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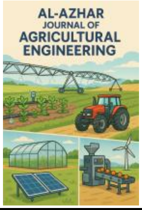

ORIGINAL PAPER

Impact of thermal and mechanical treatments on date juice extraction

Kassem H.A.[a,✉], Ghanem T.H.[b], Badr M.M.[b], Hassan M.H.A.[a]

[a] Department of Agriculture Products Process Engineering, Faculty of Agricultural Engineering, Al-Azhar University, Assuit, Egypt.
[b] Department of Agricultural Products Process Engineering, Faculty of Agricultural Engineering, Al-Azhar University, Cairo, Egypt.

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ABSTRACT

The present work studied two varieties of dates, mainly Siwi and Gondaila. Date juice was hot extracted using different mechanical treatments mainly cutting, without cutting, stirring, and stirring under different temperatures of 70, 75, and 80 °C to be adaptable for future work on a solar heat exchange system for dates. The measured parameters are elapsed time, juice Brix, energy efficiency, and juice quality. The best-fit equation is optimized by the lowest chi-square (X^2) and largest coefficient of determination (R^2). Linear empirical equations are satisfied for all studied thermal and mechanical treatments with R^2 and chi-square (x^2) ranges 0.87 – 1 and 0.000015- 0.034. The rate of increasing time was 0.03, 0.37, 0.54, and 0.6, 1.04, 1.69 min / oC, and the rate of increasing Brix was also 0.3, 0.35, 0.2, and 0.2. 0.1, 0 Brix/ °C and the rate of increasing energy efficiency 1.22, 4.63, 8.41 and 1.49, 4.21, 9.29 % / °C for Siwi and Gondaila respectively. The quality of extracted date juice showed good results due to its dielectric properties as an insulating material with a thermal conductivity of 0.55 W/m. K for PH, Ash, total sugar, reduced sugar, non-reduced sugar, and color. Thermal treatment of 80 °C could be used for higher efficiency and to reduce extraction time.

1. Introduction

Date palm *(Phoenix dactylifera L.)* is one of the oldest fruits that play a major role in Egyptian life. The world's data production has increased largely during the last three decades. On the other hand, the extraction process plays a major role in dibs production; juice extracted from dates could be optimized with the aid of combined thermal and mechanical treatments. Carefully selecting and combining thermal and mechanical treatments could serve to optimize juice extraction while preserving the quality and flavor of the final product. Thermal and mechanical treatments significantly affect juice extraction from dates; they could inactivate enzymes, break down date wall cells, and cause pectin degradation, and they may alter the flavor and aroma profile. On the other hand, mechanical treatments may disrupt cell walls, flavor, and aroma preservation and increase juice yield.

In Egypt, date palm *(Phoenix dactylifera L.)* is one of the oldest fruits that play a major role in Egyptian life; its production has increased largely during the last three decades, with a total area of 72395 ha and an annual production of 1867064.5 Mg (FAO, 2023). Date juice could be an excellent substitute for traditional sugar, which could be used as a beverage with a unique flavor and many nutritional benefits (Mahmoud et al., 2022). Heat treatments cause several biological, physical, and chemical changes in foods, resulting in sensory, textural, and nutritional changes. Heating has been shown to improve food safety by destroying or inhibiting microorganisms and inactivating anti-nutritional factors. It also forms desired compounds such as flavor

✉ Corresponding author(s)
E-mail address: hussienabduk@gmail.com (Kassem, H.A.)

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compounds, antioxidants, and coloring agents. Furthermore, heating improves food digestibility and nutrient bioavailability (Echegaray et al., 2021). Chemical constituents of food products could be affected by processing methods. Understanding the effect of processing on functional components is critical for preserving or improving the original activity of dates during date juice preparation (Burapalit, 2019).

Dates are a great energy source, free fat, cholesterol, and sodium. They may stop the absorption of LDL cholesterol. On the other hand, the sugar in dates can be converted from sucrose, which humans can absorb without the need for digestion, to glucose and fructose, they can shield the skin and eyes and stop infections. Additionally, it can shield cells and other organs from damage to stop heart disease and cancer. Additionally, it can support the formation of bones and red blood cells. Date syrup is often specified to have a minimum 70° Brix and a pH range of 4.2 - 6.0 (Farahnaky et al., 2016). El-Sharnouby et al. (2014), in their work studying the effect of the extraction method on Siwi date dibs, used 100 grams of date pulp placed in a 1-liter Erlenmeyer flask with varying amounts of water added ratios (Date/Water) 1:2, 1:3, 1:4, and 1:5. A hand-held blender (Phillips, Holland) was used to blend the samples. After adjusting the pH at 6.0 ± 0.2, every sample was kept in a water bath at 70°C for two hours in triplicate. Doma et al. (2013) applied two extraction techniques in his work on date honey, first of them by adding hot water 80 – 90 °C to date flesh with 1.5:1 ratio, the other one was by adding hot water of 70 °C with a ratio of 3:1. The sugar extraction rate increased as the water-to-flesh ratio increased, Zahdy dates recorded the highest at 95.00% with a 3:1 W/D ratio and 77.00% with a 1.5:1 W/D ratio. In contrast, Siwy dates showed the lowest, reaching 93.00% at a 3:1 W/D ratio and 75.00% at a 1.5:1 W/D ratio.

Sorour and Assous (2008) studied three different methods of extracting date juice of the Siwi variety at tamr stage. In the first method, the date was extracted with a wafer at 25 °C for 2 minutes; in the second method, the date residue of the first treatment was subjected to 75 °C for 15 min at a water date ratio of 3:1; the third treatment in treating the residue of the first treatment with stirring by paddle impeller at (20 – 200 r.p.m) with heating at 75 °C for 15 min. Excellent date juice quality and minimal processing time were recorded when dates were extracted at 75°C for 15 minutes at a 3:1 water-to-date ratio (wt/wt). The mixing of dates with water was performed using a paddle impeller. It is also recommended to use mixer speeds in the range of 45–91 rpm. Through previous studies, it was found that there are a lot of problems facing dibs production in all countries producing dibs, such as reduced efficiency of extraction and net production, unstable characteristics of the produced dibs, chemical changes in the color of dibs, problems associated with quality and sensory attributes, forming sugar during storage and dibs turned black. In addition to the above, the dibs turn dark, especially when extracted at a high temperature (Al-Ogidi, 2011).

