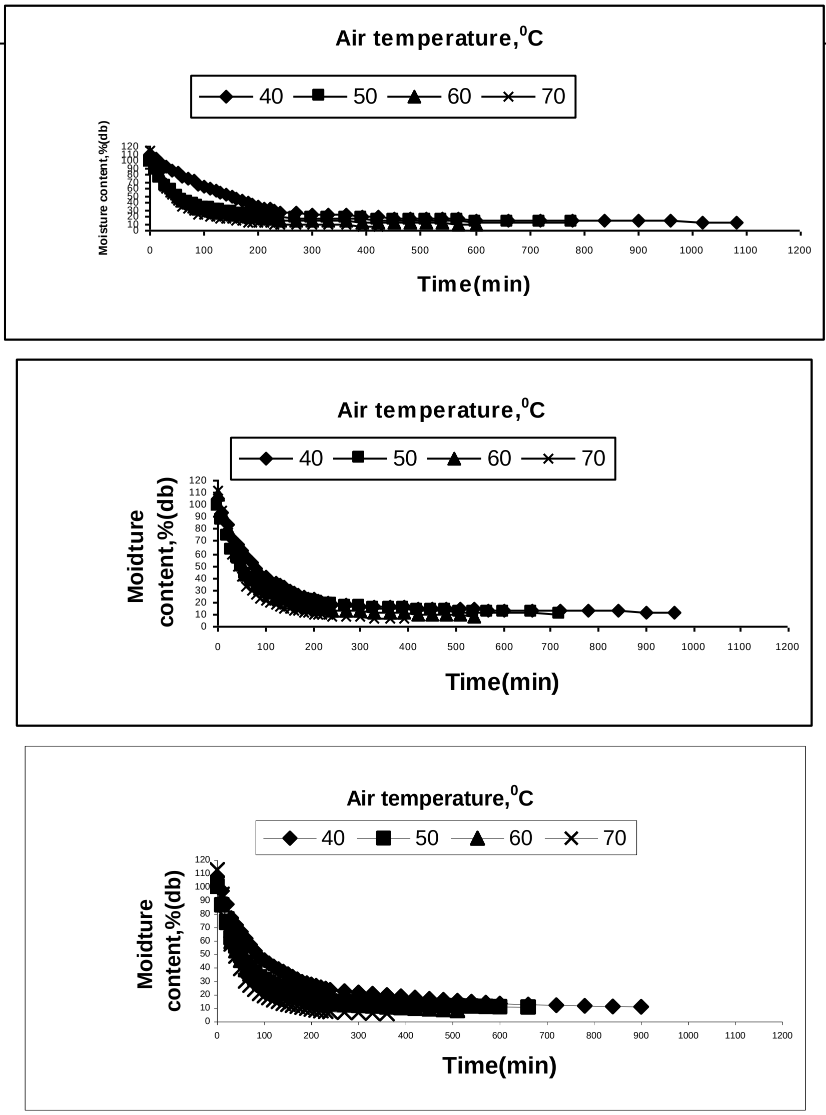


Fig.(3): Change in moisture content of peeled date as related to drying time.

To determine the interaction effect of both drying air temperature and air velocity with the values of final moisture content, a multiple regression analysis was employed. The nature of dependence could be described as follows :

$$M_f = a - b\,(V) - c(T) \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where:

M_f = the final moisture content,% (d.b)

a, b, c = constants

T = drying air temperature, °C

V= drying air velocity, m/s

As shown in table (1) the values of (R^2) for the obtained equation revealed that, the final moisture content (M_f) was strongly affected by the drying air temperature and air velocity.

Table (1): Constants of equation (7) relating the final moisture content with the drying parameters.

