SOME ENGINEERING FACTORS AFFECTING DATE PITS CRUSHING

Khairy, M. F. A. *; S. H. Desoky**; R. A. Werby**; K. A. M. Ali***

ABSTRACT
The main objective of the present work was to study and evaluate some engineering factors affecting date pits crushing for small locally made crushing unit at moisture content of 7.75 % db. The performance of date pits crushing unit was evaluated at different cylinders speeds (150, 250, 350 and 450 rpm), clearances between cylinders (zero, 1 and 2 mm) and opening feed areas (30, 37.5 and 45 cm²). The results showed that the highest productivity was 822 kg/h obtained at 150 rpm cylinder speed, 2 mm clearance between cylinders and 45cm² opening feed area. The best result for crushed date pits particle size was obtained at 350 rpm, 0 mm clearance between cylinders and 37.5 cm² opening feed area. While the minimum specific energy 1.11kW.h/Mg was obtained at 150 rpm, 45 cm² opening feed area and 2 mm clearance between cylinders.

INTRODUCTION
Date palm trees are grown all-over Egyptian lands. In addition, date palm trees considered as the most successful fruit tree that cultivated in the new reclaimed lands in Toshki, El-Ewinates, and Sinai areas (Bekheet, 2013). Egypt is considered as one of the most important producers of date in the whole world. It produce about 1.47 Tg on 2012 (FAO, 2012). There are many by-products from palm trees some of them, date pits (that represents 10 - 15 % of the date fruit), palm tree leaves, and non-edible dates could be used in animal feeds. The date pits is composed of both organic and inorganic substances such as carbohydrates 62.51 %, fats 8.49 %, proteins 5.22 %, fibers 16.20 %, and ash 1.12% (El-Agamy et al, 2003).

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This study is a part of outcomes from Ali (MSc thesis)
Almana and Mahmaud (1994) evaluated date pits as an alternative source of dietary fiber in comparison with wheat bran, and suggested that they may provide a valuable contribution to dietary fiber intakes. Therefore, date pits were examined because they may have an extractable high value-added component for including in functional foods. Allam et al. (1997) mentioned that Date pits (date stone) by-product meals have been examined in livestock (poultry, and ruminants), and fish (for aquaculture) diets as a nonconventional source to substitute or supplements for expensive conventional feed, and to cut-down on the feed gap between production and consumption. Date stone by-product meal provides a good potential as concentrated feed source for poultry, ruminants and fish feeding instead of maize or other grains that are used for human foods.

Khairy and Attalla (1995) studied physical and mechanical properties of twelve date palm cultivars commonly growing in Gassim region. 50 date fruit were examined for each cultivar. The shapes of these cultivars were studied in terms of fruit length "L", maximum width "A", minimum width "B", pulp thickness "T", pit length "L1", maximum width "A1", minimum width "B1", the angle of friction between date fruit and both of wood "Φw" and galvanized mild steel "Φs" surfaces were measured by inclination-plate method. Pit separation force "PF" (N) and pulp rigidity "RG" (MPa) were measured by an apparatus developed, constructed and calibrated by first author.

Maynard and Heid (1964) and Kozmin (1988) classified the types of milling equipment according to the principles of action of their working organs upon the treated product as follow:

1. Cutting (chipping off) machines.
2. Pressing (crushing) machines.

Milling equipment may depend upon a single one of these actions or upon a combination of two or more. Miller also can be designed and frequently are to produce attrition and impact grinding. Simmons (1963) and Kozemin (1988) showed that grinders may be placed in two categories:

1. Stone grinders or mill stone:
a. Horizontal grinders. (the top – runner type and the under – runner type)
   b. Vertical grinders.
   2. Roller mills which can be designed to produce both compression and attrition grinding.

The main objective of the present work is to develop a small locally made crushing unit and study some engineering factors affecting date pits crushing and evaluating the performance of crushing unit.

MATERIALS AND METHODS

The experiments were carried out at Faculty of Agricultural Engineering, Al-Azhar University, Nasr City during the years of 2013 – 2015 for small crushing machine locally manufactured.

