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DESIGN AND MANUFACTURE OF A LOCAL DATE PITTING MACHINE TO PRODUCE DATE PASTE (AGWA)

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ABSTRACT

Date fruits are considered one of the greatest sources to provide a concentrated energy food. It's also used in producing many industrials products. The flesh dates are utilized for many purpose of making sweets, preserves, condiments, breakfast foods, desserts, derived date products, confectionery, baking products, institutional feeding and health foods. To produce these products with date paste, the date pits should be manually or mechanically removed.

For the sake of industrial requirements to produce date paste (AGWA) from semi dried date fruits especially the Egyptian common variety (siwi variety) in maturity mode (tamr), a roller date pitting machine has been designed, constructed and experimented to evaluate it's performance under the designed operating conditions. The tested operating parameters were five levels of rotating speed (40, 60, 80, 100, and 120 rpm), five levels of (P/D) pitch/diameter ratio (1, 1.3, 1.6, 1.9, and 2.2), and three levels of clearances between the two drums (0, 1, and 2 mm). It was evaluated based on the machine productivity, machine efficiency, energy requirement and operating cost.

Some physical and mechanical properties for the investigated fruits and their pits (Siwi variety) were studied such as; (dimensions, mass, density, friction angle between date and stainless steel sheet, and force required for strip the date pit.).

The obtained results indicated that the average values of the physical and mechanical properties of the fruit were 34.12mm, 20.96mm, 19.61mm, 10.98g, 9.40g, 1.59g, 0.6545g/cm3, 24.65cm, 10.94mm, 9.56mm. for fruit length, width, thickness, mass, flesh mass, seed mass, bulk density, pit length, width, and thickness. The pit take-off force was found to be 48.90 N, and the friction coefficient between dates and stainless steel surfaces was 0.67 .

The most important results can be concluded as: The highest machine productivity (423 kg/h) with the optimum machine efficiency (86.6 %) by using the pitting machine with drum speed of 80 rpm, with 1.6 P/D ratio, and drums clearance of 1 mm. The energy consumed to pit one ton of date with manual pitting is about 10.69 kW.h/ton. While, the energy required for the designed pitting machine was recorded as 3.47 kW.h/ton. The operating costs for the designed date pitting machine was 29.50 LE/ton, whereas the manual date pitting cost is about 178.57 LE/ton.

INTRODUCTION

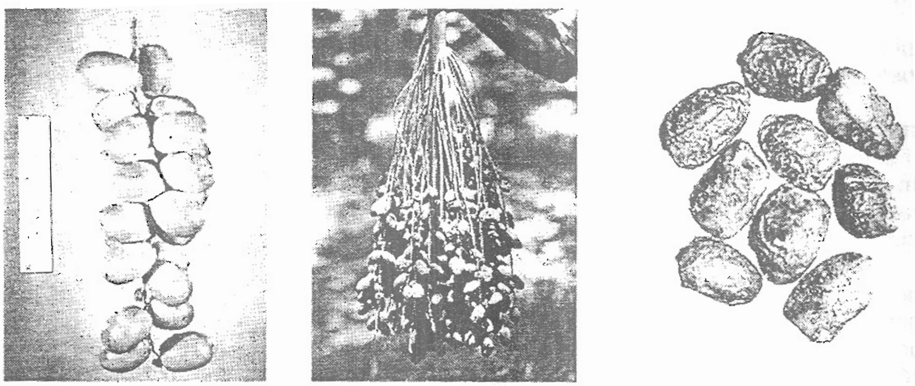
Egypt is considered one of the greatest countries all over the world for producing date palm. In Egypt the productivity of date palms in year 2002 is about 1.2 million Mg (ton) produced from 10.4 million palm trees which were planted in 73.6 thousand feddans. (Baday *et al.*, 2003).

Sawaya *et al.* (1986) mentioned that in the ancient date production countries the date has been used more as a sugar source than as a fruit. Water is boiled with dates to make tea, the nomads boil milk with dates, or they are simply chewed to obtain daily calorie intake (a date of 20% moisture content will provide about 12552 kJ/kg date flesh, for the greatest part derived from its sugar content).

For practical purposes all sugars in dates consist of a mixture of sucrose ($C_{12}H_{22}O_{11}$), glucose ($C_6 H_{12} O_6$) and fructose ($C_6 H_{12} O_6$) of which the latter two are the derivations of sucrose after inversion. Total sugars (at the tamr stage) on a dry weight basis for the more known varieties in the world do not appreciably differ in quantity

Moustafa *et al.* (1989) reported that whole dates are harvested and marketed at three stages of their development. The choice for harvesting at one or any other stage depends on varietal characteristics, climatologically conditions and market demand as shown in Fig. (1). the three stages are described as follow:

- <u>(sweet) khalaal</u>: dates, physiologically mature, hard and crisp, around 50% moisture content and over, bright yellow or red in colour, perish-able.
- <u>rutab</u>: partially or wholly browned, reduced moisture content (average 30-35%), fibres softened, succulent flesh, perish-able.
- <u>tamr</u>: colour from amber to dark brown, bluish or almost black, moisture content further reduced (below 25% down to 10% and less), texture from soft and pliable to firm, to hard, it can be used in a wide range of industrial



Khalaal(Sweet) Rutab Tamer to produce Agwa

Fig. 1: Three Major Stages of Maturity in which Dates are Consumed.

Due to the high nutrient value of date palm fruits, the manufactories were established for packing and compressing them in different shapes and manners. The dates are generally expected to contain pits, but the dates for cooking and some manufacturing processes, or for bakery and sweets have to be pitted (Oassey and Attijarat, 1991).

Barreveld (1993) mentioned that date pits, also called pips, stones, kernels, or seeds form part of the integral date fruit in the order of, depending on variety and quality grade, 6-12% of its total weight in the <u>tamr</u> stage (Fig.2). They become available in concentrated quantities when pitted dates are produced in packing plants or in industrial date processing plants based on juice extraction. In the latter case they may still be mixed with the exhausted press cake or they have been screened out in the process. At the rural level one may find some accumulation of date pits when immature dates are pitted before sun drying (e.g. on the coast of Libya) or countries where dates are pitted and preserved as a paste (Agwa). For the rest, date pits follow the dispersed ways of distribution routes of the whole fruit and have no importance as an individual raw material.

