

MODIFICATION AND EVALUATION OF A RECIPROCATING MACHINE FOR SHELLING PEANUT

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ABSTRACT

A reciprocating peanut sheller was fabricated as a multi-crop sheller to shell peanut, soybean, bean, etc.... (Helmy, 2001). It was constructed at the Ag. Eng. Workshop, Fac. of Ag., Kafr El-Sheikh Governorate and modified at the workshop of Rice Mechanization Center, Meet El-Deeba, Kafr El-Sheikh Governorate, Egypt. The present study was mainly carried out to evaluate the performance of a reciprocating peanut sheller before and after modification by supplying the sheller with feeding mechanism (conveyor belt), increasing the friction area of shelling box, and using rubber for enhancing shelling process.

The experimental results showed that, the performance of a reciprocating peanut sheller after modification is better than, that before modification. Where, the value of shelling efficiency after modification was of 98.85%, damaged seeds of 1.36%, unshelled seeds of 1.15%, total losses of 2.51%, sheller productivity of 155.98×10^{-3} Mg/h, unit energy consumption of 2.87kW.h/Mg, cleaning efficiency of 99.06% and criterion cost of 42.17LE/Mg at feed rate of 160kg/h, box speed of 1.4m/s, moisture content about 17.12%d.b. and air velocity of 8.37m/s.

But before modification shelling efficiency was of 95.32%, damaged seeds of 6.12%, unshelled seeds of 4.68%, total losses of 10.8%, sheller productivity of 89.20×10^{-3} Mg/h, unit energy consumption of 3.47kW.h/Mg, cleaning efficiency of 98.88%, and criterion cost of 84.93LE/Mg at feed rate of 100kg/h and the other studied operating conditions.

INTRODUCTION

Kittichai (1984) developed a power-operated groundnut sheller. He found that the best performance of the sheller was achieved at 20mm clearance and shelling bar speed of 180rpm.

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At these parameters the machine capacity, shelling efficiency and percentage of breakage were 210.5kg-kernels/h, 98% and 5.3% respectively. The power consumption of the sheller ranged from 1.0 to 1.1kW. **Gore et al. (1990)** classified the groundnut shellers, depending on their power source, into manually operated and power-operated. Based on shelling action, the shellers could be classified into reciprocating type and continuous or rotary type. The manually operated groundnut shellers could be classified into three subclasses a) semi rotary type sheller, b) hand-operated sheller with shelling cylinder which was rotated by hand, and c) foot operated sheller. **Abou El-Kheir and Shoukr (1993)** studied the effect of some operating parameters of sheller and natural properties of crop material on shelling efficiency. The increase in number of drum beaters from 4 to 8 increased the number of hits per unit time and increased shelling efficiency from 74 to 80.6% at drum speed of 1.83m/s and from 87 to 92.5% at drum speed of 4.58m/s. Shelling efficiency, using rubber drum, was less than that of both steel and wooden drum. **Singh (1993)** tested two types of concave in manual sheller, the first was wire mesh concave and the second was slotted grate. Shelling capacity with wire mesh concave was higher (86kg/h) compared to that of slotted grate (60kg/h). This is due to increased opening area. For wire mesh concave the shelling efficiency ranged from 83 to 89% compared to the slotted type, which ranged from 82 to 84%. Also, the percentage of breakage ranged from 3.7 to 6.7% and from 8.4 to 12.6% for wire mesh and slotted grate respectively. **Younis et al. (1997)** developed a peanut sheller. Results of the modified sheller evaluation indicated that breakage was reduced from 57 to 54%, cleaning efficiency increased from 67 to about 96%, and separation efficiency increased from 28 to 93% compared to the original sheller. The total loss was also decreased from 57 to about 4% compared to the original sheller.

Helmy (2001) designed, built and evaluated a reciprocating sheller to study the effect of some operating parameters on shelling peanut from the pods. He concluded that, the peanut shelling efficiency was 95.44% at about 17.12%d.b. moisture content when the box speed, the clearance and feed rate were 1.4m/s, 18mm and 80kg/h respectively. The lowest value of total cost of 64LE/Mg was obtained at the same operating conditions.

