EVALUATION OF MACHINES USED FOR CRINA PROCESSING

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ABSTRACT

This study was carried out to compare and evaluate two different types of Crina processing machines (Pins and knifes systems). The experimental work was carried out at Dakahlia and Damietta governorates. The studied parameters included three different levels of feed rate (100, 120 and 140 kg/h) and three palm leaves moisture content (15, 35 and 50 %). The results showed that, increasing palm leaves moisture content from 15 to 50 % increased Crina fineness, machine productivity and total losses. While increasing feed rate from 100 to 140 kg/h increased Crina fineness, machine production and total losses at all levels of moisture content for the two machines tested. The Crina fineness, cost of production and net profit were increased, while the total losses were decreased for pin machine in comparison with the knife machine. However, the machine productivity was about the same for both machines.

In general, the pin type machine should be used at 140 kg/h feed rate and palm leaves moisture content of 35 % to obtain the best Crina fineness, machine productivity and the highest net profit.

INTRODUCTION

Date palms (Phoenix Dactylifeera, L.) are not only grown for their fruit, but for several other uses of their parts. The utilization of every part of the palm has been known for a long time among farmers. Leaflets of the palm are cut for weaving and plaiting. In Egypt, the palm leaflets famous process like a Crina by a very threading action on the palm leaflet. The Crina can be used for upholstery chairs and other furniture.

In Egypt, the local production number of palm tree were about 7.9 million trees. Each one produces about 142,200 ton leaves (leaflet) yearly (FAO, 1999). Badr (1995) in Arabic reference cleared that the palm leaves can be used to fill the choirs, mattresses and pillows if cut as a hair (Crina). He also noted that pruning the dry and disease leaves is very important for the growth of the pinnae.

Ibrahim and Mohamed (1997) in Arabic reference pointed that the objectives of pruning the palm tree is to:

1. built the palm frame.
2. replace the new-pinnae to the old.
3. utilize the palm residual in some processes.

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In the experiment, Sisal (*Agave sisalana*) and Henequen (*Agave fourcroydes*) leaves are cut at the base, fed between rollers that squeeze out most of the water and turn the soft tissues into an amorphous mush that is scraped away from the fibers. The fibers are hung in the sun to dry.

Several properties that are important to know about each fiber before that fiber can be used to reach its highest potential. Fiber dimensions, defects, strength, variability, crystallinity, and structure are some of the important considerations. *Fiber Dimensions* (fiber length and width) is important for comparing different kinds of fibers. A high aspect ratio (length/width) is very important in agrobased fiber composites as it give an indication of possible strength properties. The fiber strength is an important factor in selecting a specific agro-fiber for a specific application. The ultimate tensile strength of palm leaf is 98.14 (MPa) (Roger et al., 2000). El-Shaaer et al. (1993) in Arabic mentioned that the fineness in Egyptian cotton was about 0.00115 g/cm for fine varieties to 0.00175 g/cm for rough varieties. Adgoroye et al. (1990) explained that efficient packaging for transit and storage will decrease post-harvest losses, particularly in countries not using modern handling methods. They found that the tensile and compressive strength increased can be by using sun drying, this gave a good compromise between strength and cost.

The present work aims to study and evaluate two different types of local Crina processing machines (pins and knifes). The approach may lead to modify and improve these types of machines and increase their working performance, productivity and final quality.