Despite significant technical developments in all processing fields, the conversion industries that are concerned with dates have not received enough technical engineering development due to the lack of specialized factories and businesses. The extraction of date syrup has not developed much, and customary traditional methods rely on heavy weights above the date bags and waiting until the extraction of syrup due to difficulties facing the traditional methods of date dibs extraction in terms of long extraction period. In the present work, two varieties of dates were used, namely the Siwi and Gondaila varieties, to maximize their extracted juice yield. This goal could be achieved by studying:

1. The effect of different mechanical treatments, mainly cutting, without cutting, stirring, and without stirring under different temperatures of 70, 75, and 80 °C, which is adaptable for future work on solar heat exchanging systems for both Siwi and Gondaila dates as a preliminary treatment before the concentration process.

2. The effect of two different incubating treatments using a water bath heat exchanger, namely with stirring at 2 r.p.m or un-stirring date after adding hot water at three different moderate temperatures 70, 75, and 80°C on extraction time at constant date juice Brix of (23.9 -26.3).

3. Energy efficiency and juice quality will also be studied.

2. Materials and methods

2.1. Materials

The experimental part of the present study was carried out in the Agricultural Engineering Laboratory, Faculty of Agricultural Engineering Al-Azhar University, Assiut Governorate to develop and evaluate a laboratory-scale date juice extraction unit able to be operated in moderate temperatures and adapted in the future to be operated using electrothermal solar energy in remote areas and that have a lack of electricity as El Bawitty, El Frafra, El Dakla, El Karga and Sewwa. The best-fit equation is optimized for the lowest chi-square (x^2) and largest coefficient of determination (R^2). The extraction process is terminated at a constant water date mixture mass of 2650 g, and then Brix, time, juice mass, and pressed cake mass are evaluated. Energy efficiency and consumption are also considered.

2.1.1. Raw material preparation

The Siwi date variety was obtained from the New Valley Governorate. Siwy is one of the finest cultivars (semi-dry) in Egypt. Gondaila is a variety with a low market value that has not a satisfactory commercial value when sold. Gondaila is a cultivar (dry) in Egypt. Dates were washed thrice with clean water and left to dry in an ambient laboratory atmosphere for 24 hours. Pulps were separated and then chopped. The Siwi variety has an average moisture content of 17.98%. The Gondaila has an average moisture content of 11.10%, and the physiochemical properties of date fruit for both studied varieties are shown in Table 1.

Table 1
Some Physiochemical properties of date fruit.

Analysis Physiochemical properties	Types of date	
	Siwi date	Gondaila date
Ph	5.60	5.04
Ash %	1.79	2.21
Total sugar	85.21	65.30
Moisture (W.b) %	17.98	11.10

2.1.2. The date of the juice extracting system setup

The extracting system consists of a water bath, Prank, control unit, and auxiliary tank, as shown in Fig. 1.

- **Water bath:** The water bath is made of an insulated stainless-steel container of rectangular prism shape of 210 × 210 × 340 mm; their thermal conductivity is (K_1 = 18 W/ m. K). Insulating material glass wool of thermal conductivity of (K_2 = 0.042 W/ m. K). The inner diameter of the water bath is 124, and a 280 mm heigh container is used for preparing the date–water mixture, date is mixed using a prank. In the present work, water was used as thermal fluid because it absorbs and stores thermal energy, low price, and its specific heat is about 4.18 kJ/kg °C, which is adaptable for solar heat exchanger system (water bath) that regularly distributes the heat energy in the juice extracting process.
- **Control system:** The control system consists of a prank, tow heater, and control unit (Arduino Uno R3, Bluetooth Module, waterproof temperature sensor (WPT), a relay, and load cell), as shown in Fig. 2. A relay was used to turn on and off (heater 1 and heater 2 and moving), when temperature from the sensor is greater than (70, 75 or 80 ºC) turn on moving but heater 1 and heater 2 turn off, load cell to control the mass entering and leaving the system.
- **Auxiliary tank:** An auxiliary cylindrical stainless-steel tank with a diameter of 150 mm and 250 mm in height. The auxiliary tank is used to supply hot water for temperature loss compensation; it contains a heater with a power of 1.4 kW and a sensor to adjust the required temperatures.

2.1.3. Filtration and pressing unit

The date mixture is pressed into a perforated cylinder using a hand press as in Fig. 3, and then the juice is filtered in cheese molds and pressed. The juice was filtered in cheese clothes (double layer), the solid remainder after the compressing process (cake), could be used in complementary industries and not extracted again because preliminary experiments showed that after extracting the brix relativity is about 7%, which is not economically to be used.

2.2. Measuring instruments

2.2.1. Clamp meter

The power requirement (kW) was determined by using the clamp meter to measure the line current strength (I) and the potential difference value (V). The origin of the manufacture is China, Battery12VX1 or GP23A.

2.2.2. Electric dry oven

An electric dry oven was used to date samples to determine moisture content. The origin of the manufacture is Canada, and the model is a 655F Cat. No. 13-245-655, power source " Electricity " Temperature range between 50 to 300 ºC and accuracy 5 ºC.

2.2.3. Refractometer

A refractometer was used to measure total soluble solids (HI96801). The sucrose is displayed digitally and can also be used for lab or field measurements. This instrument offers a specific analysis to determine accurate sugar concentration in date juice (dibs) range (0 to 85% Brix) and resolution (0.1 Brix).

2.3. Methods

2.3.1. Experimental Procedure

The date pulp of the Siwi and Gondaila varieties was separated from the kernel, weighed, washed, and cut into small parts as shown in the flow diagram Fig. 4.