The specific objectives of the present study are directed to the following:

- a) To specify the optimum conditions of peanut sheller before and after modification.
- b) To increase the sheller productivity.
- c) To reduce the total losses percent.
- d) To lower costs per production unit.

MATERIALS AND METHODS

The reciprocating peanut sheller has two function units for shelling and cleaning. The main parts of peanut sheller are shown in Fig. 1. The sheller consists of the following parts:

Feeding and shelling box was constructed from wood and steel sheets. The two walls of the box were adjusted to obtain the proper slope for sliding the samples smoothly towards the feed opening. The feed rate of sample could be controlled through two gates fixed on the sides of the feed box walls. The bottom section of the shelling box was provided with fixed wooden strips for enhancing shelling process. The shelling box was driven by using a crank having a radius of 5cm. That results in box stroke length of 10cm. Meanwhile, the box speed was changed by using different pulleys varying in their diameters. To determine the reciprocating speed of the shelling box, the crank rotational speed was measured by a tachometer expressed in rpm, and it was converted to a linear velocity in terms of m/s.

The shelling screen was fixed under the feed box and the clearance between the feed box and shelling screen could be adjusted by using four bolts moving the screen in perpendicular direction. The screen is of 45cm length and 35cm width and made of a number of wooden strips with the dimensions of 2x3x30cm.

The blower (centrifugal type) has four straight blades and two inlet openings. The inlet openings is of circular shape of 28.5cm diameter, while the outlet opening is of rectangular shape of 16x39cm. On the two inlets, there were two gates for controlling airflow rate. Air velocity was measured by using a digital vane-probe anemometer (Model: BREMI-BRI 5080-USA), which reads the velocity directly in m/s. The frame was constructed from wood, steel angles and steel sheets. The machine is powered by electric motor.

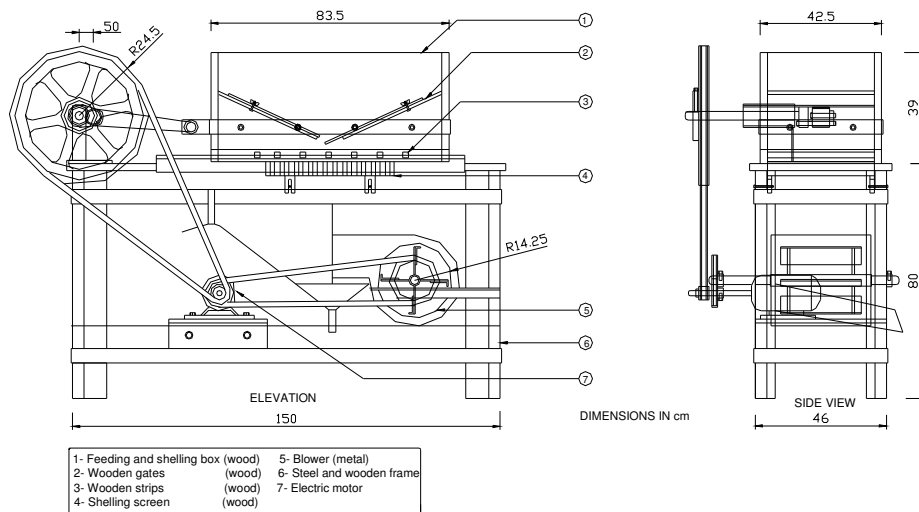


Fig. 1: Elevation and side view of the reciprocating peanut sheller before modification.