Fig. 2: Date pits

Khairy and Attalla (1995) reported that the inclination of side wall and other surfaces of delivery hoppers should be greater than 35° to insure the free falling of date fruits. The pit take-off force and rigidity may be greatly affected by the cultivars and slightly by moisture content and total sugar percentage.

Ismail (1996) reported that the mean force of date pitting of all types was found to be 16.6 kg for no cutting method while it was 12.42 kg for cutting 1/2 cm-layer from the date cap. Cutting a 1/2 cm layer from the date cap was much better than from date tail where cutting the date cap reduced the pitting force by about 17.8 % to 46.9 %.

Ibrahim (1987) studied the feasibility of using the rubber husker machine in shelling Egyptian peanuts. The machine was used under different clearances, speeds and moisture contents for peanuts. It was found that the rubber roller husker machine provides satisfactory levels of Egyptian peanuts.

Singh (1982) described the rubber rolls which can be used for husking paddy. It was stated that the rolls are mounted on two horizontal shafts of paddy husker. One shaft has a fixed position while the other is adjustable to obtain desired clearance between the pair rolls which are driven mechanically in opposite direction with differential speeds. When the paddy kernels are fed between the rolls, they are caught under pressure by the rolls.

In Egypt dates are commonly pitted manually, while the manual pitting gives the lowest productivity of pits left by mistake among the pitted dates, nevertheless; very careful checking is necessary. Manual pitting is also more expensive than mechanical pitting. The mechanical pitting, however, existed in the food factories are not working properly and suffer many problems. Design a mechanical pitting machine from local materials will help for increasing farmer income in additional to increase the quality of pitted date paste (Agwa). Therefore, the aims of the present studying are summarized in the following points:

1- Study some physical and mechanical properties of the whole fruit dates and their pits for the investigated Egyptian common variety used to produce Agwa (Siwi variety).
2- Establish a parametric study required for designing and constructing a date pitting machine.
3- Design and fabricate a suitable local simple pitting machine according to the previously measured properties.
4- Study the most operating factors to overcome the problems of manual pitting as well as the mechanical pitting
5- Evaluation the pitting machine performance as influenced by five levels of drum speeds, five levels of pitch diameter ratio, clearance between drums.

MATERIAL AND METHODS

1. Materials:

To achieve the aims of the present study the experiments were carried out using the most common variety of semi dried date palm in Egypt (Siwi variety at 18.39 % MC w.b.), which represents 78 % of the semi dried varieties used for producing date paste (Agwa).(Rizk and EL-Sharabasy, 2006).

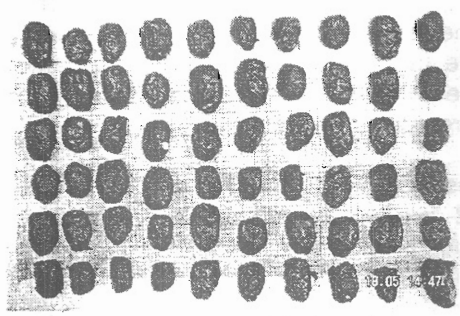


Fig. 3: the tested siwi variety.

1.1. Physical and mechanical properties of dates:

For the sake of clarity 100 date fruits were taken from Siwi variety at 18.39% moisture content and examined. The dimensions of fruits and their pits were studied in terms of (length, width, and thickness), using a digital vernier caliper with an accuracy (± 0.05 mm).

The volumes of date fruit and pit were measured by immersing the sample in a checked cylinder filled up with water, and the displaced volume of water was recorded. The mass of date fruit and pit were measured by an electrical digital balance with ± 0.01 g accuracy.

The angle of friction between date fruits and stainless steel surface was measured by inclination-plate method.

Moisture content of date fruit samples were measured by drying date in a natural air oven for 72 hours at 103 °C, (Nelson, 1980).

The force required for pit take-off was measured by using the digital force gauge with accuracy 0.2 %. The date was placed in a wooden claw which can be adjusted by side levers that move toward the inside or outside to hold the date below the digital force gauge. This claw is placed on a holed plate to pass the date pit downward. Dates were placed into a claw and adjusted laterally until its cap become below the force gauge. Force was then increased gradually until pitting occurred. The maximum recorded force is the required force for pit take-off.

2. Pitting machine:

The designed machine as shown in Fig. (4) consists of a structure of steel frame, feeder tank made from galvanized sheet 2 mm thick and it has a hopper with a shutter to control the flow rate. It also has two stainless steel roller drums (110 cm long, and 16 cm diameter) with different numbers of grooved spirals to apply enough force for stripping date flesh and collecting the pits into one side of the drums, the numbers of spiral groove attributed to the relation between pitch of the spiral and diameter of the drums. An adjustable spring pressure were used for holding the two drums together, therefore they used to control the variable clearances between the two drums.

A variable speed electric motor of 10 hp (7.35 kW) used to supply power to the rotating drums. The power transmission system consists of (sprockets and chain) used to transfer the power from the motor to the driver drum, and the gears to transfer the reverse motion from the driver drum to the driven drum.

Two long knifes (110 cm long × 5 cm wide ×1 cm thick with a sharp edge) were supported under the two drums in a tangential position at the sharp edges, the sharp edges of the knifes used to clean the drums from the stripping flesh date after separating the pits, the obtained date paste (Agwa) drop down intc the receiver sliding tray, It was made from 2 mm stainless steel sheet supported to the frame with angle of 25 deg. under the roller as shown in Fig. 4.

3. Design Consideration:

In order to design, construct, and test the proposed pitting machine for producing date paste (Agwa), the following theoretical analysis was performed to study the behavior of the acting forces on date fruit and it's pit during pitting operation to describe the mechanism of pitting process and to estimate the different design factors such as: (diameter of pitting drums, the suitable peripheral speed of drums, and to study the relation between different Pitch/Diameter ratios and the number of pit removal spiral) as follow:

3.1. Determination diameter of pitting Drums:

Figure (5) indicates that the forces acting between the date fruit (S) and the two rotating drums (A & B), may be expressed as follows:

$2 F \sin\theta \geq 2 N \cos\theta + P$ ....(1)

$F = \mu N$ ....(2)

Where:

F = Frictional force between date and drums.