2.3.1.1. The extraction process

The steps of the extraction process can be summarized as follows:

1. Preparation of the fruits of dates of the two varieties (Siwi, and Gondaila) and then washing the fruits.
2. Denucleation.
3. Mechanical treatment of the date pulp resulting by cutting into pieces 10 ×10 ×3 mm according to Doma et al., (2013) or leaving it without cutting

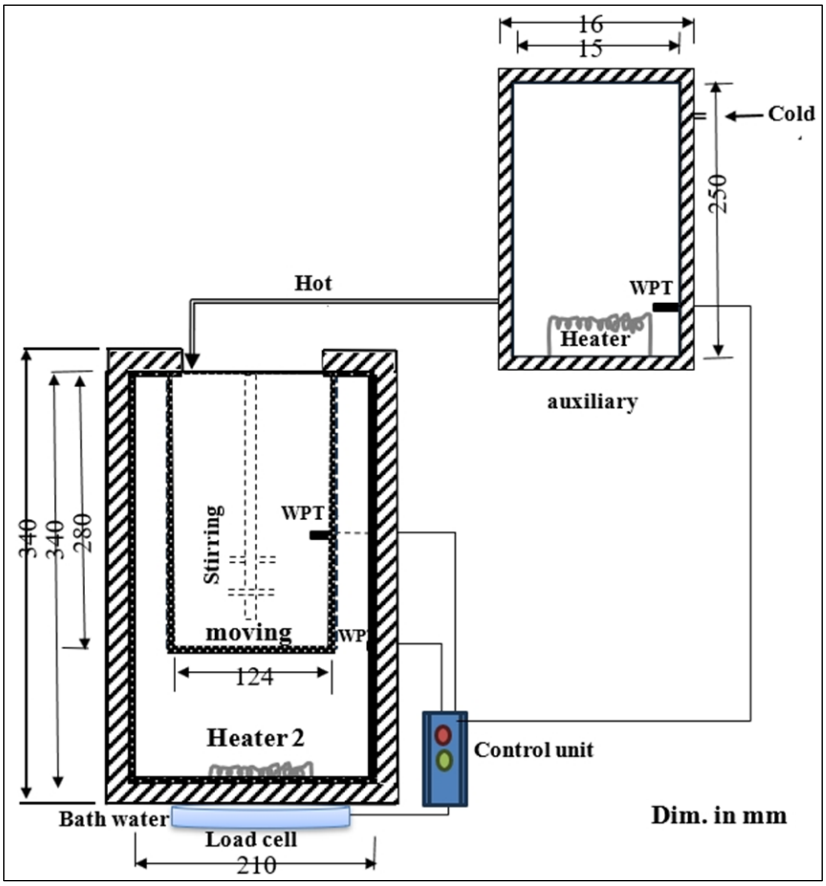

Fig. 1. Schematic diagram of date juice Extraction system.

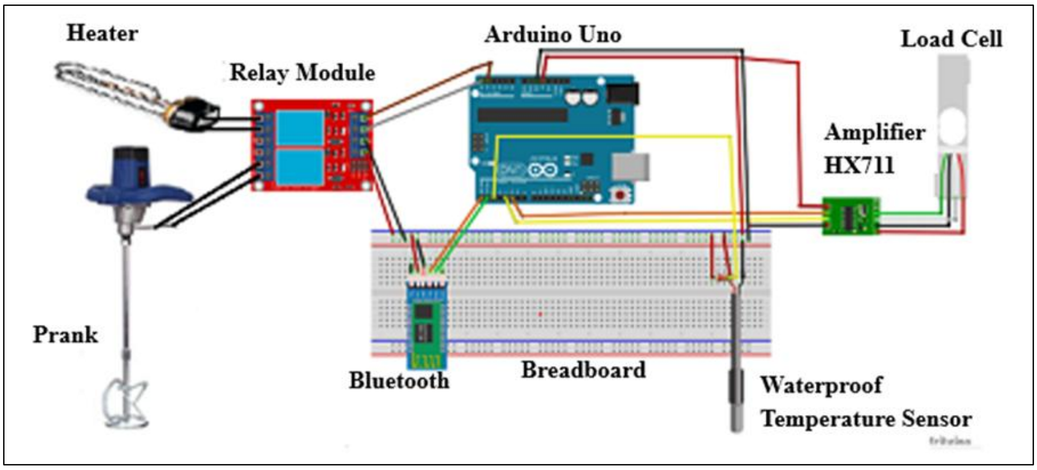

Fig. 2. Circuit diagram for automatic control temperature date juice extraction.

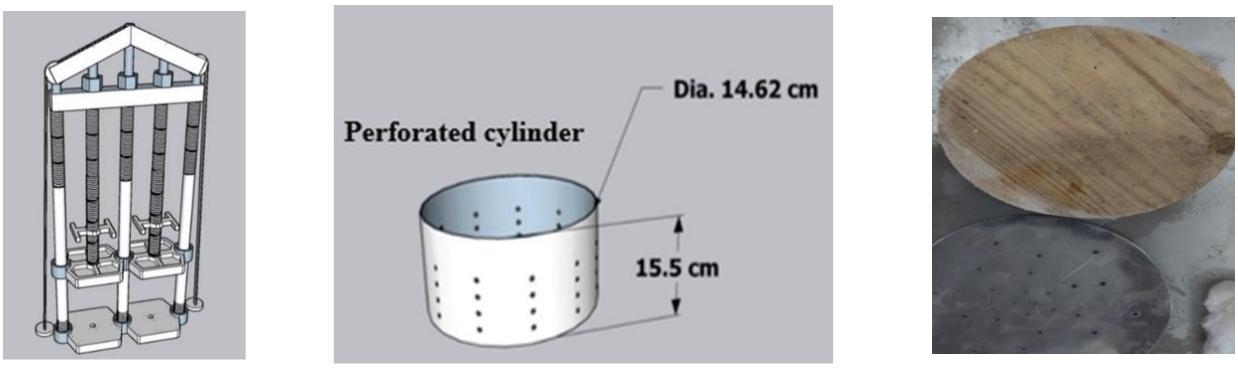

Fig. 3. Hand press unit.