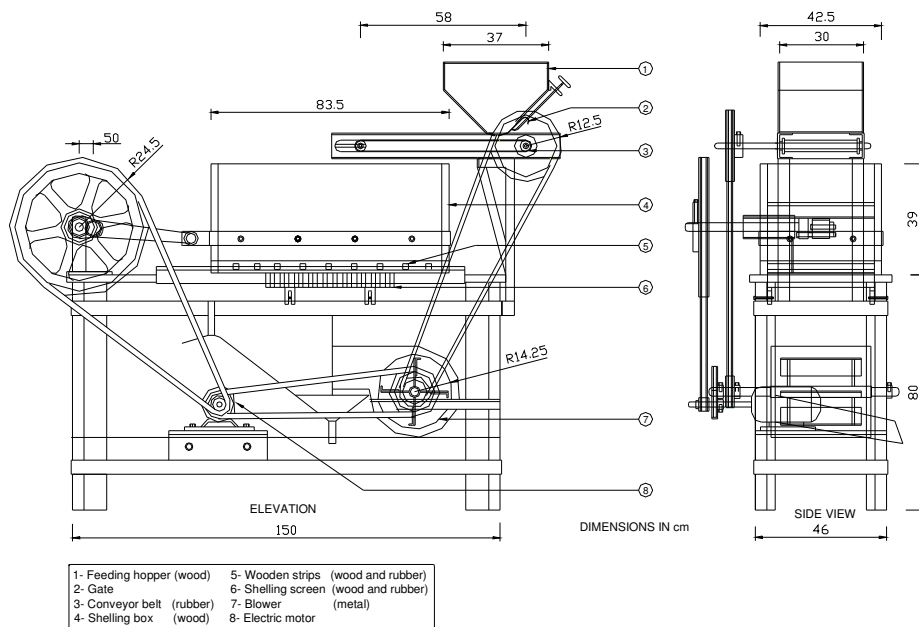


Fig. 2: Elevation and side view of the reciprocating peanut sheller after modification.

MODIFICATION:

- The two gates in shelling box were eliminated and altered by a conveyor belt to increase the total friction area of shelling box and facilitate the feeding rate.

- The numbers of wooden strips of shelling box were doubled to increase the total friction area. While the wooden strips of shelling screen and shelling box were covered by rubber to minimize seed damage (Fig. 2).

The dimensions of pods and seeds forms are considered important as limiting factors in passing the seed and the hull between the screen strips grate holes and in determination of clearance between box bottom and separating screen. For all experiments, this clearance was selected at constant value of 18mm according to study of the physical properties of the same variety by **Helmy, 2001**. The studied parameters were; three levels of moisture content (11.6, 17.2 and 23.52%d.b.), three levels of box speed before and after modification (1.0, 1.4 and 1.7m/s), three levels of feed rate before modification (80, 100 and 120kg/h) and after modification (140, 160 and 180kg/h) and three levels of air velocity (6.25, 8.37 and 10.11m/s). All the experimental treatments were repeated three times and the averaged values of the investigated parameters were taken.

The technical indices in the present investigation were determined as follows: Moisture content of peanut pods was calculated according to **ASAE, 1989** as follows:

$$\text{Pods moisture content, \%} = AC + BD \dots\dots\dots 1$$

Where:

- A moisture content of seeds, %;
- C seeds in average, %;
- B moisture content of hull, % and
- D hulls in average, %.

Total shelling losses are defined as the sum of the damage percentage and unshelled seeds. They were determined according to relations used by **Gore et al., 1990**:

$$\text{Damage percentage, \%} = \frac{\text{Mass of damaged seeds}}{\text{Total mass of seeds}} \times 100 \dots\dots\dots 2$$

$$\text{Unshelled seeds percentage, \%} = \frac{\text{Mass of unshelled seeds}}{\text{Total mass of seeds}} \times 100 \dots\dots\dots 3$$

Shelling efficiency was determined according to the formula by **El-Sayed, 1992**:

$$\text{Shelling efficiency, \%} = 1 - \frac{\text{Mass of unshelled seeds}}{\text{Total mass of seeds}} \times 100 \dots\dots\dots 4$$

Ammeter and voltmeter were used for measuring the current strength and potential difference respectively. Readings of Amperes and Volts were taken before and during each treatment. The power consumption was calculated by using the following formula (**Lockwood and Dunstan, 1971**):

$$\text{Total power consumption, kW} = \frac{\sqrt{3}}{1000} (I.V.\cos\theta.\eta) \dots\dots\dots 5$$

Where:

I current strength, Amperes;

V potential difference, Volts;

$\cos\theta$ power factor, decimal (being equal to 0.71) and

η mechanical efficiency of motor assumed to be 80%.