Date conditions	Final moisture content (Mf) % (d. b.)				
	a	b	c	(R^2)	±SE
T_1	21.93333	-1.01	-0.16767	0.99	0.248529
T_2	21.23167	-1.01	-0.16833	0.99	0.163571
T_3	20.66017	-1.475	-0.16037	0.95	0.491932

Drying constants k_s, k_P and u:

A multiple regression analysis was also functioned to study the interaction effect of both air temperature and air velocity on the drying constants k_s of the simple exponential equation and the drying constants k_{page} and u of the page equation . The nature of dependence can be described as follows :

$$k_s = d + e(T) + f(V) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$k_p = g + h(T) + k(V) \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

$$u = l + m(T) + n(V) \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

The constants of equations (8, 9 and 10) are presented in table (2).

Table (2): Constants of equations (8, 9 and 10) for different date conditions.

Drying constant	Date treatment	d	e	f	R^2	±SE
Ks	T1	-0.00825	0.0013	0.000274	0.99	0.000318
	T2	-0.00669	0.001475	0.000259	0.96	0.0007
	T3	-0.00864	0.001475	0.000309	0.92	0.00123
Drying constant	Date treatment	g	h	k	R^2	±SE
Kp	T1	0.03255	0.0081513	0.000915	0.99	0.001447
	T2	0.03506	0.009374	0.000962	0.98	0.001806
	T3	0.0283	0.011017	0.000833	0.99	0.00089
Drying constant	Date treatment	i	m	n	R^2	±SE
U	T1	0.637708	-0.03925	0.004312	0.96	0.012589
	T2	0.598833	-0.049	0.004935	0.96	0.014444
	T3	0.592133	-0.05318	0.005061	0.98	0.008658

SE : Standard Error

Also Fig (4) illustrate**s** the drying constants k_s , k_p and u as related to drying air temperature and velocity for unpeeled date. The same trend was also observed for the other two treatments (T_1 and T_2). In general the drying constants k_s, k_{page} increased with the increase of drying air temperature and air velocity. While the constant u increased with the drying air temperature and decreased with air velocity.