MATERIALS AND METHODS

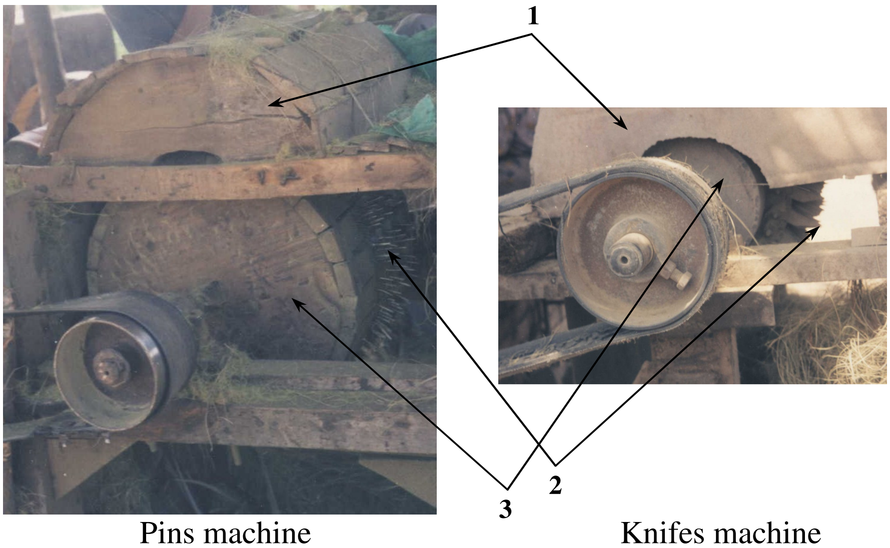
The experimental work was carried out at Dakahlia and Damietta governorates during 2003 and 2004 Crina seasons. The studied parameters were two different types of machines (pins and knifes), three different levels of palm leaves moisture content (15, 35 and 50 %) and three different levels of machine feed rate (100, 120 and 140 kg/h).

1- Preparation of palm leaves

The palm leaves were collected from Damietta governorate. The collected leaves were soaked in water pool for about 8-12 hours to increase the leaves moisture content prior to the threading process using the proposed machine.

2- Crina threading machines

Two traditional Crina processing systems (local manufacturing) were used. These systems included Pins and knife threading methods. The production method is preceded by threading the leaves through a set of iron pins or knifes fixed on a rotated drum. The technical data and specifications for the two studied systems are shown graphically and by drawing in Figs. (1) and (2) respectively. Their specifications are explained in Table (1).



Pins machine Knifes machine

Figure (1): Crina process machines.

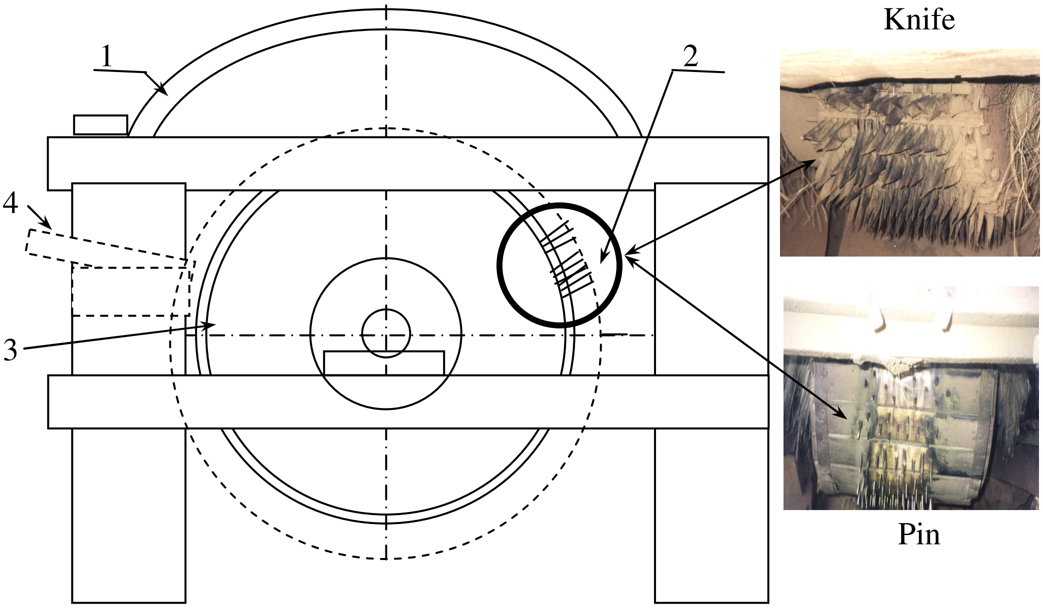


Figure (2): Sketch of the Crina process machine.

1- Machine concave 2-Effective part (pins or knife) 3- Machine drum 4- Feed inlet

Table 1: Specifications of pins and knives machines for Crina process.

