DEVELOPMENT AND EVALUATION OF A LOCAL OIL SEEDEXPLIER TO IMPROVE THE EXTRACTION EFFICIENCY

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ABSTRACT

In small-scale industries for dyeing and in medicines as anti-inflammatory substance. Seeds have been used as insecticide and oil extraction for fuel, soap and varnish production. Seed cake has been used as fertilizer, as solid fuel, or in biogas production. Non toxic varieties detoxified seed cake has been used as feed for animal.

An local oil extraction machine used to extract different varieties of oil seeds developed and evaluated to increase the extraction efficiency, and find the solution for the most problem of all oil press extraction machines that the high percentage of oil in cotton seed cake by use the press screw pitch of double flight, number of blades of 18 blades, development the machine head to control the clearance between machine head and press screw of 1, 1.5, 2 and 2.5mm, and studying the effect of press screw speed of 30, 60, 90 and 120 rpm on machine efficiency and final product quality. The optimum parameters and condition of machine were 32.43kg/ h machine productivity, 88.10 kW .h/ton energy requirement, 63.905 extraction efficiency, 11.08% oil extracted percentage, 6.51% oil percentage in cake, by using double flight press screw, clearance of 1.5mm, screw speed of 90 rpm and 18 blades number. The obtained results were very important for oil extraction industries that use the oil press method for oil extraction.

INTRODUCTION

Total Egyptian oilseed production declined in 2009/2010 by about 11 percent from the 2008/2009 level. However, total oilseed production is forecast to increase by 37 percent in 2010/2011 due to the expected increase in cotton production. Cotton is the major oilseed grown in Egypt.

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It is produced primarily for fiber, with oil and meal production being of secondary importance. The government sells cottonseed to farmers, at 3.60 LE/kg. Egypt’s annual oilseed crushing capacity is currently estimated at 1.8 million tons. About 60 percent of Egypt’s crushing capacity is owned by public sector companies. (Central Agency of Public Mobilization and Statistics 2010). Oil recovery from oil-seed is by one of four methods namely, the aqueous (or traditional) method, hydraulic pressing, screw pressing and solvent extraction. In the traditional method, the seed is ground into a paste, the paste is heated in boiling water and the mixture stirred periodically while it is being heated until the oil is seen floating on the meal-water mixture. The mixture is then allowed to cool off during which time oil is scooped off the top of the mixture, (UNIFEM 1987).

Herz (1997) reported that oil can be extracted mechanically with a ram press, an expeller or even a wooden mortar and pestle, a traditional method that originated in India. Presses range from small, hand-driven models that an individual can build to power-driven commercial presses. The ram press uses a piston inside a cage to crush the seed and force out the oil. Expellers have a rotating screw inside a horizontal cylinder that is capped at one end. The screw forces the seeds or nuts through the cylinder with gradually increasing pressure. The seed is heated by friction and electric heaters or a combination of the two. Once the cap is removed, the oil escapes from the cylinder through small holes or slots and the press cake, or meal, emerges from the end of the cylinder. Both the pressure and temperature can be adjusted for different kinds of feedstock. Oyinlola et al (2003) reported that, a model screw press was designed and fabricated. In the design of the screw press, the size of the screw material, the optimum shaft length for a given screw pitch, appropriate shaft speed, the tapering angle of the conical shaft, the maximum shaft diameter and the inside diameter of the enclosing barrel were determined. A shaft speed of not more than 90 rpm was found to be suitable for working the screw press while the clearance between the shaft and the barrel was 3 mm. Quality evaluation of the product showed that the acid
value, the saponification number and the peroxide value of the oil obtained from roasted peanut were lower than that obtained from fresh peanut, implying that oil expressed from roasted peanut is of better quality to the oil.

Mpagalile et al. (2005) designed a simple pressing mechanism was carried out using a vertical screw that was rotated by a gear system through a 12VDC motor connected to the solar PV panels. The press cylinder (Fig. 2) was made of a perforated 5mm thick mild steel cylinder with 10mm holes placed 5mm apart along its circumference. The cylinder was lined with a 2mm wire mesh on the inside. The frame was made up of four vertical solid mild steel rods of 50mm diameters while the press base was made up of a 200mm_600mm_12.7mm mild steel plate and was designed for better stability under possible uneven surfaces in villages. An average specific energy of 36.55 and 20.35 W.h/kg was recorded for peanuts and coconuts, respectively, after 12 min of pressing.

The objective of this study were:

1. Development of a local oil seed extraction machine to improve the extraction efficiency.
2. Determine the optimum screw press pitch, and screw speed, number of blades, and the clearance between the screw end and machine head that affect on extraction efficiency.
3. Reducing the percentage of oil in produced cotton seed meal cake.
4. Reducing the power requirements of this type of machines.