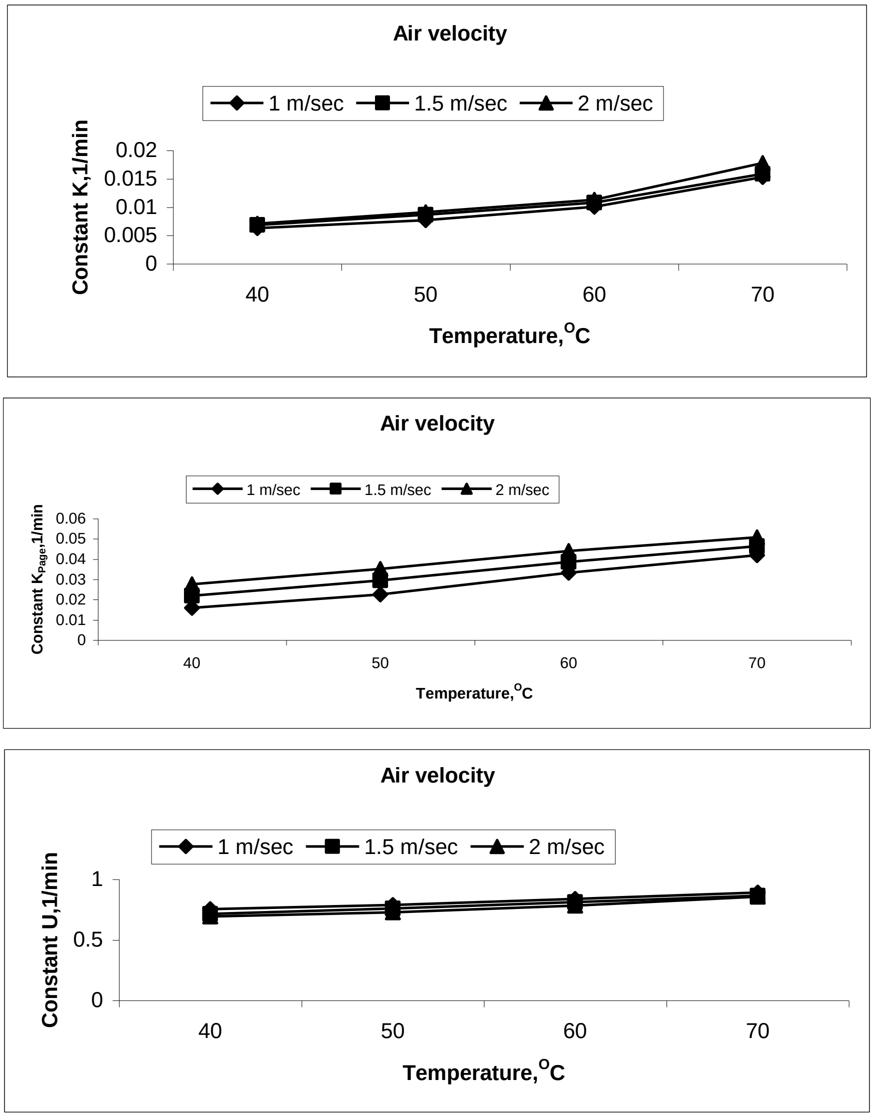


Fig.(4) : Drying constants (k_s, k_p and u) as related to drying temperature at different air velocity for peeled date.

Evaluation of the mathematical models:

In order to compare and evaluate the two examined models for describing the drying behaviour and predicting the change in date moisture content, a straight line was fitted by least square method to the values of the observed and the predicted moisture contents. The values of standard error were estimated and coefficients of determination were then computed and tabulated in table (3).

Table (3): Values of regression coefficient of determination (R^2) and standard error (SE) for both forms of simple and Page drying equations.

Date conditions	Air temperature , °C	Simple exponential model					
		Air velocity , m/s					
		1		1.5		2	
		SE	R^2	SE	R^2	SE	R^2
T1	40	4.637	0.97	4.459	0.97	3.97	0.97
	50	6.683	0.9	6.31	0.93	6.274	0.93
	60	6.006	0.93	4.322	0.97	5.77	0.94
	70	5.111	0.97	5.68	0.96	5.268	0.96
T2	40	6.122	0.95	8.41	0.88	3.152	0.99
	50	5.908	0.94	5.802	0.94	5.589	0.93
	60	5.154	0.95	5.701	0.95	5.768	0.95
	70	4.443	0.97	4.778	0.97	5.001	0.97
T3	40	3.56	0.98	8.133	0.87	4.964	0.96
	50	6.16	0.91	5.032	0.95	4.386	0.96
	60	6.038	0.94	5.021	0.96	6.356	0.93
	70	4.696	0.97	4.305	0.98	3.837	0.98
Date conditions	**Air temperature, °C**	**Page model**					
		Air velocity , m/s					
		1		1.5		2	
		SE	R^2	SE	R^2	SE	R^2
T1	40	0.0003	1.00	0.0002	1.00	0.0003	1.00
	50	0.0615	0.99	0.0272	0.99	0.0323	0.99
	60	0.0263	0.99	0.0061	1.00	0.0243	0.99
	70	0.0089	100.	0.0099	1.00	0.0077	1.00
T2	40	0.001	1.00	0.1334	0.99	0.0004	1.00
	50	0.0147	1.00	0.0279	0.99	0.0318	0.99
	60	0.0093	1.00	0.0151	1.00	0.0287	0.99
	70	0.0077	1.00	0.0029	1.00	0.0038	1.00
T3	40	2.04E-05	1.00	0.0076	1.00	0.0045	1.00
	50	0.0394	0.99	0.0299	0.99	0.041	0.99
	60	0.0402	0.99	0.0153	1.00	0.0287	0.99
	70	0.0037	1.00	0.0079	1.00	0.0036	1..00

The results showed that, both the simple exponential and the page drying models could satisfactory describe the drying behaviour of date under the tested ranges of experimental treatments. While, the page's model was found to be more appropriate for describing the drying behaviour of date and predicting the change in date moisture content during the drying process.

Fig. (5) illustrate**s** the observed and predicted moisture content of peeled date using the Page's model. Similar pattern was also noticed for the results of other runs.