μ = Coefficient of friction between date and drums.

N = Drum reaction normal force.

P = The force required for pit take-off

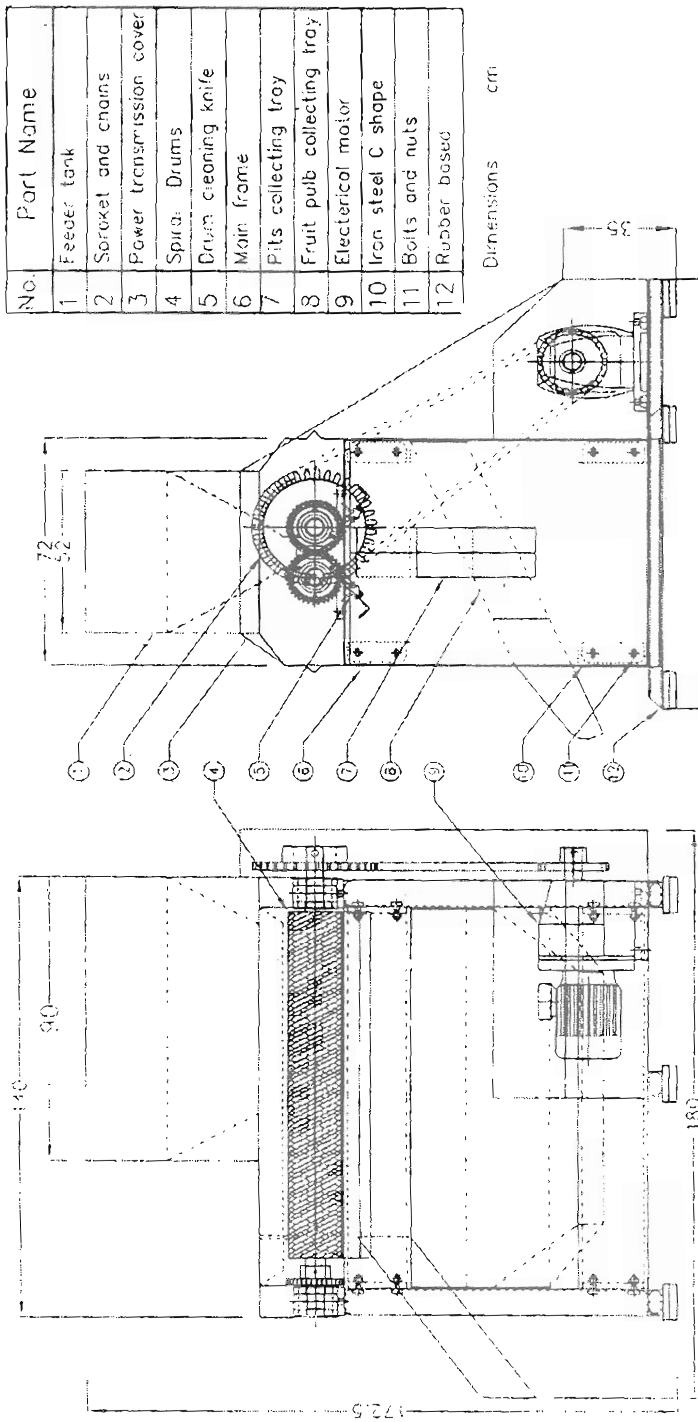


Fig. 4: Schematic diagram of the designed date pitting machine

Hence:

$$2F\left\{\sin\theta - \frac{\cos\theta}{\mu}\right\} \geq P \quad \text{.........(3)}$$

Since P is the force required for pit take-off, its value cannot be negative. Therefore,

$$\cot\theta \leq \mu \quad \text{.........(4)}$$

$$\cot\theta = \frac{\sqrt{(r + r_s)^2 - r^2}}{r} \quad \text{.........(5)}$$

Therefore

$$\sqrt{\frac{r_s}{r}\left\{2 + \frac{r_s}{r}\right\}} \leq \mu \quad \text{.........(6)}$$

Where, r_s is the radius of date fruit.

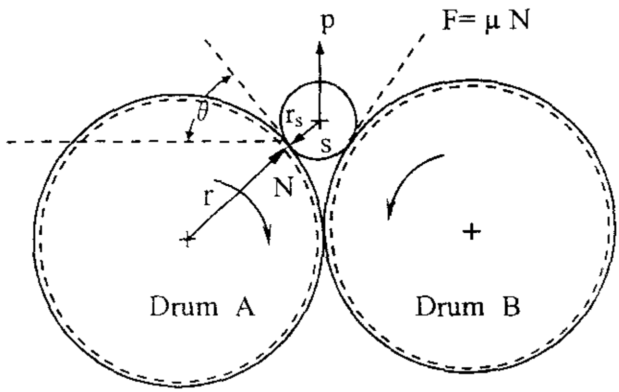


Fig. 5: Theoretically analysis of forces acting between drums and Date fruit during pitting process.

The equation (6) establishes the minimum value for radius of rollers. With substituting in equation (6) using the obtained results of physical and mechanical properties of fruits such as; r_s = 10.5 mm and μ = 0.67.

Then the solution of equation (6) should be as follow:

$x^2 + 2x - 0.44 \leq 0$ where $x = (r_s / r)$

$x < 0.2$

Therefore;

r (radius of drums) $\geq$ **52.5 mm,** therefore the diameter of the drums should be more than 105 mm.

Another limiting condition on the size of the drums is established in the following way:

$F_H = 2 (F \cos\theta + N \sin\theta)$ ....(7)

Using equation (2), equation (7) and (1) can be reduced to

$$F_H = \frac{P(\mu \cos\theta + \sin\theta)}{\mu \sin\theta - \cos\theta} \quad \text{.........(8)}$$

The maximum horizontal force date pit can with stand is F_H < 500 Newton (compression force of date pit).

$$F_H = \frac{P(\mu \cos\theta + \sin\theta)}{\mu \sin\theta - \cos\theta} < \mathbf{500}\ \text{N} \quad \text{.........(9)}$$

Drum radius was selected according to the previously calculation to be r = 53 mm, r_B = 10.5 mm and Pit separation force, P = 48.9 N.
by equation (5). Cot θ = 0.496; therefore, θ = 63 deg. 34 min.
Substitute in equation (9), therefore, F_H = 374.86 N < 500 Newton (compression force).