Items	Pins	Knives
Drum diameter, cm	50	40
Drum speed, m/s.	15.70	12.56
No. of pins or knives	420	300
Feed inlet length, cm	32	26
Feed inlet width, cm	20	25
Feed inlet height, cm	7	6
Sheet cover length, cm	70	60
Sheet cover width, cm	50	53
Sheet cover height, cm	25	25

Measurements

1- Leaves moisture content:

The moisture content of the palm leaves was determined using an electric oven adjusted at (105 ^{o}C) for 24 hours. The leaves moisture content was estimated at Agric. Eng. Dept., Fac. of Agric., Mansoura Univ., and the moisture content percentage was calculated on a wet basis using the ASAE (1978) method:

$$M = \frac{Mw - Md}{Mw} \times 100 \qquad \text{.................. (1)}$$

Where

M = leaves moisture content, %
Mw = wet leaves mass, g
Md = dry leaves mass, g

2- Mass fineness

The mass fineness of threads was calculated for the different studied treatments using the following relationship (El-Shaaer et al., 1993) in Arabic reference:

$$MLC = \frac{TMCS}{ALS \times NS} \qquad \text{.................. (2)}$$

Where:

MLC = mass fineness, g/cm
TMCS = total mass of the cutting threads, g
ALS = average length of threads, cm
NS = number of threads

3- Energy requirements

The following formula was used to estimate the power requirement (P):

$$P = Fc\,\left(\frac{1}{60 \times 60}\right) P.F \times LCV \times 427 \times \eta_{th} \times \eta_{m} \times \frac{1}{75} \times \frac{1}{1.36}; \quad kW \quad \text{....... (3)}$$

Where:

Fc = the fuel consumption L/h

P.F = the fuel density, kg/L (for solar = 0.85)

L.C.V.= the lowest calorific value of fuel (k_{cal}/kg) average L.C.V of diesel is 11000 k_{cal}/kg)

η_{th} = the thermal efficiency of the engine, (considered to be about 35% for diesel engine)

427 = thermo-mechanical equivalent, kg.m/kcal

η_m = the mechanical efficiency of the engine, (considered to be 80% for diesel engine)

So, the energy can be calculated as following:

$$\text{Energy requirement} = \frac{\text{Engine power (kW)}}{\text{Production (kg/h)}} \quad \text{kW.h/kg} \qquad (4)$$

4- Cost estimation

Cost was estimated on the basis of the current costs and rates according to (El-Awady, 1979); (Notice that units are similar on both sides of the equation), and the machine could be used for Crina processing also water pool.

a- Fixed cost

The fixed costs generally included the depreciation, interest of investment, insurance, taxes, and shelter.

$$\text{Depreciation cost (D)} = \frac{\text{Initial price - Salvage value}}{\text{Useful life in hours}} \quad \text{LE/h} \qquad (5)$$

$$\text{Interest on the investment costs (I)} = \frac{\text{(initial price + salvage value)} \times \text{Interest rate}}{2\,\text{(annual working hours)}} \quad \text{LE/h} \qquad (6)$$

Interest rate has been assumed to be 14 %.

$$\text{Taxes, insurance and shelter (TIS)} = 2\,\% \times \text{Initial price} \quad \text{LE/h} \qquad (7)$$

$$\text{Total fixed costs} = \text{D} + \text{I} + \text{TIS}\,, \quad \text{LE/h/year} \qquad (8)$$

b- Variable cost

The variable costs (operating costs) commonly included the fuel, grease, lubricant, repair and maintenance, and labor. These costs were computed according to the operating time.

- Fuel cost (F) = Fuel consumption (L/h) × Price of fuel (LE/L) , (LE/h)
- Oil, grease and lubricant (OGL) can be taken as 15 % of the fuel costs
- Repair and maintenance cost (RM) = 60 – 70 % of the fixed costs
- Grease and daily services = 1 % of purchase price.
- Labor cost (L_a) = 0.94 × 3 = 2.8 LE/h.

$$\text{The total operating costs} = \text{F} + \text{OGL} + \text{RM} + \text{L}_a\,, \quad \text{LE/h} \qquad (9)$$

Machine costs = Fixed costs + Variable costs, LE/h (10)

RESULTS AND DISCUSSION

1- Mass fineness

Figures (3-A and 3-B) show the relationship between thread leaves (Crina) moisture content and the threads mass of 1.0 cm length (related to Crina fineness degree) at different feed rate. These Figures show that the increase in palm leaves moisture content from 15 to 50 % w.b decreases the palm leaves fineness degree from 0.00225 to 0.0152 g/cm and 0.00235 to 0.00161 g/cm for pins and knifes machines, respectively. Also, the increase in feed rate from 100 to 140 kg/h decreases the leaves fineness degree from 0.00215 to 0.00155 g/cm and 0.00225 to 0.00168 for pins and knifes machines, respectively.