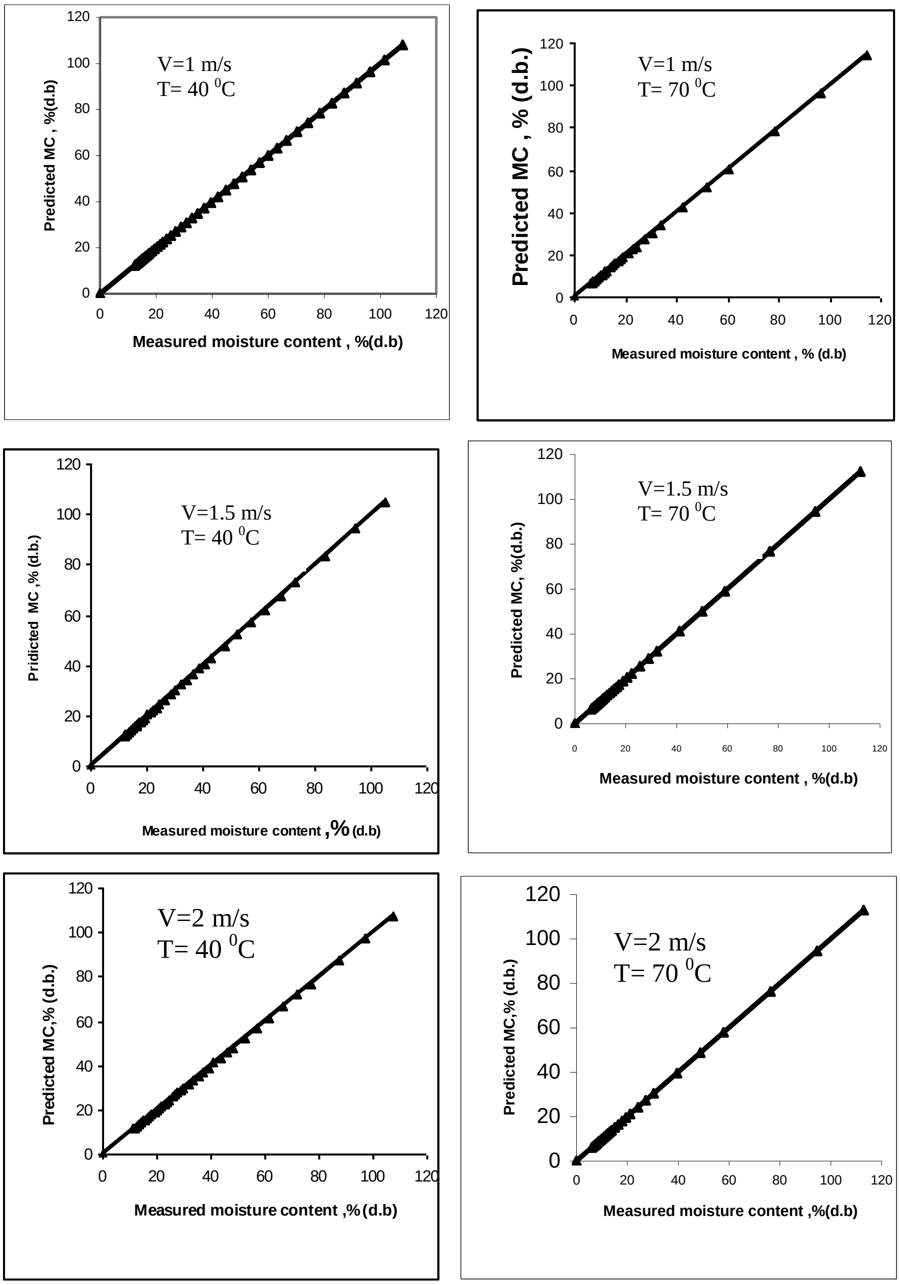


Fig. (5): Measured and predicted moisture content for the peeled date.