1. Date pits Variety.

Experiments were carried out on date pits variety sewi. Some physical and mechanical properties of 100 date pits are studied according to (Khairy and Attalla 1995) and listed in table (1).

### Table (1): Some physical and mechanical properties of date pits.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>mean</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content db (%)</td>
<td>7.75</td>
<td>1.18</td>
</tr>
<tr>
<td>Length &quot;L&quot; (mm)</td>
<td>21.50</td>
<td>8.52</td>
</tr>
<tr>
<td>Width &quot;W&quot; (mm)</td>
<td>10.02</td>
<td>4.89</td>
</tr>
<tr>
<td>Thickness &quot;T&quot; (mm)</td>
<td>8.53</td>
<td>4.90</td>
</tr>
<tr>
<td>Mass &quot;m&quot;(g)</td>
<td>1.33</td>
<td>14.94</td>
</tr>
<tr>
<td>Real density &quot;ρ_r&quot; (g/cm³)</td>
<td>1.27</td>
<td>4.67</td>
</tr>
<tr>
<td>Bulk density &quot;ρ_b&quot;(g/cm³)</td>
<td>0.83</td>
<td>1.15</td>
</tr>
<tr>
<td>Friction angle &quot;α&quot; ° (degree)</td>
<td>27.47</td>
<td>3.00</td>
</tr>
<tr>
<td>Angle of repose &quot;θ&quot; ° (degree)</td>
<td>15.96</td>
<td>14.99</td>
</tr>
<tr>
<td>Compression force (kN)</td>
<td>2.55</td>
<td>4.8</td>
</tr>
<tr>
<td>Shear force (kN)</td>
<td>1.37</td>
<td>8.3</td>
</tr>
</tbody>
</table>

2. Crushing unit:

The crushing unit installation used in this study is shown in Fig (1). The frame was constructed of steel plate (60×60×3) mm to carry the
engine and fixed it by means of four sets screw bolts and nuts. The frame also carried the crushing unit and the power transmission system. The feeding hopper was installed to feed the date pits into the crushing unit. The gate of this hopper sloped gradually by 30° to keep a free flow of date pits. The gate was drilled on the side of hopper to control on the feeding rate of date pits from hopper to crushing unit. The crushing unit was necessary for crush the date pits to facilitate the crushing process. Cracking process is done by a pair of herringbone cylinders of 80 mm diameter and 290 mm length. The clearance between cylinders was adjusted by tow screws. An electrical motor (1400 rpm, 1.5 kW) was used to drive the crushing unit the power from the source was transmitted to crushing unit by means of pulley and V belt and sprocket wheels and chain.

Fig. (1): Isometric of the developed crushing unit.

The effect of the following variables on the date pits particle size, crushing unit productivity and specific energy requirement for date pits were studied:
1. Four cylinders speed of 150, 250, 350 and 450 rpm.
2. Three clearances between cylinders of zero, 1 and 2 mm.
3. Three opening feed areas of 30, 37.5 and 45 cm².

1. Particle size distribution:
The date pits mean particle size (mm) was measured by using different sizes sieves "Ci" (mm) and weighting the weight over each sieves "Wi" (gm) where i is the sieve number and the following equation were used (Finch, 2009).

\[ L = \frac{(C1 \times W1 + C2 \times W2 + C3 \times W3 + \ldots + Cn \times Wn)}{W1 + W2 + W3 + \ldots + Wn} \]

2. Productivity:
Crushing time of 1 kg of date pits was measured by means of a stopwatch to determine the machine productivity in kg /h.

\[ Productivity = \frac{mass \ of \ crushed \ date \ pits \ (kg)}{Time \ of \ crushing \ (h)} \]

3. Crushing power requirements:
A digital AVO meter was used for measuring the current Amber before and during experiments the total consumed electric power under machine working load (kW) was calculated according (Lockwood and Denstan, 1971) by the following equation.