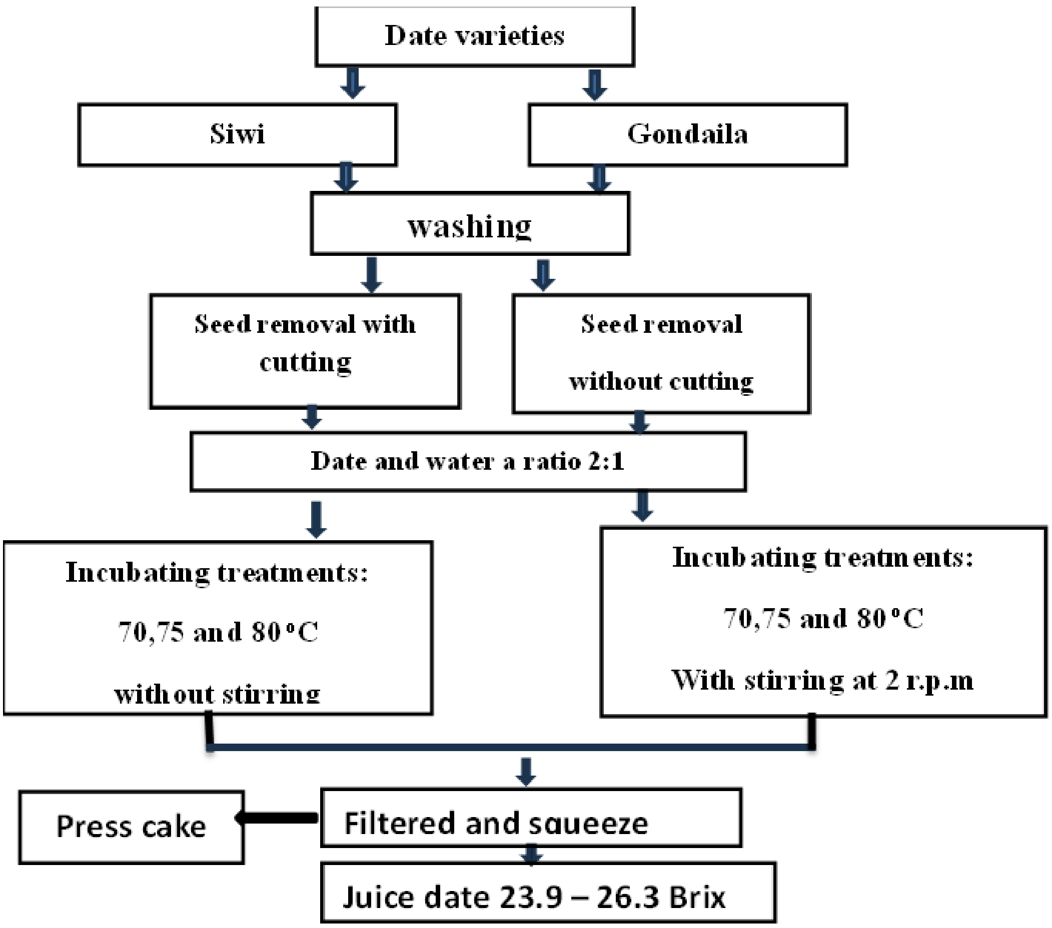

Fig. 4. Schematic diagram for date juice extraction.

4. Preparing the extraction system by placing the water bath on a sensitive balance to calculate the amount of water added during the experiment.
5. The inner pot is the date pulp resulting from step 3, which is added by a ratio of 2:1. According to Morsy, 2022), it was devised in three different incubation temperatures of 70. 75, and 80 °C.
6. The treatment of the mixture resulting from step 5 by stirring using a mechanical mold or without stirring with adjusting the degree of water bath (72, 77, and 82 °C) as an experimental variable.
7. Separation and termination of the experiment after the mixture reaches a certain equal weight in all samples.
8. Filtration process.

The experimental variables of the extraction process for both varieties (Siwi, Gondaila) cut and without cutting, mixed, and stirring for the two studied varieties at different incubation temperatures of 70, 75, and 80 °C is shown in Table 2.

2.3.2. *The moisture content*

The moisture content of randomly selected date fruits was measured by drying in an air oven at 70 °C (Ragab, 2011**)** until a constant weight of samples. The moisture content was calculated as follows (Kacem-Chaouche et al., 2013).

$$MC = \frac{M_{wet} - M_{dry}}{M_{wet}} \times 100 \quad \ldots\ldots\ldots \ (w, b\%) \qquad \ldots [1]$$

where: MC: is the moisture content (w.b%)
M_{wet}: is the wet mass (g)
M_{dry}: is the dry mass (g)

Table 2
The experiment variables.

Experiment variables	varieties Siwi	varieties Gondaila
Without cutting and without stirring	Ts11	Tm11
Cutting and without stirring	Ts21	Tm21
Without cutting and stirring	Ts31	Tm31
Cutting and stirring	Ts41	Tm41

2.3.3. Energy efficiency calculations for the extraction process

2.3.3.1. Electrical energy available

Energy consumption by the heater is measured by using an equation according to (**Siddeeg et al., 2019):**

$$Q_i = Pt = V\,I\,t \quad \ldots [2]$$

where: Q_i: is energy available (kJ)
P: is electrical power available (kW)
V: is voltage, Volts
I: is current, Amaper
T: is time operating, seconds

2.3.3.2. Absorbed heat energy

The energy absorbed by water from the heater:

$$Q_a = Q_u + Q_g = Q_s + Q_l + Q_g \quad \ldots [3]$$

where: Q_a: is the energy absorbed by water from the heater (kJ)
Q_u: is Useful heat energy gain mixture (kJ)
Q_g: is the energy heat stored in water (kJ)
Q_s: is Sensible heat energy absorbed (kJ)
Q_l: is Latent heat energy absorbed (kJ)

Useful heat energy gain of juice it is considered heat required for cooking:

$$Qu = m_m\,C_{p_m}\,\Delta T + m_v l_f \quad \ldots [4]$$

where: m_m: is mass of mixture (kg)
c_{p_m}: is Specific heat of the mixture (kJ/kg. ^{o}k)
ΔT: is different temperature water, mixture before and after heating (^{o}C)
m_v: is the mass of water evaporated (kg)
L_f: is Latent heat of evaporated water (2560 kJ/kg)

2.3.3.3. Energy heat stored in water

$$Q_g = M_w C_{pw}\,\Delta T_w \quad \ldots [5]$$

where: M_w: is the mass of water (kg)
C_{pw}: is the specific heat of the water (kJ/kg.^{o}k)
ΔT_w: is Different temperature of water before and after heating water (^{o}C)

2.3.4. Absorption efficiency calculations

In present study thermal energy efficiency was calculated by using equations according to Hosainpour et al. (2014), which were used as follows:

$$\eta_a = \frac{Q_a}{Q_i} \times 100\% \quad \ldots [6]$$

Heat transfer efficiency calculations:

$$\eta_h = \frac{Q_u}{Q_a} \times 100\% \quad \ldots [7]$$

Overall system efficiency calculations "η_o":

$$\eta_o = \frac{Q_u}{Q_i} \times 100\% \quad \ldots [8]$$

2.3.5. Determination of water removed

Water evaporated in an evaporator was calculated using brix of entering juice and the syrup leaving the system, using mass balance according to Chen, (1993).

$$W_2 = \frac{W_1 \times B_1}{B_2} \quad \ldots [9]$$

$$E = W_1 - W_2 = W_1 \times \left(1 - \frac{B_1}{B_2}\right) \quad \ldots [10]$$

where: B_1: is brix of clear juice entering (%).
B_2: is brix of dibs leaving (%).
W_1: is mass of clear juice date (kg).
W_2: is mass of dibs (kg).
E: is water removed (kg).