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(A) Pin machine (B) Knife machine

Figure 3: The relationship between palm leaves moisture content and thread mass of 1 cm at different feed rate.

On the other hand, when comparing the fineness degree of the two types of Crina machines (pin and knife), it was clear that, the pin machine shows higher fineness degree as compared to knife machine at all levels of palm leaves moisture content and feed rate. The above mentioned results revealed that, the re-stroke by pin on palm leaves which cause the tearing action especially with higher leaves moisture content could increase the threads of leaves as compared to the splitting action of the knife machine.

2- Machine productivity

The machine productivity at different levels of palm leaves moisture content and feed rate are presented in Figure (4-A and 4-B) for pin and knife machines respectively. The figures show that the machine productivity decreases by increasing both the moisture content and the feed rate for the two traditional machines (pins and knife).

The machine productivity for the pin machine at a feed rate of 100 kg/h were 79.0, 70.0 and 63.5 kg/h for leaves moisture content of 15, 35 and 50 % respectively, while at 140 kg/h feed rate the corresponding values were 102.0, 90.0 and 83.7 kg/h respectively. On the other hands, the machine productivity for the knife machine at a feed rate of 100 kg/h were 85.0, 72.0 and 60.0 kg/h for leaves moisture content of 15, 35 and 50 % respectively and the corresponding values for 140 kg/h feed rate were 108.0, 90.0 and 72.0 kg/h respectively.

The total pins machine productivity was slightly higher by about 1.5 % than the knife machine. This means that, with increasing the palm leaves moisture content, the tearing action of pins or the splitting action of knife takes longer time to cause leaves threading due to the increased of leaves tenderness.

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(A) Pin machine (B) Knife machine

Figure 4: Effect of palm leaves moisture content on Crina machine productivity at different feed rate.

3- Crina losses

Figures (5-A and 5-B) illustrated that the Crina losses increased with the increase of leaves moisture content and feed rate for both types of machines. The machine losses for the pin machine at a feed rate of 100 kg/h were 21.00, 30.00 and 36.5 % for leaves moisture content 15, 35 and 50 % respectively, while at 140 kg/h feed rate the corresponding values were 27.10, 35.70 and 40.21 % respectively. On the other hands, the losses for the knife machine at a feed rate of 100 kg/h were 15.00, 28.00 and 40.00 % for leaves moisture content of 15, 35 and 50 % respectively and the corresponding values for 140 kg/h feed rate were 22.90, 35.71 and 48.57 % respectively.

The above mentioned results show that, for the pin machine the re-stroke cause high tearing action which increase the percentage of the very thin threads (more fineness degree) beside some thick threads which can not be re-processed by the machine that increased the total losses as compared to the knife machine

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(A) Pin machine (B) Knife machine

Figure 5: Effect of palm leaves moisture content on the percentage of Crina losses at different feed rate.

4- Energy requirement

Figure (6) shows that the energy requirement for the pin type machine at leaves moisture content of 15, 35 and 50 % were 27.882, 26.192 and 21.759 W.h/kg respectively and the corresponding values for the knife type machine were 22.229, 20.286 and 18.380 W.h/kg respectively.

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Figure 6: Effect of palm leaves moisture content on energy requirement for both machine types.

In general, even the splitting action of the knife machine requires lower energy consumption; it has lower action in fineness processing of Crina as compared to the tearing action of pin machine.

5- Cost analysis

From the fixed and variable costs, the hourly costs can be determined as shown in Table (2). From the table the total hourly cost were 15.873 and

15.129 LE for the pin machine and knife machine with a correspondence cost of 0.14 and 0.15 LE/kg respectively.

This could be attributed to the nearly similar fixed and variable costs of the two machines. However, the hourly net profit were about 8.187 and 3.371 LE for the pin and knife machines respectively. This difference could be attributed to the sealing cost/kg which is nearly double (58.83 %) for the pin machine which give higher quality of Crina with suitable fineness degree.