Total and reducing sugars:

Total and reducing sugars decreased with the decrease of the drying air temperature and air velocity. As shown in table (4) at the minimum drying air temperature of 40 ^oC and air velocity of 1 m/sec, the recorded average total sugars for (T_1,T_2 and T_3) were 56.01, 55.95 and 56.39% (d.b) and the corresponding average reducing sugars were 44.58 , 44.66 and 44.86% (d.b) respectively . While the total sugars at the maximum drying air temperature of 70^{o}C and air velocity of 2 m/sec, were 64.73, 64.51 and 65.14% (d.b) and the average reducing sugars were 51.08, 51.38 and 51.76% (d.b) respectively. The increase of reducing and total sugars with the increase of drying air temperature and velocity may be attributed to the liberation of sugars from soluble tannins and other compounds such as hemicelluloses as reported by Kamal (1968), also the long time of heating led to decrease the total and reducing sugars during the drying process due to the browning reaction as mentioned by Reynolds, (1965). In general, the peeled date treatment at air temperature of 70 ^{o}C and air velocity of 2 m/sec recorded the highest percentages of reducing and total sugar of 51.76 and 65.14% d.b., respectively.

Table (4): Reducing and total soluble sugars % (d.b) of the dried date.

Air velocity m/sec	Draying air Temperature, ^{0}C	Reducing sugars, %(d.b)			Total soluble sugars, % (d.b)		
		T_1	T_2	T_3	T_1	T_2	T_3
1	40	44.58	44.66	44.86	56.01	55.95	56.39
	50	45.56	45.76	45.78	57.86	58.08	58.67
	60	46.44	46.51	46.72	58.2	59.16	58.44
	70	47.79	47.91	48.26	59.67	60.24	60.97
1.5	40	45.1	45.02	45.36	57.18	57.28	57.63
	50	46.08	46.12	46.28	59.03	59.41	59.91
	60	46.87	46.96	47.22	59.37	60.49	59.67
	70	48.27	48.31	48.77	60.84	61.57	62.21
2	40	45.38	45.62	45.86	58.35	58.61	58.87
	50	47.08	47.29	47.41	60.73	60.42	60.79
	60	48.93	49.15	49.27	62.92	62.35	62.84
	70	51.08	51.38	51.76	64.73	64.51	65.14

Thermal Efficiency of the Proto-Type Dryer

The thermal efficiency was determined for actual drying tests at different levels of drying air temperature and air velocity. The obtained results are listed in table (5). The dryer thermal efficiency increased with the increase of drying air temperature and air velocity and it ranged from 32.23 to 69.84 % for the un-peeled date, from 33.82 to 71.63 % for the un-peeled treated date and from 35.42 to 75.13% for the peeled date.

Table (5): Thermal efficiency of the proto-type dryer at different drying air temperature and velocity.

Air velocity, m/s	Date conditions	Air temp. (°C)	final date Mc, % (db)	Loss of water, Kg	Required energy for water evaporation, kJ	Input energy , kJ	Thermal Eff.,%
1	T_1	40	15.91	5.90	14200.12	259920	32.23
		50	15.92	5.91	14082.348	196080	42.45
		60	15.8	5.94	14009.49	168720	49.32
		70	15.5	6.08	14189.504	141360	61.03
1.5		40	15.94	5.88	14151.984	250800	33.18
		50	15.96	5.98	14249.144	177840	47.91
		60	15.55	6.00	14151	164160	51.72
		70	15.42	6.07	14166.166	135888	63.28
2		40	15.86	5.89	14176.052	248520	33.60
		50	15.41	6.03	14368.284	157320	55.07
		60	15.12	6.00	14151	145920	58.19
		70	15.52	6.07	14166.166	123120	69.84
1	T_2	40	15.04	6.07	14609.276	262200	33.82
		50	15.71	5.99	14272.972	183540	46.58
		60	15.34	6.00	14151	155040	54.76
		70	15.32	6.07	14166.166	136800	62.86
1.5		40	15.02	6.09	14657.412	255360	34.96
		50	15.56	5.97	14225.316	157320	53.98
		60	15.45	6.03	14221.755	150480	56.99
		70	15.3	6.08	14189.504	127680	67.57
2		40	15.39	6.04	14537.072	241680	36.33
		50	15.64	5.89	14034.692	141360	58.48
		60	15.07	6.04	14245.34	133608	64.40
		70	15.17	6.09	14212.842	120840	71.63
1	T_3	40	15.12	6.02	14488.936	246240	35.42
		50	15.64	5.88	14010.864	143640	57.35
		60	15.67	5.96	14056.66	131100	63.90
		70	15.92	6.02	14049.476	127680	66.24
1.5		40	15.1	5.99	14416.732	221160	39.05
		50	15.44	5.91	14082.348	150480	55.31
		60	15.21	6.02	14198.17	141360	60.46
		70	15.47	6.04	14096.152	123120	69.15
2		40	15.66	5.98	14392.664	200640	42.90
		50	15.01	5.95	14177.66	136800	61.66
		60	15.59	5.93	13985.905	118560	69.95
		70	15.08	6.07	14166.166	114456	75.13