\[ power \ (kW) = \frac{(I \times V \times \eta \times \cos \theta)}{1000} \]

Where:
- I : Current strength in Amperes.
- V: Voltage strength (equal to 220 V),
- \( \cos \theta \): Power factor (equal to 0.85) and
- \( \eta \): Mechanical efficiency assumed to be (90%)

4. Specific energy requirement
The specific energy requirement (kW.h/Mg) was calculated by using the following equation:

\[ CE = \frac{Power(kW)}{productivity(Mg/h)} \]
RESULTS AND DISCUSSION

There are no results for the following operational conditions:
At zero mm clearance between cylinders and 450 rpm for cylinders speed at all opening feed area (30, 37.5 and 45 cm\(^2\)) and at the same clearance where the speed was 350 rpm for 45 cm\(^2\) opening feed area. That is because of the high loud on the electric motor led to stop the crushing operation.

- **Effect of cylinders speeds on date pits particle size:**
Fig (2) illustrated the relationship between the cylinder speed "Cs" (rpm) and date pits mean particle size (mm) at different opening feed areas and clearances between cylinders.

![Graph](image-url)

**Fig (2): Date pits mean particle size (mm) Vs Cylinder speed "Cs" (rpm) at different opening feed areas and clearances between cylinders.**
The obtained data showed that the date pits mean particle size decreased with the increase of both opening feed area and cylinders speed and it increased with the increase of clearance between cylinders. The minimum value of date pits mean particle size was 6.34 mm at opening feed area of 37.5 cm², 350 rpm cylinders speed and 0 mm clearance between cylinders while the maximum value of date pits mean particle size was 7.37 mm at opening feed area of 30 cm², 150 rpm cylinders speed and 2 mm clearance between cylinders.

- **Effect of cylinders speeds on crushing unit productivity:**

  Fig (3) illustrated the relationship between crushing unit productivity "CPr" (kg/h) and cylinder speed "Cs" (rpm) at different opening feed areas and clearances between cylinders.

![Crushing unit productivity vs cylinder speed and opening feed area](image-url)

Fig (3): Crushing unit productivity "CPr" (kg/h) Vs Cylinder speed "Cs" rpm at different opening feed areas and clearances between cylinders.
The obtained data showed that the crushing unit productivity increased with the increase of both opening feed area and clearance between cylinders and decreased with the increase of the cylinder speed. The maximum value of the crusher unit productivity was 822 kg/h at opening feed area of 45 cm², 150 rpm cylinders speed and 2 mm clearance between cylinders; while the minimum value of the crusher unit productivity was 152 kg/h at opening feed area 30 cm², 350 rpm cylinders speed and 0 mm clearance between cylinders.

- **Effect of cylinders speed on specific energy requirement for crushing unit:**

Fig (3) illustrated the relationship between cylinders rotational speed "Cs" (rpm) and specific energy "CE" (kW.h/Mg) at different opening feed areas and clearances between cylinders.

![Diagram showing the relationship between cylinders speed and specific energy requirement.](image)

Fig (4): Crushing unit Specific energy "CE" (kW.h/Mg) Vs Cylinder speed "Cs" (rpm) at different opening feed areas and clearances between cylinders.
The obtained data showed that the specific energy requirement decreased with the increase of both opening feed area and the clearance between cylinders and increased with the increase of cylinders speed. This results were agreement with Werby et al (2012).

The maximum value of Specific energy requirement was 9.30 kW.h/Mg at opening feed area of 30 cm$^2$, 350 rpm cylinders speed and 0 mm clearance between cylinders; while the minimum value of specific energy requirement was 1.11 kW.h/Mg at opening feed area of 45 cm$^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders.

**CONCLUSION**

The minimum value of date pits particle size was 6.34 mm at opening feed area of 37.5 cm$^2$, 350 rpm rotational speed and 0 mm clearance between cylinders while the maximum value of date pits particle size was 7.37 mm at opening feed area of 30 cm$^2$, 150 rpm cylinders speed and 2 mm clearance between cylinders.