3.2. Determination of the drums Peripheral speed:

Another limiting condition on the peripheral speed of the drums is established on the following way:
Using equation (1) and (2) can be reduced to

$$2\,N\,(\mu \sin\theta - \cos\theta) \ge P \quad \text{.........(10)}$$

$$N \ge \frac{P}{2(\mu \sin\theta - \cos\theta)} \quad \text{.........(11)}$$

$$N = m\,r\,\omega^2 \quad \text{.........(12)}$$

Where:
m = drums mass, kg.
ω = angular velocity of drums, s^{-1}.
Use μ = 0.67; P = 48.9 N; θ = 63 deg. 34 min.; and m = 10 kg and substitute in equation (11).
N ≥158.9 Newton.
For N = 175 Newton and by equation (12)
$\omega = 5.8\ s^{-1}$
Where r = 0.053 m, Therefore:
n (revolution speed of drums) **should be ≥ 56 rpm.**
V (Peripheral speed of drums) **should be ≥ 0.3 m / s.**

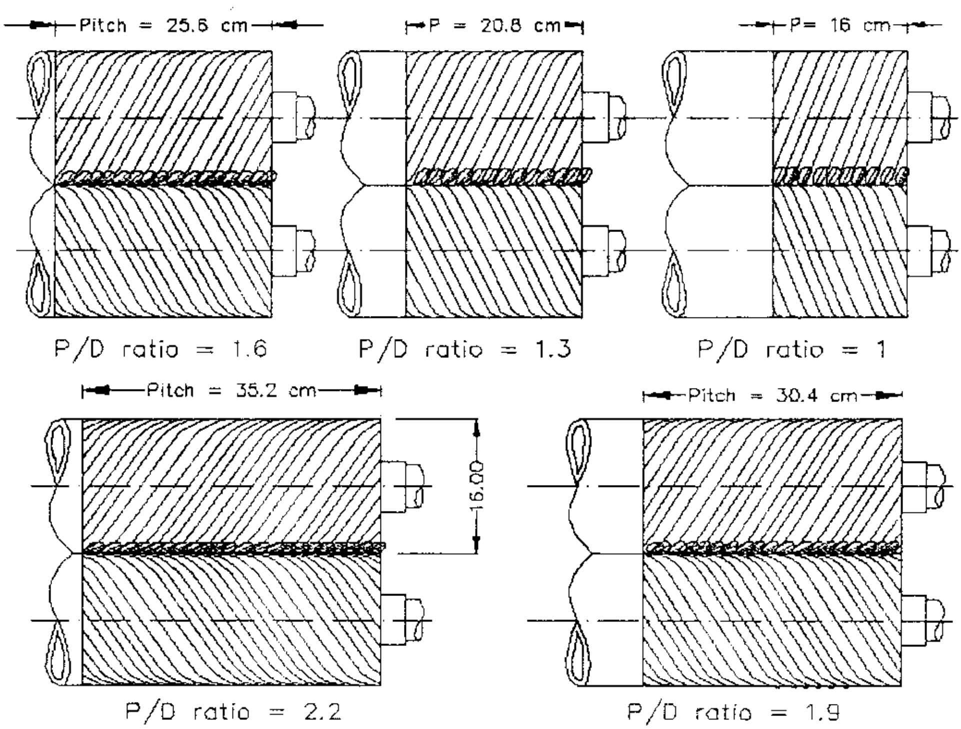
3.3. Pitch/diameter ratio of drum spiral and their relation to the number of spirals for removing pits:

The designed spiral grooves on the outer diameter of drums, and the number of these spirals plays very important role for removing date pits outside the machine. Pitches were assumed to be different ratios from the diameter within the recommended ranges of those ratios according to (El-Saharigi 1997) as shown in Fig. (6). While, number of spiral depends on both pit width and pitch of the spiral, therefore, it can be calculated according to the following equation:

$$No_{sp} \le \frac{Pi}{Wi_{max.} + X} = \frac{Pi}{Wi_{max.} + 0.26\,Wi_{max.}} = \frac{Pi}{1.26\,Wi_{max.}} \quad \text{.........(13)}$$

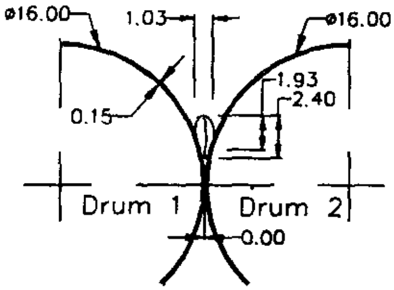
Where:
No_{sp} = Number of spirals in one pitch.
Pi = Pitch of spiral groove, cm;
$Wi_{max.}$ = Maximum width of pit, cm.
X = Spaces between two pits, assumed to be 0.26 Wi_{max}.
Consequently, the numbers of spirals groove were calculated corresponding to the variable P/D ratio as follow:

P/D ratio	Drums diameter, cm	Pitch, cm	Calculation of spiral No.	No. of spirals
1.0		16.00	=16.00/(1.26 * 1.25) ≈	10
1.3		20.80	=20.80/(1.26 * 1.25) ≈	13
1.6	16	25.60	=25.60/(1.26 * 1.25) ≈	16
1.9		30.40	=30.40/(1.26 * 1.25) ≈	19
2.2		35.20	=35.20/(1.26 * 1.25) ≈	22

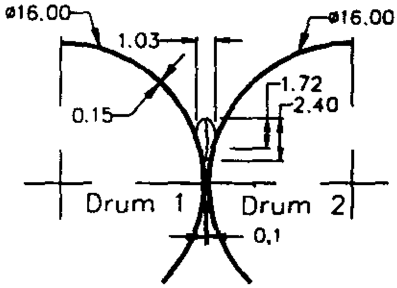


The clearance (c) between the two pitting drums is varied in such a way that depending on the thickness of the date pit (d) as shown in **Fig. 7**.