Conclusions

1- Both of the examined models could satisfactory describe the change in date moisture content during the drying process. While the, Page's model could predict the change in moisture content of date more adequately than the simple model.

2- Drying constants k_s, k_{page} increased with the increase of drying air temperature and air velocity. While the constant u increased with the drying air temperature and decreased with air velocity.

3- The dryer thermal efficiency increased with the increase of drying air temperature and air velocity and it ranged from 32.23 to 69.84 % for the un-peeled date, from 33.82 to 71.63 % for the un-peeled treated date and from 35.42 to 75.13% for the peeled date.

4- Total and reducing sugars percentages decreased with the decrease of drying air temperature and air velocity and it ranged from 44.58 to 51.76 % d.b. for the reducing sugar and from 55.95 to 65.14 % d.b. for the total soluble sugar.

5- The lowest drying time of 123 min, the highest thermal efficiency of 75.13% and the highest percentages of reducing and total sugar of 51.76 and 65.14 % d.b. respectively were obtained for the peeled date treatment (T_3) dried at air temperature of 70 ^oC and air velocity of 2 m/sec .

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تجفيف البلح الحياني في طبقات رقيقه بإستخدام مجفف متنقل

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أجريت هذه الدراسة لإختبار وتقييم مجفف ميكانيكي لتجفيف البلح بإستخدام غاز البوتوجاز كمصدر للطاقة الحرارية. وذلك بإجراء مجموعة من التجارب المعملية لدراسة تأثير مستويات مختلفة من درجة حرارة هواء التجفيف(40 , 50 , 60, 70 °م) وسرعة سريان هواء (1, 1.5, 2 م/ث) .

تم أيضا إختبار نموذجين رياضيين لوصف منحني التجفيف للبلح في طبقات رقيقه شملت (المعادلة البسيطة , معادلة Page).

وقد أظهرت النتائج مايلي:

1. وصف كلا النموذجين الرياضيين التغير في المحتوي الرطوبي للبلح بشكل مرضي, بينما أعطت , معادلة Page نتائج أكثر دقة للتغير في المحتوي الرطوبي للبلح أثناء عملية التجفيف مقارنة بالمعادلة البسيطة.
2. زادت قيم كل من ثوابت التجفيف (k_s and k_{page}) بزيادة كلا من درجة حرارة وسرعة هواء التجفيف بينما زادت قيم ثابت التجفيف u بزيادة درجة حرارة هواء التجفيف وانخفضت بزيادة سرعة هواء التجفيف.
3. زادت الكفاءة الحرارية للمجفف بزيادة درجة حرارة وسرعة الهواء. حيث تراوحت بين 32.23 إلي 69.3% للبلح بقشره , 33.82 إلي 71.63 % للبلح بقشره والمعامل كيميائيا, بينما تراوحت الكفاءة بين35.42 إلي 75.13 % للبلح بدون قشرة.
4. إنخفضت نسبتي السكريات الكلية والمختزلة بإنخفاض درجة حرارة وسرعة هواء التجفيف حيث تراوحت السكريات المختزلة بين 44.58 – 51.76 % على الأساس الجاف بينما تراوحت السكريات الكلية بين 55.95 – 65.14 % على الأساس الجاف.

قام بتحكيم البحث

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