2.3.6. Total soluble solids **(T.S.S)**

Total soluble solids (T.S.S) are determined using a digital refractometer; their scale is 0-100, measurement according to the AOAC (2010).

2.3.7. The **pH** *value*

The pH values were measured by using a Systolic 324- combination glass electrode pH meter at 25°C according to the AOAC (2010).

2.3.8. Color

Color was measured as the optical density (OD) of the diluted extract (5% T.S.S), and the absorbance at 420nm was measured using a Perkin Elmer Lambda-UV/VIS spectrophotometer (Abdel-Aleem, 2020).

2.3.9. Sugars content

Sugar content (sucrose and reducing sugar) was evaluated for all studied treatments according to AOAC (2010). Non-reducing sugars were calculated by difference.

2.3.10. Ash content

Ash content was determined as described by AOAC (2010) using a muffle furnace at 550°C.

2.3.11. Best fit empirical equation

Linear regeneration analysis could be used to optimize values of empirical equation parameters through equations (11-12) using Microsoft Office Excel version (2016). The suitability of empirical models fitting the experimental data can be evaluated and compared using the determination coefficient (R^2) and chi-square (x^2) as described by Rabha et al. (2017).

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\left(y_{bre,i} - y_{obs,i}\right)^2}{\sum_{i=1}^{N}\left(\bar{y}_{bre,i} - y_{obs,i}\right)^2} \qquad \text{... [11]}$$

$$X^2 = 1 - \frac{\sum_{i=1}^{N}\left(y_{bre,i} - y_{obs,i}\right)^2}{N - n} \qquad \text{... [12]}$$

3. Results and discussions

3.1. The effect of different temperatures and mechanical treatments on heating elapsed time:

Linear regression analysis was preceded to optimize the relationship between three different temperatures studied 70, 75 and 80 oC and elapsed extraction time for both studied varieties. Fig. 5 showed that linear relationships were satisfied for different treatments and varieties of the form:

$$y = AX + B$$

It is clear that there is a direct proportion between elapsed time and extraction temperature for all varieties studied. While elapsed time is decreased as mechanical treatments introduced cutting or stirring, combined cutting and stirring for all studied varieties, assuming uncutting and unstirred is considered as control treatment.

Table 3 shows the parameters of the empirical equations for all thermal and mechanical treatments of both studied varieties. The predicted time is changed from 70, 75 and 80 °C with respect to control for cut, stirring and combined treatments 0.03, 0.37, 0.54 minutes and 0.6. 1.04, 1.69 with a rate of 0.338, 0.372, 0.389 and 0.381, 0.425, 0.490 min / °C change, and the coefficient of determination R^2 and chi-square X^2 are ranged between 0.8671 - 0.9998, 0.0003 - 0.0377 and 0.9061 – 0.9761 and 0.00135 – 0.0339, for Siwi Gondaila respectively, The rate of change of Gondaila is large that of Siwi variety which may be related to their chemical composition which in turn affect their insulation characteristics as thermal conductivity of 0.68 W/m. K and dielectric characteristics agree with Al-Mahasneh and Rababah (2017).

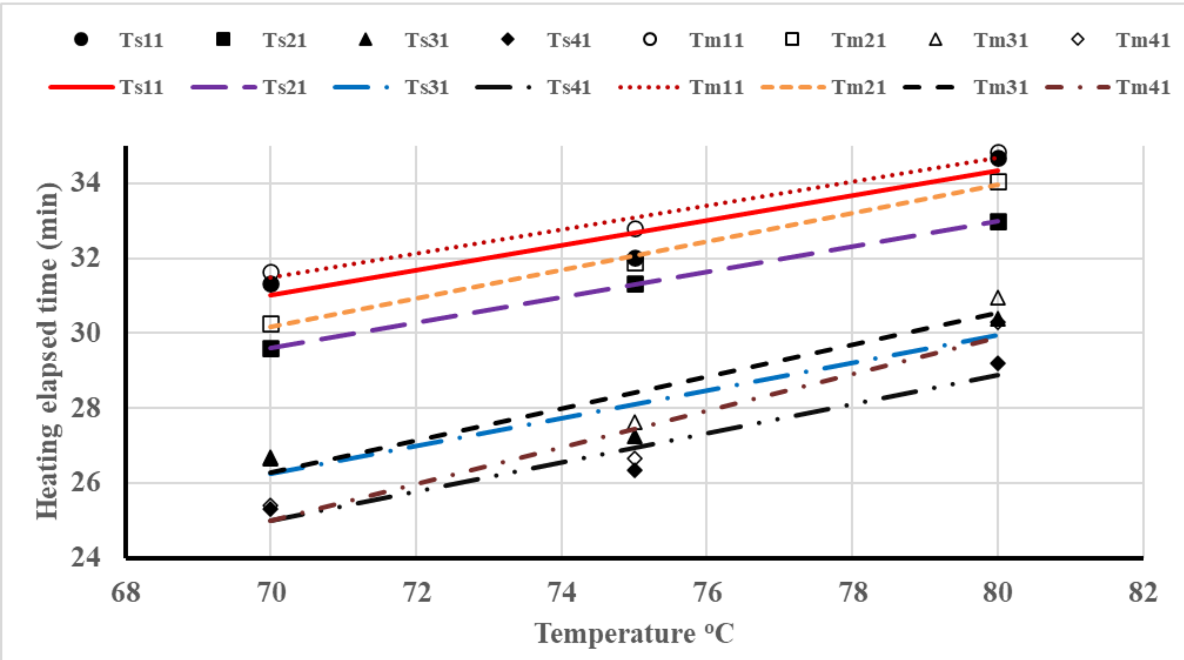

Fig. 5. Elapsed extraction time affected by thermal and mechanical treatments.