Table (2): Fixed and variable costs of pin and knife Crina machines.

Category	Pin machine	Knife machine
Fixed cost:		
Depreciation	0.0219	0.0188
Interest of investment	0.66	0.48
Taxes, insurance and shelter	0.00049	0.00042
Total fixed cost (LE)	0.682	0.499
Variable cost:		
Fuel cost	0.38	0.22
Oil, grease and lubricant cost	0.057	0.033
Repair and maintenance	0.324	0.447
Grease and daily services	3.5	3.0
Labor cost	2.8	2.8
Date palm leaves cost	8.13	8.13
Total variable cost (LE)	15.191	14.63
Total costs (LE/h)	**15.873**	**15.129**
Returns (LE/h)	**24.06**	**18.50**
Net profit (LE/h)	**8.187**	**3.371**

CONCLUSION

To obtain the optimum fineness degree of Crina and the highest productivity with the lowest percentage of losses and energy requirement, a machine feed rate of 140 kg/h and palm leaves moisture content of 35 % are recommended. Also the pin type machine showed better results as compared to the knife type machine.

This study recommended that the Crina machine should be developed to obtain the high at production without losses of palm leaves, to save the soaking water and to make it safe to use.

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الملخص العربى

تقييم الآلات المستخدمة فى تصنيع الكرينة

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تعتبر المنتجات الثانوية لأشجار النخيل من أهم المنتجات التى تقوم عليها العديد من الصناعات البيئية، وأهم هذه الصناعات المنتشرة فى جمهورية مصر العربية صناعة الكرينة. والتى يتم تصنيعها بتمشيط الخوص (وريقات النخيل) وتتم خطوات التصنيع بأن يتم نقع الخوص فى الماء ثم يمشط باستخدام آلات محلية الصنع (الالة ذات المسامير – الالة ذات السكاكين) وذلك للحصول على الياف الكرينة التى تسخدم فى حشو المقاعد فى الاثاث المنزلى.

ويهدف هذا البحث الى تقييم أداء آلتى تصنيع الكرينة حيث تمت الدراسة بمحافظتى الدقهلية (الآلة ذات المسامير) ودمياط (الآلة ذات السكاكين). وتم أختبار الآلتين عند ثلاث معدلات للتغذية (١٠٠، ١٢٠، ١٤٠ كجم/ساعة) وثلاث مستويات رطوبة للخوص (١٥، ٣٥، ٥٠ %) وكانت أهم النتائج المتحصل عليها كما يلى:

- عند زيادة رطوبة الخوص من ١٥ % إلى ٥٠ % أدى إلى زيادة درجة نعومة الكرينة الناتجة وزيادة الفواقد (كرينة ناعمة أو خشنة أزيد من المطلوب) وإنخفاض إنتاجية كلا الآلتين. وكان تأثير معدل التغذية طردياً مع كل من درجة نعومة الكرينة الناتجة وإنتاجية الآلة والفوافد وذلك فى كلا الآلتين ذات المسامير وذات السكاكين.
- وعند مقارنة أداء الآلتين تحت الدراسة لوحظ زيادة كل من درجة نعومة الكرينة والطاقة المستهلكة وتكاليف الإنتاج والعائد عند إستخدام الآلة ذات المسامير بينما إنخفضت قيمة الفواقد فى الآلة ذات السكاكين وكانت إنتاجية الآلتين متقاربة.

ومن البحث إستنتج أن أفضل أداء للآلة ذات المسامير بمعدل تغذية ١٤٠ كجم/ساعة عند خوص ذو نسبة رطوبة ٣٥ % وذلك للحصول على كرينة ذات جودة عالية (درجة نعومة) مع معدل إنتاجية وتكاليف مناسبة. ومن هذه الدراسة يوصى بإجراء تطوير هذه النوعية من الآلات للحصول على إنتاج أعلى فى الكم والكيف مع توفير بعض مستلزمات الإنتاج لما لها من أهمية (مثل ماء النقع، حوض النقع) يراعى فيها توفير عنصر الأمان والسلامة للعامل.

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