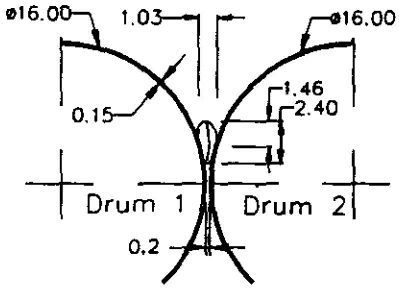
The clearances between the drums were analyzed using Auto-CAD program and the minimum thickness of pits to find the maximum clearance which could be used as operating parameter. The computer analysis indicated that the clearances between the drums could be tested within range from 0 to 2 mm.



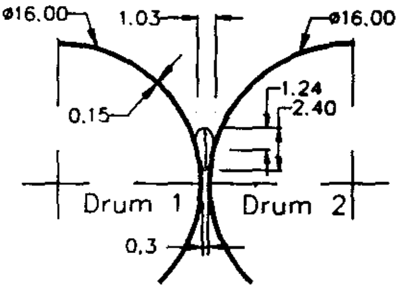
0 mm Clearance



1 mm Clearance



2 mm Clearance



3 mm Clearance

4- Evaluation tests and experiments:

The fabrication, development, and the experimental test of pitting machine for producing date paste (Agwa) under study was carried out in a private workshop in Damanhour City, Behera Governorate.

The experiments were carried out to study the effect of the following parameters on the designed machine:

a- Pitting drums speed:

Five levels of drum speeds (40, 60, 80, 100, and 120 rpm) which equivalents to (0.335, 0.503, 0.670, 0.838, and 1.006 m/s) were tested.

b- P/D ratio of drum spiral:

Five levels of pitch/diameter (P/D) ratios (1.0, 1.3, 1.6, 1.9, and 2.2 m/s) were examined.

c- Clearance between drums:

Three levels of clearances (0, 1, and 2 mm) were studied.

5-Measurements:

The following measurements were carried out to investigate the effect of the previously mentioned parameters on the fabricated pitting machine performance.

a- Machine productivity (Machine capacity):

The pitting productivity (q) for the designed machine was calculated using the following formula:

$$q = M / t \quad \text{.....(14)}$$

Where:

q = Machine productivity, kg/h;
M = Mass of pitted dates, kg;
t = The time consumed in pitting operation, h.

b- Machine efficiency:

The machine efficiency (η) was calculated according to the following formula:

$$\eta = (q / Q) \times 100 \quad \text{.....(15)}$$

While Q can be calculated according to the following formula:

$$Q = 60 \; No_{sp} \times m_f \times n \quad \text{.....(16)}$$

Where:

η = Pitting machine efficiency, %;
q = Actual machine capacity, kg/h;
Q = Theoretical machine capacity, kg/h;
No_{sp} = No. of spirals on machine drums;
m_f = Mass of one date fruit, kg;
n = Drums speed, rpm;

c- Energy requirement:

In order to measure the energy requirement for operating the designed date pitting machine, a super clamp meter-300 k was used for the measurements of the current strength and potential difference before and during experiments. The consumed power was calculated according to the following formula (Gustafson,1980):

$$Total\ consumed\ power, (kW) = \frac{\sqrt{3}\ I\ V \cos\theta}{1000} \quad \text{.....(17)}$$

Where:

I = Line current strength in amperes;
V = Potential difference (Voltage) being equal to 380 V;
Cos θ = Power factor (being equal to 0.84);
$\sqrt{3}$ = Coefficient current three phase (being equal 1.73);

The energy requirement for the designed machine in (kW.h/ton) was calculated by the following equation:

$$Energy\ requirement, (kW.h/ton) = \frac{Consumed\ power (kW)}{Machine\ productivity (ton/h)} \quad \text{.....(18)}$$

While the human energy was calculated as the following equation:

$$Human\ energy = \frac{P_{man}}{q_{man}} \quad \text{.....(19)}$$

Where:

P_{man} = Manpower, kW;
q_{man} = Manual productivity, ton/h.

The manpower was computed by assuming that one normal labor supplies 0.0748 kW according to (Ezeike, 1987) cited by (Matouk *et al.* 1999)

The manual productivity was (7 kg/h = 0.007 ton/h) according to the average of five replicates were carried out laboratory.

d- Operating cost of the unit:

The total cost was determined by using the following equation (Awady, 1978):

C = p/h (1/a + i + t/2 + r) + (Ec × Ep) + m/144 ....(20)

Where:

C =	Operation hourly cost;	p =	Price of machine;
h =	Yearly working hours;	a =	Life expectancy of the machine;
i =	Interest rate/year;	t =	Taxes;
Ec =	Electricity energy;	r =	Overheads and indirect cost ratio, consumption, (kW.h);
m =	Monthly wage, LE ;		
Ep =	Electricity price, (E.L./kW.h);		
144	are estimated monthly working hours, h/month.		

The operation cost can be determined by using the following formula:

$$Operating\ cost\ (L.E / ton) = \frac{Machine\ operation\ hourly\ cost\ (L.E / h)}{Machice\ capacity\ (ton / h)} \quad ....(21)$$

RESULTS AND DISCUSSION

1- Physical and mechanical properties of dates:

The obtained results of the physical and mechanical properties of whole dates and their pits were summarized in table 1 as follow:

Table 1: Physical and mechanical properties of date fruits and their pits.

Item	Date fruits			Pits		
	Min.	Max.	average	Min.	Max.	average
Length, mm.	20.22	42.06	34.12	18.54	29.31	24.65
Width, mm.	17.52	25.00	20.96	8.81	12.52	10.94
Thickness, mm.	23.38	16.32	19.61	7.60	10.95	9.56
Mass, g.	4.50	18.70	10.98	1.10	2.20	1.59
Volume, cm^3.	3.81	12.72	8.84	0.89	1.27	1.01
Density, g / cm^3.	1.18	1.47	1.25	1.24	1.73	1.58
Flesh mass, g.	3.40	17.00	9.40	-----		
Moisture content, %	18.39			-----		
F. C. on stainless steel	0.67			-----		
Pit separation force, N	-----			48.90		
Compression force, N	-----			500		

These properties were used in selecting the operational parameters of the designed machine.