Table 3
Empirical equations parameters.

Mechanical treatments	Varieties date	Symbol	Constant A	Constant B	X^2	R^2	Remarks
Without cutting and without stirring	Siwi	Ts11	0.335	7.548	0.02021	0.9848	Control
	Gondaila	Tm11	0.321	9.015	0.00381	0.9761	
Cutting and without stirring	Siwi	Ts21	0.338	5.953	0.00003	0.9998	cutting only
	Gondaila	Tm21	0.381	3.495	0.00135	0.9941	
Without cutting and stirring	Siwi	Ts31	0.372	0.2	0.0377	0.8671	stirring only
	Gondaila	Tm31	0.425	-3.455	0.00135	0.9061	
Combine cutting and stirring	Siwi	Ts41	0.389	-2.225	0.02074	0.9313	Combine cutting and stirring
	Gondaila	Tm41	0.49٠	-9.303	0.03391	0.9282	

3.2. The effect of thermal and mechanical treatments on date juice Brix

Fig. 6 shows that linear relationships between date juice Brix affected thermal and mechanical treatments. The same trend is recorded for empirical equations as in the previous item. Table 4 shows empirical equations parameters for all studied thermal and mechanical treatments. The predicted Brix of filtered date juice has a lower thermal conductivity than that of mixture 0.55 W/m. K, (El-Samahy and Youssef, 2009). It is changed within the range of temperature changes between 70 ºC to 80 ºC concerning control of cut, stirring and combined treatments 0.3, 0.35, 0.2 and 0.2, 0.1, 0, Brix, with a rate of 0.04, 0.035, 0.05 and 0.05, 0.02, 0.03 Brix / ºC, the coefficient of determination (R^2) and chi-square (X^2) are ranged between, 1.0 – 0.9423, 0 – 0.00006 and 1.0 – 0.096, 0 – 0.000068 for Siwi and Gondiala treatments respectively.

3.3. Effect of mechanical treatments on Energy efficiency as affected by temperatures

Fig. 7 shows that thermal and mechanical treatments affect linear energy efficiency relationships. The same trend is recorded for empirical equation as in previous items. Table 5 shows empirical equations parameters for all studied thermal and mechanical treatments. The energy efficiency predicted is changed linearly within the studied ranges of temperature from 70 ºC to 80 ºC concerning control treatment for cut, stirring and combined treatment by 1.22, 4.63, 8.41 and 1.49, 4.21, 9.29% with a rate of 1.807, 1.312, 0.943 and 1.824, 1.254, 0.78 % /ºC, the coefficient of determination (R^2) and chi-square (X^2) are 0.99 – 0.95, 0.132 – 0.022 and 0.99 - 0.97, 0.29 - 0.002 for Siwi and Gondiala treatments respectively. The Siwi dates juice has a lower efficiency than the of Gondiala, which may be due to their lower thermal conductivity.

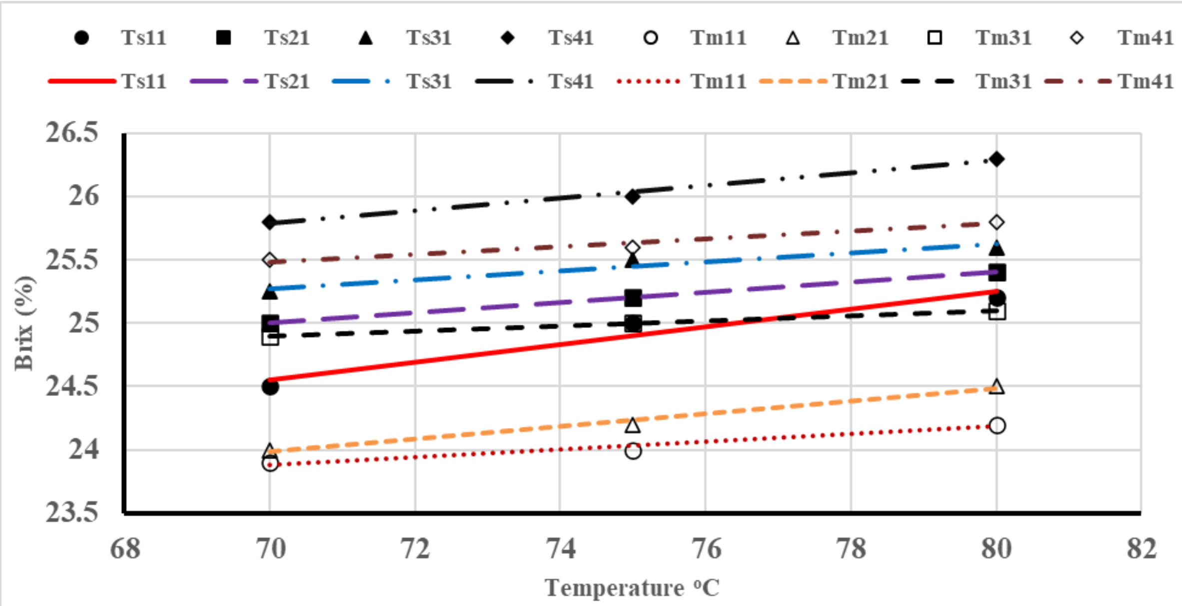

Fig. 6. Date juice brix as affected by thermal and mechanical treatments.

Table 4
Empirical equations parameters

Mechanical treatments	Varieties date	Symbol	Constant		X^2	R^2	Remarks
			A	B			
Without cutting and without stirring	Siwi	Ts11	0.070	19.65	0.000602	0.9423	Control
	Gondaila	Tm11	0.030	21.783	0.000069	0.9643	
Cutting and without stirring	Siwi	Ts21	0.040	22.2	0	1	cutting only
	Gondaila	Tm21	0.050	20.483	0.000068	0.9868	
Without cutting and stirring	Siwi	Ts31	0.035	22.825	0.000147	0.9423	stirring only
	Gondaila	Tm31	0.020	23.5	0	1	
Combine cutting and stirring	Siwi	Ts41	0.050	22.283	0.000069	0.9868	Combinel cutting and stirring
	Gondaila	Tm41	0.030	23.383	0.03391	0.9282	