MATERIALS AND METHODS

Materials:

The oil extraction machine manufactured in small workshop in Zagzag-El Sharkia, and evaluated in Agriculture engineering research institute (AEnRI) Giza. Cotton oil seeds harvested in season of 2009-2010 used in this study, the nutrient composition of standard cotton oil seed meals resulting from solvent or mechanical extraction showed in Table (1).
Table (1): Nutrient composition of standard cotton oil seed meals resulting from solvent or mechanical extraction

| Nutrient composition of Cotton oilseed meals resulting from solvent or mechanical extraction |
|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| DM, % | CP, % | Fat, % | TDN, % | NEm, Mcal/lb | NEg, Mcal/lb | ADF, % | Ca, % | P, % |
| cotton seed meal, mechanical extraction, | 92.6 | 36.9 | 14.1 | 88 | 1.09 | 0.77 | NG | 0.6 | 1.02 |
| Cotton meal, solvent extraction | 89 | 49 | 1.2 | 84 | 0.94 | 0.64 | NG | 0.33 | 0.71 |

Specifications of a local developed extraction machine:

The oil extraction machine consists of:

1- **Machine base**: Machine base made from U shape steel bars has width of 50mm, highest of 30mm, and thickness of 10mm, the base has dimension of 1060 mm length, 350 mm width and 130mm highest. (Fig 1)

2- **Feeding hopper**: The feeding hopped of cotton seed made from steel sheet has thickness of 1mm, and upper diameter of 140mm, And bottom diameter of 80mm, the highest of feeding hopper were 130mm. (Fig 1)

3- **Extraction barrel**: The extraction barrel has cylindrical shape has 370 mm length, 80 mm diameter and 2mm thickness, the cylinder opening from the both sides the front end fixed with the extraction head, and the back end closed by bearing plate has diameter of 116mm, and thickness of 100mm, there are 8 holes has diameters of 12mm, for oil output. (Fig 1)

4- **Extraction screw press**: The extraction screw press, has length of 360mm, 30mm diameters, 40 mm diameters in bearings section, and
33.5mm pitch. the screw teeth has width of 10mm, and teeth deeps of 12mm. (Fig 2)

5- Extraction head: Extraction head has conk shape. The big diameter were 116mm, and the small were 95mm, (Fig 3).

Fig(1): Elevation of oil extraction machine

Fig(2): Extraction screw press
6- Power transmission and electric motors: The power transmitted from an electric 4 kW, 1400 rpm 3 vase, the electric motor shaft has pulley 120mm in diameter, connected with the screw pulley has diameter of 100mm by rubber belt 17 inch.

Methods:
An local oil extraction machine used to extract different varieties of oil seeds developed and evaluated to increase the extraction efficiency, by studying the effect of different operating parameters on machine efficiency and product quality such as:
1- Press screw pitch of double flight
2- Number of blades of 18 blades
3- Clearance between machine head and press screw of 1, 1.5, 2 and 2.5 mm
4- Screw speed of 30, 60, 90 and 120 rpm

Evaluation of extruder efficiency and product quality Performance

1- Extruder production rate was measured for each treatment by taking sample for 2 min after 10 min. of extruder running at steady condition
2- Specific mechanical energy (SME), was calculated as the following relation:

\[ Total \ consumed \ power, (kW) = \frac{\sqrt{3} \ I \ V \ \eta \ \cos\theta}{1000} \]
Where: \( I \) = Line current strength in amperes.
\( V \) = Potential difference (Voltage) being equal to 380 V.
\( \cos \theta \) = Power factor (being equal to 0.84).
\( \eta \) = Mechanical efficiency assumed (90 %).

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

\[
\text{Energy consumed} = \frac{P}{Q} = \text{kW.h/ton}
\]

Where: \( P \) = The consumed power for mixing ration, kW.
\( Q \) = Machinery line productivity, ton/h.

3- Extraction efficiency: was determined as per ASAE standards method DEC01(2000), at 3 replicates.

\[
\text{Efficiency (\%)} = \frac{W_o}{W_i} \times 100
\]

Where: \( W_o \) : oil mass after extcration (g),
\( W_i \) : oil mass in seed(g)

4- oil extracted percentage:

\[
\text{oil \& extracted (\%)} = \frac{W_o}{W_b} \times 100
\]

Where: \( W_o \) : Oil extracted mass (g),
\( W_b \) : Total sample mass(g)

5- Oil in cake percentage:

\[
\text{oil \& cake (\%)} = \frac{W_i - W_o}{W_i} \times 100
\]

6- Product thickness: was determined by digital scale

RESULTS AND DISCUSSION

Evaluation of oil press performance and product quality was carried out under the following items:.