2- Machine productivity:

Inspections of Fig. (8) revealed that the pitting drum speed had a noticeable effect on the machine productivity. Results showed that the date pastes are more easily removed during pitting as drum speed increased. It could be seen (Fig 8) that machine productivity was increased by about 38 % as the drum speed was increase from 40 to 80 rpm. On the other hand as the drum speed increased above 80 rpm the machine productivity was dramatically decreased. It can be seen that the machine productivity was decreased by about 26 % as drum speed was increased from 80 to 120 rpm, therefore, it can be concluded that the highest pitting machine productivity of 432.66 kg/h was accomplished at 80 rpm pitting drum speed. This may be explained by the fact that at low speeds, the date may be delayed and stayed for a longer time on the drums, and consequently, decrease machine productivity. But, at high drums speed over 80 rpm, according to force analysis in Fig. (5) the drum reaction centrifugal forces may be increased against the forces occurs from pits mass, consequently, the productivity of the machine was decreased. One may also say that the increasing of drum speed increase the friction between the conveyed pits with the spirals and drums which let the tangential forces between the two drums overcome on the lateral forces of pits and take it down in-between of the two drums especially with 1 and 2 mm clearances as it can be seen in Fig. (7).

The obtained data in Fig. (9) indicated that the pitting machine productivity was highly affected by P/D ratios at the three investigated levels of clearances at drum speed 80 rpm. Where, the productivities at 1 mm clearance were 317.25, 375.55, 402.50, 380.2 and 281.78 kg/h at P/D ratio of 1.0, 1.3, 1.6, 1.9 and 2.2, respectively. That means, the productivity increased by about 27 % when the P/D ratio increased from 1.0 to 1.6, and it decreased about 30 % with increasing P/D ratio from 1.6 to 2.2.

Also Figs (8 & 9) show that there is a clear effects of pitting drum clearance on the machine productivity. It can be noticed that for all drum speeds, the maximum machine productivity was recorded at 0 mm clearance between pitting drums, on the other hand the minimum machine productivity was recorded at drum clearance of 2 mm. This may be due to the increase in the friction force between the dates and drums at 0 mm drum clearance which in turn gives an increasing effect on pitting process. It was observed that high clearance of 2 mm as well as 3 mm spiral groove depth caused pit clogging between drums which in turn leads to a decrease in machine productivity.

Generally, a maximum machine productivity of 432.66 kg/h was obtained at drum speed of 80 rpm (0.67 m/s), 0 mm clearance, and 1.6 P/D ratios.

3- Machine efficiency:

The obtained data in Fig. (10) indicate that the machine efficiency was highly affected by the pitting drum speed. It can be noticed that the efficiency was noticeable increased as the drum speed increased up to 80 rpm. Meanwhile, it can be seen that as the drum speed increased above 80 rpm, the machine efficiency decreased. It can also be seen that the efficiency increased by about 9.2 % when the drum speed increased from 40 rpm to 80 rpm, but when the drum speed increased from 80 to 120 the machine efficiency was highly decrease by about 42%.

Consequently, the highest machine efficiency of 86.6 % was obtained at 80 rpm, while the lowest efficiency was obtained at 120 rpm.

Also Fig. (10) shows that the machine efficiencies were 78.11, 86.18, 86.63, 63.87, and 36.38 at P/D ratio of 1.0, 1.3, 1.6, 1.9, and 2.2, respectively at 1mm clearance and 80 rpm. This means that the efficiency increased by about 14 % when P/D ratio increased from 1.0 to 1.6, then it dramatically decreased by about 57 % when P/D ratio increased up to 2.2. This may be due to the increase of pits conveying regularity as the P/D ratio increased up to 1.6 and consequently increase the machine efficiency. On the other hand at ratios grater than 1.6 the conveying of pits becomes turbulent and resulted in machine efficiency decrease.

Results in Fig. (10) also indicate that the machine efficiency had a tendency to decrease when the drum clearance increased, it can be seen that the machine efficiencies were 90.16, 89.18, and 81.17 at drum clearances of 0, 1, 2 mm, respectively. It can be seen that there is not a noticeable difference between machine efficiency at 0 and 1 mm clearances.

Generally, the experimental results indicated that the optimum performance of pitting machine was recorded at 80 rpm drum speed, 1.6 P/D ratio and 1 mm drum clearance to achieve the highest machine efficiency.

4- Energy requirement:

The obtained results indicated that the drum clearance had a noticeable effect on the date pitting energy requirement. It can be seen Fig. (11) that the energy requirement was inversely related to the clearance between drums. Whereas, the required energies at 80 rpm drum speed were 3.58, 3.47 and 3.91 kW.h/ton at clearances of 0, 1 and 2 mm, respectively. This means that the lowest energy requirement was accomplished at drum clearance of 1 mm and increased by about 3.17 % and 12.68 % with drum clearance of 0 and 2 mm, respectively.

It can also be seen (Fig. 11) that the energy requirement (kW.h/ton) was highly affected by the drum speed. The energy requirement was positively proportional to drum speed. Where, at 1 mm clearance the lowest energy (2.53 kW.h/ton) was recorded at 40 rpm. Meanwhile the highest energy (4.12 kW.h/ton) resulted from 120 rpm. Generally , when the drum speed increased from 40 to 60, 80, 100 and 120 at the clearance 1 mm, the percentage of increase energy requirement (kW.h/ton) were 5.93 %, 29.48%, 3.46 % and 14.76 %, respectively.