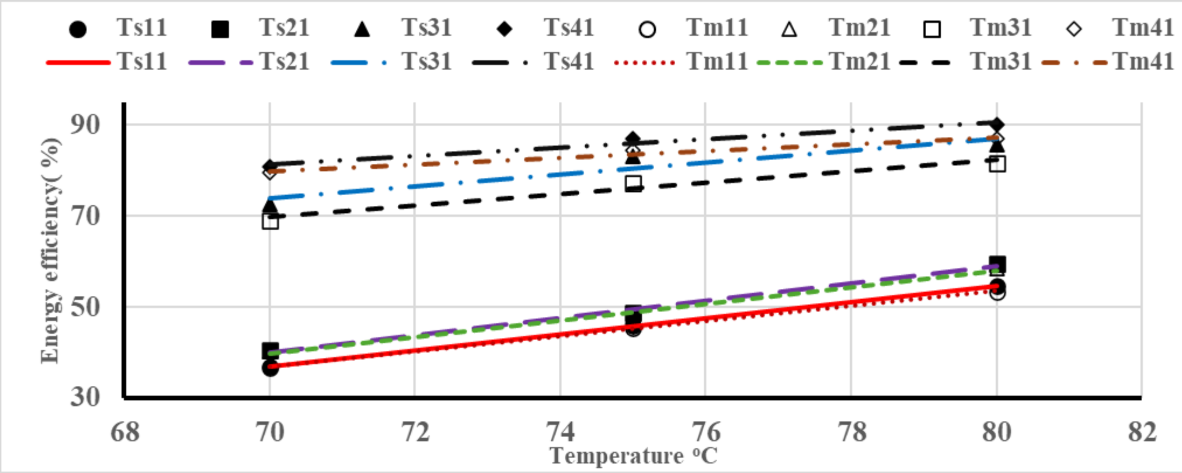

Fig. 7. Effect of mechanical treatments on Energy efficiency as affected by temperatures.

Table 5
Empirical equations parameters.

Mechanical treatments	Varieties date	Symbol	Constant A	Constant B	X^2	R^2	Remarks
Without cutting and without stirring	Siwi	Ts11	1.775	-87.282	0.000309	0.9999	Control
	Gondaila	Tm11	1.675	-80.448	0.0023	0.9993	
Cutting and without stirring	Siwi	Ts21	1.807	-92.688	0.02248	0.9939	cutting only
	Gondaila	Tm21	1.824	-87.973	0.00232	0.9913	
Without cutting and stirring	Siwi	Ts31	1.312	-17.987	0.1329	0.8897	stirring only
	Gondaila	Tm31	1.254	-18.023	0.0302	0.9727	
Combinel cutting and stirring	Siwi	Ts41	0.934	15.947	0.02322	0.9563	Combinel cutting and stirring
	Gondaila	Tm41	0.78	27.73	0.02911	0.9743	

3.4. Effect of thermal treatments on juice quality

Table 6 shows that the sugar of both studied varieties is increased by increasing treating temperatures. The ash percent decreased as the treating temperature increased for both studied varieties. The decreasing ash percent in the juice of both varieties is due to the squeezing and filtration process. The PH percent increases as the treating temperature increases for both studied varieties. The increasing PH percent in the juice of both varieties could be explained by the fact that potassium is one of the most abundant mineral compounds in dates (Ibrahim et al., 2001). Using a heating temperature of 70 – 80 °C caused good results for the color of extracted juice but also increased the total sugar (Kadlezir et al., 2024).

The quality of extracted date juice showed good results for PH, Ash, total sugar, reduced sugar, non-reduced sugar and color. Temperature change does not affect quality, which may be interpreted by their lower mal conductivity of 0.55 W/m. K (El-Samahy and Youssef, 2009), so thermal treatment of 80 °C could be used for higher efficiency and to reduce extraction time.

4. Conclusions

The extraction process plays a major role in dibs production; juice extracted from dates could be optimized with combined thermal and mechanical treatments. Carefully selecting and combining thermal and mechanical treatments could serve to optimize juice extraction while preserving the quality and flavor of the final product. In the present work, two varieties of dates were studied, mainly Siwi and Gondaila date juice was a hot extracted using different mechanical treatments mainly cutting, without cutting, stirring and without stirring under different temperatures of 70, 75, and 80 °C to be adaptable for future work on a solar heat exchange system for dates. Results could be summarized as follows:

1. The results showed the empirical equations for both studied varieties' thermal and mechanical treatments. The predicted time is changed from 70, 75 and 80 °C concerning control for cut, stirring, and combined treatments 0.03, 0.37, 0.54 minutes and 0.6, 1.04, 1.69 with a rate of 0.338, 0.372, 0.389, and 0.381, 0.425, 0.490 min/°C change, and the coefficient of determination R^2 and chi-square X^2 are ranged between 0.8671 -

0.9998, 0.0003 - 0.0377 and 0.9061 – 0.9761 and 0.00135 – 0.0339, for Siwi Gondaila respectively.

2. The predicted Brix of filtered date juice has a lower thermal conductivity than that of mixture 0.55 W/m. K**.** It is changed within the range of temperature changes between 70 ºC to 80 ºC concerning control of cut and stirring. Combined treatments 0.3, 0.35, 0.2 and 0.2, 0.1, 0, Brix, with a rate of 0.04, 0.035, 0.05 and 0.05, 0.02, 0.03 Brix / ºC, the coefficient of determination (R^2) and chi-square (X^2) are ranged between, 1.0 – 0.9423, 0 – 0.00006 and 1.0 – 0.096, 0 – 0.000068 for Siwi and Gondiala treatments respectively.

3. The energy efficiency predicted is changed linearly within the studied ranges of temperature from 70 ºC to 80 ºC concerning control treatment for cut, stirring and combined treatment by 1.22, 4.63, 8.41 and 1.49, 4.21, 9.29% with a rate of 1.807, 1.312, 0.943 and 1.824, 1.254, 0.78 % / ºC, the coefficient of determination (R^2) and chi-square (X^2) are 0.99 – 0.95, 0.132 – 0.022 and 0.99 - 0.97, 0.29 - 0.002 for Siwi and Gondiala treatments respectively. The Siwi dates juice has a lower efficiency than the Gondiala, which may be due to its lower thermal conductivity.

4. The sugar of both studied varieties is increased by increasing treating temperatures. The ash percentage decreased as the treating temperature increased for both studied varieties. The decreasing ash percent in the juice of both varieties is due to the squeezing and filtration process. The PH percent has increased as treating temperature increases for both studied varieties.