The unit energy requirement was calculated by using the following equation:

$$\text{Unit energy requirement, kW.h / Mg} = \frac{\text{Total power consumption (kW)}}{\text{productivity (Mg / h)}} \dots\dots\dots 6$$

Cleaning efficiency was determined according to the formula:

$$\text{Cleaning efficiency, \%} = 1 - \frac{\text{Mass loss of cleaning seeds}}{\text{Total mass of cleaning seeds}} \times 100 \dots\dots\dots 7$$

The total (criterion) cost of the sheller operating was estimated by using the following equation (**Awady et al., 1978**):

$$\text{Total cost, LE / Mg} = \text{unit operating cost} + \text{unit worth of shelling losses} \dots\dots\dots 8$$

Unit operating cost was determined by using the following equation:

$$\text{Unit operating cost, LE / Mg} = \frac{\text{Sheller cost (LE / h)}}{\text{productivity (Mg / h)}} \dots\dots\dots 9$$

Peanut sheller costs were determined as follows:

FIXED COSTS:

a) Depreciation:

Declining balance method was used to determine the depreciation (**Hunt, 1983**). In this method the depreciation value is different for every year of the machines life. Depreciation value was determined by using the following equation:

$$D = V_n - V_{n+1}, L.E./Yr. \dots\dots\dots 10$$

$$V_n = P \left(\frac{L-X}{L} \right)^n, L.E./Yr. \dots\dots\dots 11$$

$$V_{n+1} = P \left(\frac{L-X}{L} \right)^{n+1}, L.E./Yr. \dots\dots\dots 12$$

Where:

- D value of depreciation charged year, $(n+1)$;
- P purchase price, L. E.;
- L time between buying and purchasing, Yr.;
- n number representing age of the machine in year at the beginning of year;
- V remaining value at any time and
- X ratio of depreciation rate for used machine (the maximum rate is 1.5).

b) Interest on investment, shelter taxes and insurance:

They were estimated as 12% of the remaining value.

OPERATING COSTS:

a) Repairs and maintenance:

For machinery, repairs and maintenance is about 7% as a percent of purchase price.

b) Electricity cost. c) Lubricant cost. d) Labor cost.

RESULTS AND DISCUSSION

PERFORMANCE OF PEANUT SHELLER:

In order to establish the optimum operating conditions for the peanut sheller before modification, Fig. 3 illustrates the total shelling losses and productivity as affected by shelling box speed at various feeding rates. It is revealed that the optimum operating conditions for the sheller before modification were obtained at feed rate of 100kg/h and shelling box speed of 1.4m/s. While after modification, Fig. 4 illustrates that total shelling losses and productivity as affected by shelling box speed and various feeding rates. It is seen that the optimum operating conditions for the sheller after modification were obtained at feed rate of 160kg/h and shelling box speed of 1.4m/s. However, the suitable moisture content of peanut pods was about 17.12%d.b. for the sheller before and after modification.