1- Oil press Productivity:

Productivity of oil extraction machine one of the most important aim for any industries witch affecting the final product cost. Data in Fig. (4) indicated that the machine productivity increased from 19.61 to 24.25, 27.70 and 30.01 kg/h using 1mm clearance, from 24.10 to 28.98, 32.43 and 34.74 kg/h using 1.5 clearance, from 27.47 to 32.35, 35.80 and
38.11 kg\h. using 2mm clearance and from 32.93 to 37.81, 41.26 and 43.57 kg\h. using 2.5mm clearance under 18 number of blades and double flight screw.

The increase in machine productivity by increasing the screw speed from 30 to 60, 90 and 120 rpm could be due to the decrease in seeds retention time inside the expeller barrel, that increase the machine output in the time unit.

Data in Fig (4) showed that, expeller head the most important part in oil extraction machine with controlling the machine productivity and extraction efficiency, it is indicated that increasing the clearance between the pressing screw and machine head from 1 to 1.5, 2 and 2.5 mm increased the machine productivity from 19.61 to 24.1, 27.47 and 32.93 kg\h at screw speed of 30 rpm, from 24.25 to 28.98, 32.35 and 37.81 kg\h at screw speed of 60 rpm, from 27.7 to 32.43, 35.8 and 41.26 kg\h at screw speed of 90 rpm, and from 43.57 to 34.74, 38.11 and 30.01 kg\h at screw speed of 120 rpm.

The increase in machine productivity by increasing the head clearance from 1 to 1.5, 2 and 2.5 mm could be due to the increase in machine opening area that decrease the treatment consumed time.
2- Energy requirements:
Data in Fig (5) indicated that increasing the screw speed from 30 to 60, 90 and 120 decreased the energy requirements from 139.618 to 118.436, 106.55 and 101.333 kW.h/ton using clearance of 1mm, from 109.689 to 95.847, 88.102 and 84.819 kW.h/ton using clearance of 1.5mm, from 93.338 to 83.405, 77.182 and 75.232 kW.h/ton using clearance of 2mm and from 75.146 to 63.751, 65.153 and 68.995 kW.h/ton using clearance of 2.5mm.
The decreased in energy requirement by increase the screw speed from 30, 60, 90 and 120 rpm could be due to the high increase in machine productivity with low increase in power consumed, that decrease the energy requirements.

![Energy Requirement Graph](image)

**Fig(5): Effect of expeller screw speed, head clearance on energy requirements**

While same Fig(5) showed that increased the head clearance from 1 to 1.5, 2 and 2.5mm deceased the energy requirements from 109.689 to 139.618, 93.338 and 75.146 kW.h/ton. using screw speed of 30rpm, from 118.436 to 95.847, 83.405 and 68.995 kW.h/ton. using screw speed of 60rpm, 106.555 to 88.102, 65.153 and 77.182 kW.h/ton. using screw speed of 90rpm and from 101.333 to 84.819, 75.232 and 63.751 kW.h/ton. using screw speed of 120rpm. The decreased in energy requirements by
increase the machine head clearance from 1 to 1.5, 2 and 2.5 mm could be due to the increase in machine productivity and the decrease in power consumed by the decrease in motor load.

3- Extraction efficiency:
Data in Fig (6) indicated that increasing the screw speed from 30 to 60, 90 and 120 decreased the extraction efficiency from 68.509 to 67.875, 66.376 and 65.569% using clearance of 1 mm, from 66.030 to 65.396, 63.898 and 63.091% using clearance of 1.5 mm, from 60.612 to 62.803, 61.304 and 63.321% using clearance of 2 mm and from 57.039 to 59.229, 57.731 and 59.748% using clearance of 2.5 mm.

The decrease in extraction efficiency by increase the screw speed from 30, 60, 90 and 120 rpm could be due to the decrease in treatment retention time by the high screw speed.

On another hand, data in Fig (6) showed that increasing the clearance between the pressing screw and machine head from 1 to 1.5, 2 and 2.5 mm decreased extraction efficiency from 68.509 to 66.030, 63.321 and 59.748 % using screw speed of 30 rpm, from 67.875 to 65.396, 62.803 and 59.229% using screw speed of 60 rpm, from 66.376 to 63.898, 61.304 and 57.731 % using screw speed of 90 rpm, from 65.569 to 63.091, 60.612 and 57.039 % using screw speed of 120 rpm.

![Graph showing the effect of expeller screw speed and head clearance on machine extraction efficiency](image)

**Fig (6): Effect of expeller screw speed, head clearance on machine extraction efficiency**
4- Oil extracted percentage:
Data in Fig.(7) indicated that, the oil extraction percentage decreased slowly by increasing the screw speed from 30 to 60, 90 and 120 rpm, from 11.886 to 11.776, 11.516 and 11.376% using 1mm clearance, from 11.456 to 11.346, 11.086 and 10.946% using 1.5 clearance, from 10.986 to 10.896, 10.636 and 10.516% using 2mm clearance and from 10.366 to, 10.276, 10.016 and 9.896% using 2.5mm clearance under 18number of blades and double flight screw.
The decrease in oil extraction percentage by increasing the screw speed from 30 to 60, 90 and 120 rpm could be due to the decrease in seeds retention time inside the expeller barrel, that lead to increase in oil mass comes out with the cotton meal.