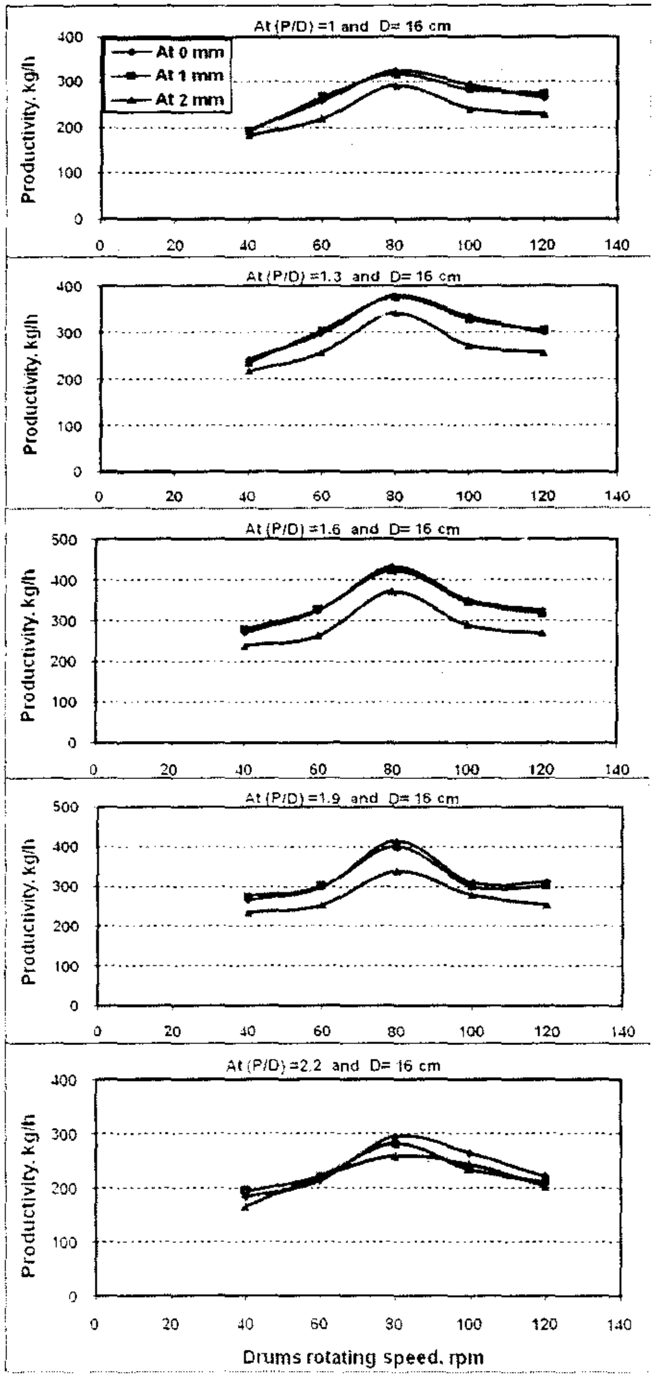


Fig. (8): Effect of drums rotating speed on machine productivity at five different ratios of (P/D) and three different clearances.

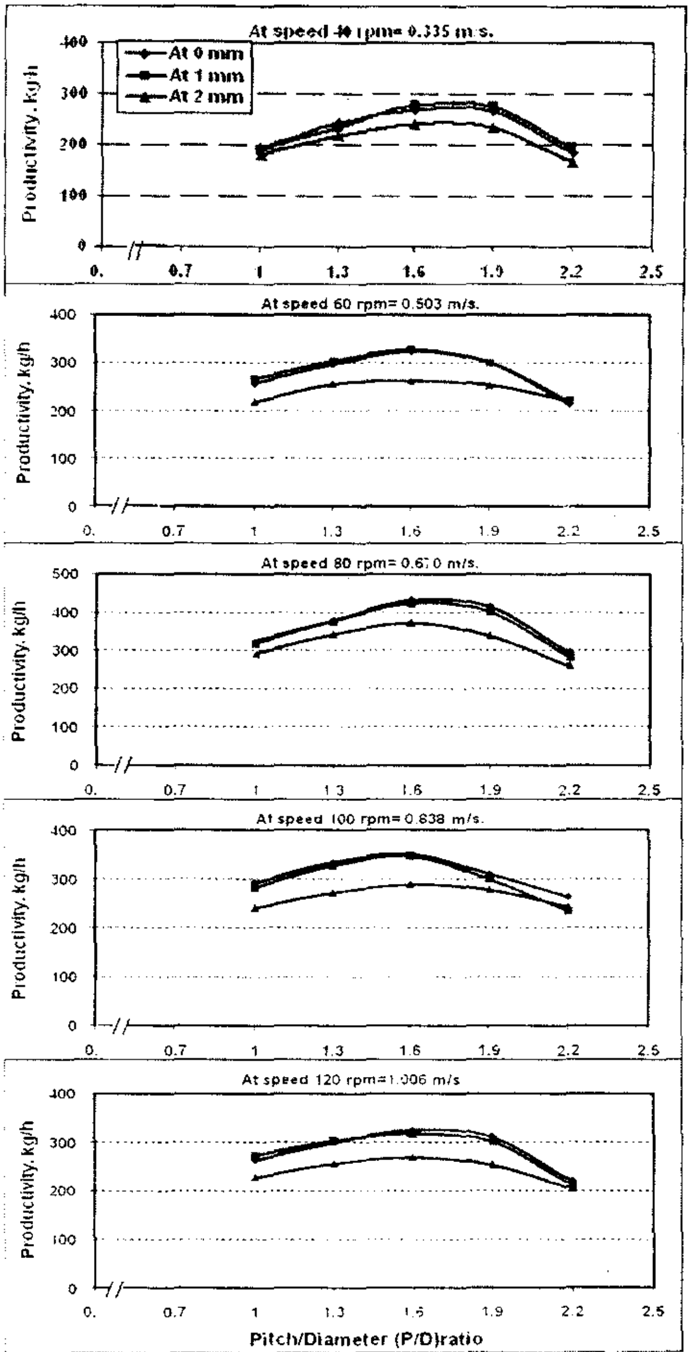


Fig. (9): Effect of different ratios of (P/D) on machine productivity at five drums rotating speed and three different clearances.