5. So, a thermal treatment of 80 ºC could be used for higher efficiency and to reduce extraction time.

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تأثير المعاملات الحرارية والميكانيكية على استخلاص عصير التمر

حسين عبده قاسم محمد [١]، طارق حسين مصطفي غانم [٢] ، محمد محمد إبراهيم بدر [٢]، محمود حسن علي حسن [١]

[١] قسم هندسة تصنيع المنتجات الزراعية، كلية الهندسة الزراعية، جامعة الأزهر، أسيوط، مصر.
[٢] قسم هندسة تصنيع المنتجات الزراعية، كلية الهندسة الزراعية، جامعة الأزهر، القاهرة، مصر.

الملخص العربي

نخيل التمر (*Phoenix dactylifera L.*) هو أحد أقدم أنواع الفاكهة التي تلعب دورًا رئيسيًا في الحياة المصرية. زاد الإنتاج العالمي للتمور بشكل ملحوظ خلال العقود الثلاثة الماضية. من ناحية أخرى، تلعب عملية الاستخلاص دورًا مهمًا في إنتاج الدبس. يمكن تحسين استخلاص العصير من التمور والاستفادة منه خلال دمج المعاملات الحرارية والميكانيكية. وقد يساعد الاختيار الدقيق والجمع بين هذه المعاملات في تحسين عملية استخلاص العصير مع الحفاظ على الجودة والنكهة في المنتج النهائي. تم دراسة نوعين من التمور، السيوي (Siwi) والجنديلة (Gondaila)، تم استخلاص عصير التمر باستخدام طرق حرارية مختلفة ومعالجات ميكانيكية متنوعة، بما في ذلك التقطيع وعدم التقطيع، والتقليب وعدم التقليب، وذلك عند درجات حرارة مختلفة ٧٠ ، ٧٥ و٨٠ درجة مئوية، مما يجعل هذا النظام قابلاً للتطبيق في النظم الكهرو حرارية الشمسية لتركيز عصائر التمور.

وقد تم تلخيص هذه الدراسة كالآتي:

تم اختيار المعادلة المثلى عن طريق أقل قيمة لمربع كاي (χ^2) وأعلى معامل تحديد (R^2) تم تقييم الزمن، البريكس (Brix)، كفاءة الطاقة، والجودة. تم استنباط معادلات تجريبية خطية لجميع المعاملات الحرارية والميكانيكية محل الدراسة.

١. أظهرت النتائج تغيير الزمن المتوقع عند درجات حرارة ٧٠، ٧٥ و٨٠ درجة مئوية مقارنةً بعينة التحكم للمعاملات الثلاثة: التقطيع، التقليب، والمركبة (التقطيع مع التقليب)، حيث كانت القيم ٠,٠٣، ٠,٣٧، ٠,٥٤ دقيقة و٠,٦، ١,٠٤، ١,٦٩ دقيقة، بلغ معدل زيادة الوقت ٠,٣٣٨، ٠,٣٧٢، ٠,٣٨٩ و٠,٣٨١، ٠,٤٢٥، ٠,٤٩٠ دقيقة لكل درجة مئوية. أما معامل التحديد R^2 ومربع كاي X^2 فقد تراوحت قيمهما بين ٠,٨٦٧١ - ٠,٩٩٩٨ و٠,٠٠٠٣ - ٠,٠٣٧٧، و٠,٩٠٦١ – ٠,٩٧٦١ و٠,٠٠١٣٥ – ٠,٠٣٣٩، للصنفي السيوي والجنديلة على التوالي.

٢. البريكس (Brix) المتوقع لعصير التمر المصفى موصلية حرارية أقل من الخليط٠,٥٥ وات /م كلفن وتم دراسة تغييره ضمن مدي التغيرات في درجات الحرارة بين ٧٠ درجة مئوية إلى ٨٠ درجة مئوية فيما يتعلق بالتحكم في التقطيع والتقليب والمركبة ٠، ٠,١، ٠,٢، ٠,٢ و٠,٣٥، ٠,٣ بريكس، بلغ معدل تغير البريكس ٠,٠٣، ٠,٠٢، ٠,٠٥ و٠,٠٥، ٠,٠٣٥، ٠,٠٤بريكس /درجة مئوية، يتراوح معامل التحديد (R^2) ومربع كاي (X^2) بين، ١,٠ – ٠,٩٤٢٣، ٠ – ٠,٠٠٠٠٦، ١,٠ – ٠,٠٩٦، ٠ – ٠,٠٠٠٠٦٨ للصنفي السيوي والجنديلة على التوالي.

٣. تم دراسة تغيير كفاءة الطاقة المتوقعة بشكل خطي ضمن نطاق درجات الحرارة المدروسة من ٧٠ إلى ٨٠ درجة مئوية مقارنةً بمعاملة التحكم، حيث كانت القيم ١,٢٢ ، ٤,٦٣ ، ٨,٤١٪ و ١,٤٩ ، ٤,٢١، ٩,٢٩٪ للمعاملات القطع، التقليب، والمُركبة على التوالي، بمعدلات تغيير قدرها ١,٨٠٧، ١,٣١٢، ٠,٩٤٣ و١,٨٢٤، ١,٢٥٤، ٠,٧٨٪ / درجة مئوية أما معامل التحديد (R^2) ومربع كاي (X^2) فقد تراوحت قيمهما بين ٠,٩٥ – ٠,٩٩ ، ٠,٠٢٢ – ٠,١٣٢ و ٠,٩٧ – ٠,٩٩ / ٠,٠٠٢ – ٠,٢٩ للصنفي السيوي والجنديلة على التوالي يتميز عصير تمر سيوي بكفاءة طاقة أقل مقارنةً بعصير تمر جنديلة.

٤. لوحظ انه تم زيادة اجمالي السكريات في كلا الصنفين المدروسين عن طريق زيادة درجات حرارة المعاملة وانخفضت نسبة الرماد مع زيادة درجة حرارة المعاملة لكلا الصنفين المدروسين .وزادت نسبة الأس الهيدروجيني مع زيادة درجة حرارة المعالجة لكلا الصنفين المدروسين

يمكن استخدام المعاملة الحرارية ٨٠ درجة مئوية لزيادة الكفاءة وتقليل زمن الاستخراج.