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**REFERENCES**


الملخص العربي
بعض العوامل الهندسية المؤثرة علي جرش نوى التمر
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تعتبر جمهورية مصر العربية من أكثر الدول إنتاجاً للبزج في العالم حيث بلغت إنتاجيتها من التمر حوالي 1,476,000 ميغا جرام لعام 2012م (FAO 2012) ويتراوح عن هذه الكمية نوى بمعدل 10 - 15% من الإنتاج. وعدد توافر نوى التمر في صورة متروكة أو مطحونة أدى إلى عدم استخدامه في العديد من الصناعات القائمة على هذا المنتج الثانوي وذلك بسبب صعوبة فتحه لاحتوائه على نسبة عالية من السيلولوز بالإضافة إلى عدم توافر آلات متخصصة في جرش نوى التمر بالأسواق المحلية. ويساهم البحث في سد العجز في المواد العقلية للمواشي والدواجن والأسماك وتوفر جزء من الحيوان التي يستهلكها المنتج حيواني مثل الذرة والشعير والتي تصلح للاستخدام الأدمي. تم إجراء هذا البحث خلال عام 2014 - 2015 م في كلية الهندسة الزراعية جامعة الأزهر.

ويهدف هذا البحث إلى الاستفادة من نوى التمر عن طريق جرشه حيث تم دراسة بعض العوامل الهندسية المؤثرة على جرش نوى التمر وتصنيف آلة محلية الصنع رخيصة الثمن يمكن للمزارع المصري اقتناها.

وأتصل إلى هذا الهدف تم دراسة الآتي:
1. دراسة بعض الخواص الطبيعية والميكانيكية لنوى التمر والتي تساعد في تحديد أسباب تصميم الآلة.
2. تصنيف آلة محلية لجرش نوى التمر تكاملت الكميات الصغيرة وذات كتاليف اقتصادية بسيطة وسهولة الصيانة.
3. دراسة أهم العوامل الهندسية التي تؤثر على أداء وكفاءة آلة الجرش وهي
   • سرعة أسطوانات الجرش وتم اختيار أربع سرعات ( 0.5 - 0.5 - 0.5 - 0.5 سِم/دقيقة)
   • الخروض بين أسطوانات الجرش وتم استخدام ثلاث مترات ( صفر - 1 - 2 مم)
   • مساحة فتحة التغذية وتم استخدام ثلاث متغيرات ( 30 - 37.5 - 45 سم²)

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وكانت أهم النتائج:

1. إنتاجية الجرّاح تتغصب بزيادة سرعة استطوانات الجرّاح لكل الخصولات بين الأساطير وتزيد مع زيادة الخصول بين الأساطير كما تتزايد بزيادة فتحات التغذية وكانت أكبر إنتاجية جرّاح (827 كجم / س) مع استخدام سرعة دوران للاسطوانات 150 لفة / د وخلوص بين الأسطوانات 2 م ومساحة فتحة تغذية 45 سم².

2. متوسط حجم الجزيئات لنوى التمر المجروش تنخفض بزيادة سرعة استطوانات الجرّاح لكل الخصولات بين الأساطير، وتزيد مع زيادة الخصول بين الأساطير مع كل سرعات الدوران وفتحات التغذية المختلفة وكان أقل متوسط لحجم النوى المجروش (34,3 و/م³) مع استخدام سرعة دوران للإسطوانات 350 لفة / د وخلوص بين الأسطوانات صفر م ومساحة فتحة تغذية 37,5 سم².

3. الطاقة النوعية المطلوبة للجرّاح تزيد بزيادة سرعة استطوانات الجرّاح لكل الخصولات بين الأساطير وتنخفض مع زيادة الخصول بين الأساطير مع كل سرعات الدوران وفتحات التغذية المختلفة وكانت أقل طاقة نوعية مطلوبة (1,11 كيلو وات / كجم) مع استخدام سرعة دوران للقرص 150 لفة / د وخلوص بين الإسطوانات 2 م ومساحة فتحة تغذية 45 سم².