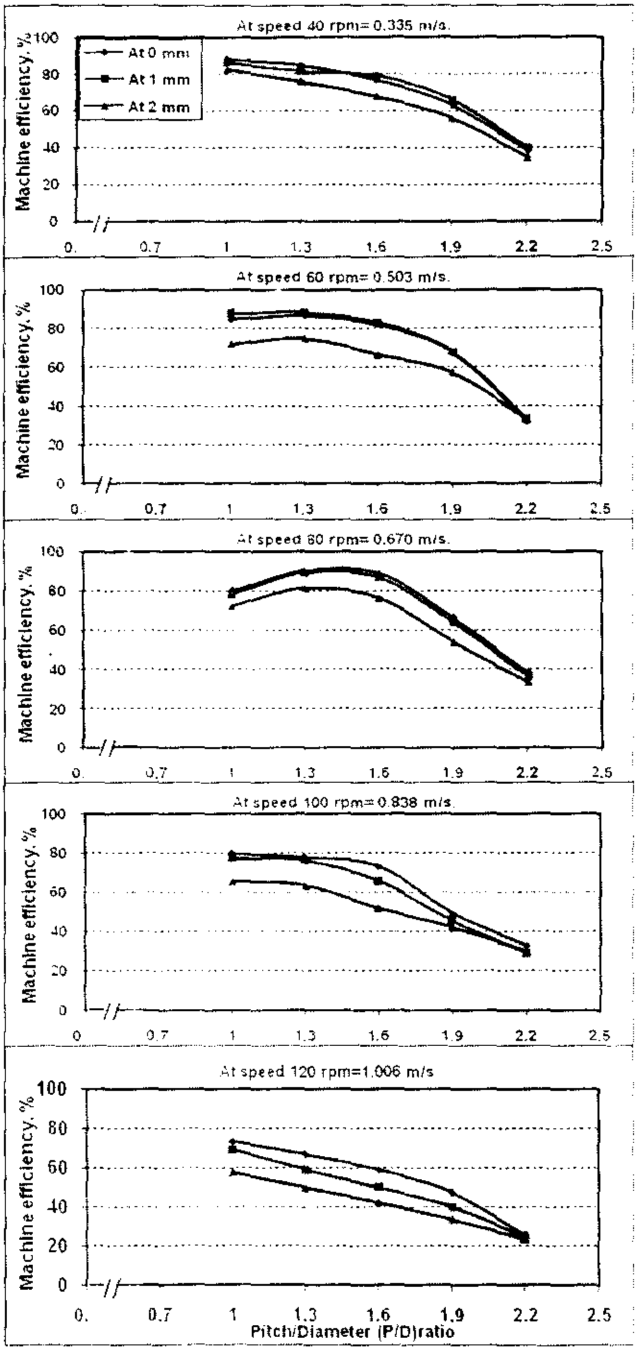


Fig. (10): Effect of (P/D) ratio on machine efficiency at five different drums rotating speed and three different clearances.

تصميم وتصنيع آلة محلية لنزع نوى البلح ميكانيكياً وإنتاج العجوة

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تنتشر زراعة النخيل فى العالم العربى حيث ينتج حوالى ٨٠ ٪ من الانتاج العالمى حيث تحتل مصر المرتبة الثالثة بين دول العالم العربى فى انتاج التمور . ونظرا للقيمة الغذائية العالية للتمر فقد أقيمت المصانع لتعبئة التمور وكبسها فى عبوات ذات اشكال مختلفة لتناسب اذواق المستهلك، كما بدا الاهتمام بتصنيع التمور كالعجوة وعجائن التمور والتمور المحشوة بالمكسرات ومنزوعة النوى. ويتم نزع النوى يدويا حيث تتصف هذه العملية بالملل والعمالة الزائدة والتكلفة العالية، ومن هنا جاء التفكير فى تصميم وتصنيع آلة لنزع نوى البلح وانتاج العجوى يمكن تصنيعها محليا وتعميمها للعمل فى المصانع. لذا كان الهدف من البحث هو:

١) دراسة بعض الخصائص الطبيعية و الميكانيكية لثمار البلح مثل قياس القوى اللازمة لنزع نواة البلح والكثافة وزاوية الاحتكاك وكذلك ابعاد وحجم الثمار وابعاد النواة.

٢) استخدام القياسات السابقة فى تصميم الاجزاء المختلفة للآلة وتحديد المعايير الهندسية والتشغيلية للآلة موضع الدراسة.

٣) تصميم وتصنيع واختبار الآلة لنزع نوى ثمار البلح ميكانيكيا وانتاج العجوة بأحد الورش الخاصة بمنطقة دمنهور محافظة البحيرة.

٤) تحليل النتائج المتحصل عليها لتحديد أهم العوامل التصميمية والتشغيلية للآلة المؤثرة على الانتاجية وكفاءة عملية الفصل والطاقة المستهلكة فى تشغيل الالة.

٥) حساب تكلفة انتاج الطن بالآلة المصنعة ميكانيكيا ومقارنتة بتكلفة انتاج الطن بالعمالة اليدوية.

وكانت أهم النتائج المتحصل عليها مايلى:

١- الخصائص الطبيعية والميكانيكية لثمار اكثر الاصناف المصرية انتشارا والمستخدمة لانتاج العجوة (صنف سيوى) فى مرحلة النضج (التمر) كانت ٣٤,١٢ مم، ٢٠,٩٦ مم، ١٩,٦١ مم ، ١٠,٩٨ جم ، ٩,٤٠ جم، ١,٥٩ جم، ٠,٦٥٤٥ جم/سم٣ ، ٢٤,٦٥ مم، ١٠,٩٤ مم، ٩,٥٦ مم، لكل من طول وقطر وسمك الثمرة، كتلة الثمرة واللحم والنواة ، الكثافة الظاهرية، طول وعرض وسمك النواه على التوالى – وكانت القوة المستهلكة لنزع النواة هى ٤٨,٩ نيوتن .

٢- أظهرت النتائج التجريبية أن أعلى إنتاجية للآلة كانت (٤٣٢,٦٦ كجم/ساعة) مع أفضل كفاءة فصل (٨٦,٦ ٪) بأقل طاقة مستهلكة (٣,٤٧ كيلوات. ساعة/طن) باستخدام آلة نزع النوى المصنعة عند مواصفات تشغيلية ٨٠ لفة /دقيقة سرعة الدوران. ١.٦ النسبة بين طول خطوة الحلزون وقطر البريمة، و ١ مم خلوص بين درفيلى نزع النوى من ثمار البلح.

٣- كانت تكلفة تشغيل الآلة المصنعة لإنتاج واحد طن هى ٢٩,٥ جنيه/طن إذا ما قورنت بتكلفة الطريقة اليدوية لإنتاج واحد طن وهى ١٧٨,٥٧ جنيه/للطن . وبتحليل النتائج تبين أن تكلفة انتاج الطن بالالة المصنعة يمثل ١٦,٥٢ % من تكلفة انتاج الطن يدويا .