![Graph showing the effect of expeller screw speed and head clearance on oil extraction percentage.](image)

**Fig(7): Effect of expeller screw speed, head clearance on oil extraction percentage.**
Data in Fig (7) showed that, increasing the clearance between the pressing screw and machine head from 1 to 1.5, 2and 2.5 mm decreased the oil extraction percentage from 11.886 to 11.456, 10.986 and 10.366% at screw speed of 30 rpm., from 11.776 to 11.346, 10.896 and 10.276% at screw speed of 60 rpm, from 11.516 to 11.086, 10.636 and 10.016% at screw speed of 60 rpm and from 11.376 to 10.946, 10.516 and 9.896% at screw speed of 120 rpm. The decrease in oil extracted percentage by increasing the head clearance from 1to 1.5, 2 and 2.5 mm could be due to the increase in machine opening area that decease the treatment consumed time, lead to increase the oil percentage in cotton meal.
5- Oil in cake percentage:
Data in Fig. (8) indicated that, the oil in cake percentage increased by increasing the screw speed from 30 to 60, 90 and 120 rpm, from 5.71 to 6.22, 6.08 and 5.82% using 1mm clearance, from 6.14 to 6.25, 6.51 and 6.65% using 1.5 clearance, from 6.61 to 6.7, 6.96 and 7.08% using 2mm clearance, and from 7.23 to 7.32, 7.58 and 7.7% using 2.5mm clearance under 18 number of blades and double flight screw.
The increase in oil in cake percentage by increasing the screw speed from 30 to 60, 90 and 120 rpm could be due to the decrease in seeds retention time inside the expeller barrel, that lead to increase in oil mass comes out with the cotton meal.

![Graph](image)

**Fig(8):** Effect of expeller screw speed, head clearance on oil in cake percentage.

Data in Fig (8) showed that, increasing the clearance between the pressing screw and machine head from 1 to 1.5, 2 and 2.5 mm increased the oil in cake percentage from 5.71 to 6.14, 6.61 and 7.23% at screw speed of 30 rpm, from 5.82 to 6.25, 6.7 and 7.32% at screw speed of 60 rpm, from 6.08 to 6.51, 6.96 and 7.58% at screw speed of 60 rpm and from 6.22 to 6.65, 7.08 and 7.7% at screw speed of 120 rpm. The increase in oil in cake percentage by increasing the head clearance from 1 to 1.5, 2 and 2.5 mm could be due to the increase in machine opening area that decrease the treatment consumed time, lead to increase the oil percentage in cotton meal.
CONCLUSION

The experimental results reveal that performance of the developed local oil press screw extraction machine was in the optimum region under the following conditions:
1- Screw speed of 60-90 rpm
2-Clearance between the screw and machine head of 1-1.5mm
3- Double flight screw increased the machine extraction efficiency

REFERENCES

ويهدف هذا البحث إلى تطوير وتقييم آلية عصر حبوب زيتية محلية الصنع لرفع كفاءة استخلاصها عن طريق تطوير نظام العصر بها من البريمات المنفردة إلى البريمات المزدوجة وكذلك زيادة مساحة سطح التلامس بين الحبوب وسكاكين العصر بزيادة عددها في محيط اسطوانة العصر تصل إلى 18 سكينة وبالتالي زيادة عدد الجيوب بين السكاكين التي تساعد على خروج الزيت من الآلة سريعا وأيضا تطوير رأس الآلة لزيادة التحكم في الخلوص ما بين نهاية بريمة العصر وخروج الكسب باستخدام خلوص 1 مم و 1.5 مم و 2 مم و 2.5 مم على الترتيب وكذلك دراسة تأثير سرعة بريمة العصر على القياسات المختلفة باستخدام سرعات 30 و 60 و 90 و 120 لفة دقيقة.

وقد أشارت النتائج أن أفضل المعاملات بعد التطوير أعطت قياسات متزنة بين الإنتاجية والجودة كانت 34 و 22 كجم/ساعة و 88 كيلو وات ساعة طن طاقة مستهلكة و 90 و 90% كفاءة استخلاص و 8 و 8% نسبة الزيت المستخلص و 91 و 5% نسبة الزيت بالمكسب و 9 و 1 مم سمك الكسب المنتج وذلك عند معاملات 90 لفة إد سرعة بريمة العصر و استخدام الريمة مزدوجة الخطوة و خلوص 1.5 مم و عدد سكاكين 18 سكين.