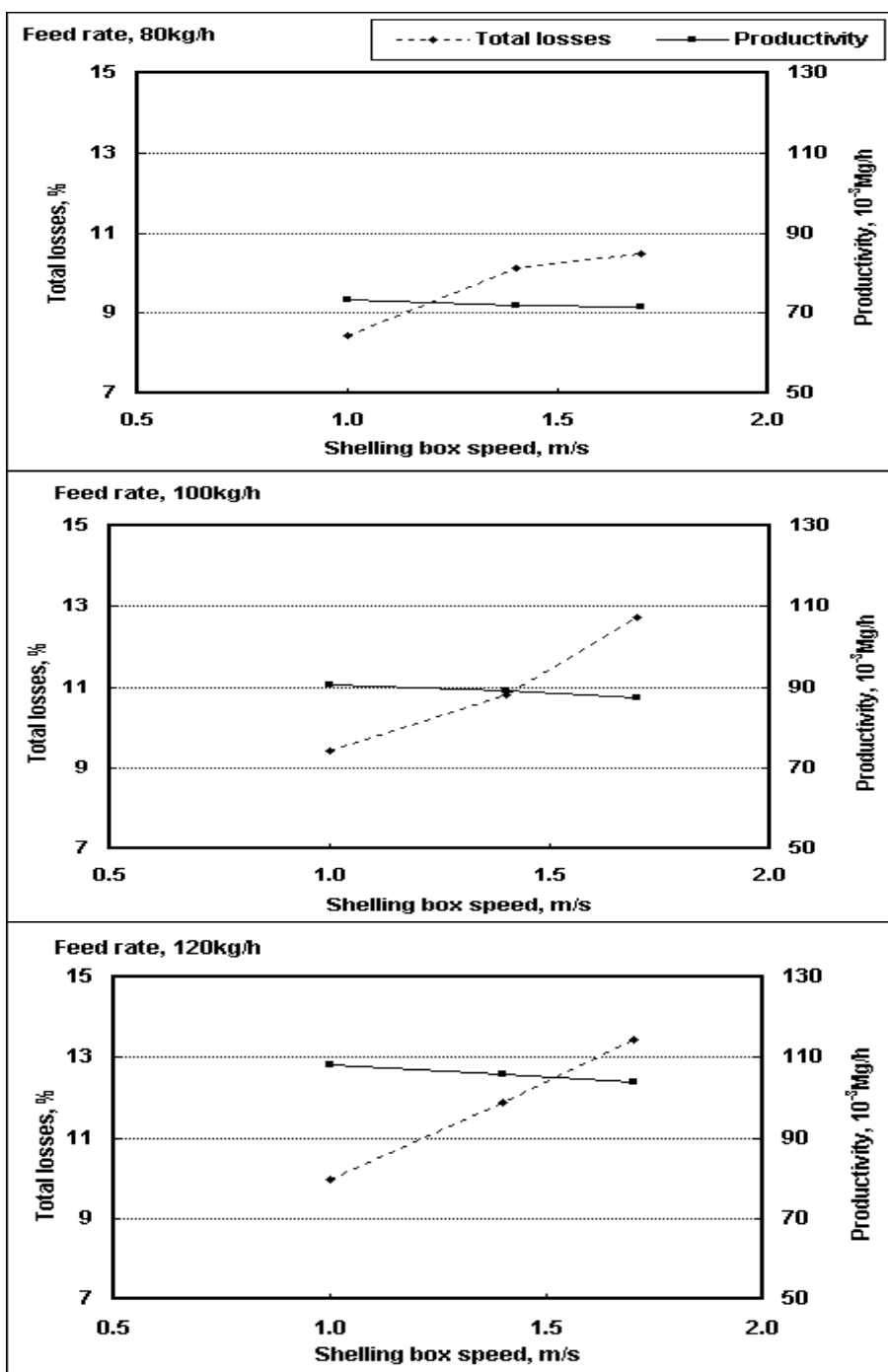


Fig. 3: Effect of shelling box speed on total losses and productivity before modification at pods moisture content about 17.12%d.b. and various feeding rates.

TOTAL LOSSES:

The damaged seeds percentage was increased by increasing feed rate for the sheller before and after modification. The damaged seeds ranged from 5.55 to 7.13 and 1.25 to 1.54% at feed rate ranges of 80-120 and 140-180kg/h, box speed of 1.4m/s and moisture content about 17.12%d.b. for the sheller before and after modification respectively. The percentage of damaged seeds for the sheller after modification is less than that before modification. This may be due to that before modification: box speed was unqualified to cover feed rate successfully. After modification: the conveyor belt controlled the feed rate to meet the box speed in the proper time, decreasing unshelled and damaged seeds.

The unshelled seeds percentage was increased by increasing feed rate for the sheller before and after modification. The unshelled seeds ranges were 4.56-4.73 and 1.08-1.14% at feed rate ranges of 80-120 and 140-180kg/h at box speed of 1.4m/s and moisture content about 17.12%d.b. for the sheller before and after modification respectively. The percentage of unshelled seeds for the sheller after modification is less than that before modification. This may be due to the conveyor belt, which gave more uniformity of feeding rate in comparison with gate system.

The total losses (damaged + unshelled seeds) percentage was also increased by increasing feed rate for the sheller before and after modification. The total losses ranges were 10.11-11.86 and 2.33-2.68% at feed rate ranges of 80-120 and 140-180kg/h at box speed of 1.4m/s and moisture content about 17.12%d.b. for the sheller before and after modification respectively (Fig. 5).

SHELLING EFFICIENCY:

Shelling efficiency of peanut sheller was decreased by increasing feeding rate before and after modification. The shelling efficiency ranged from 95.44 to

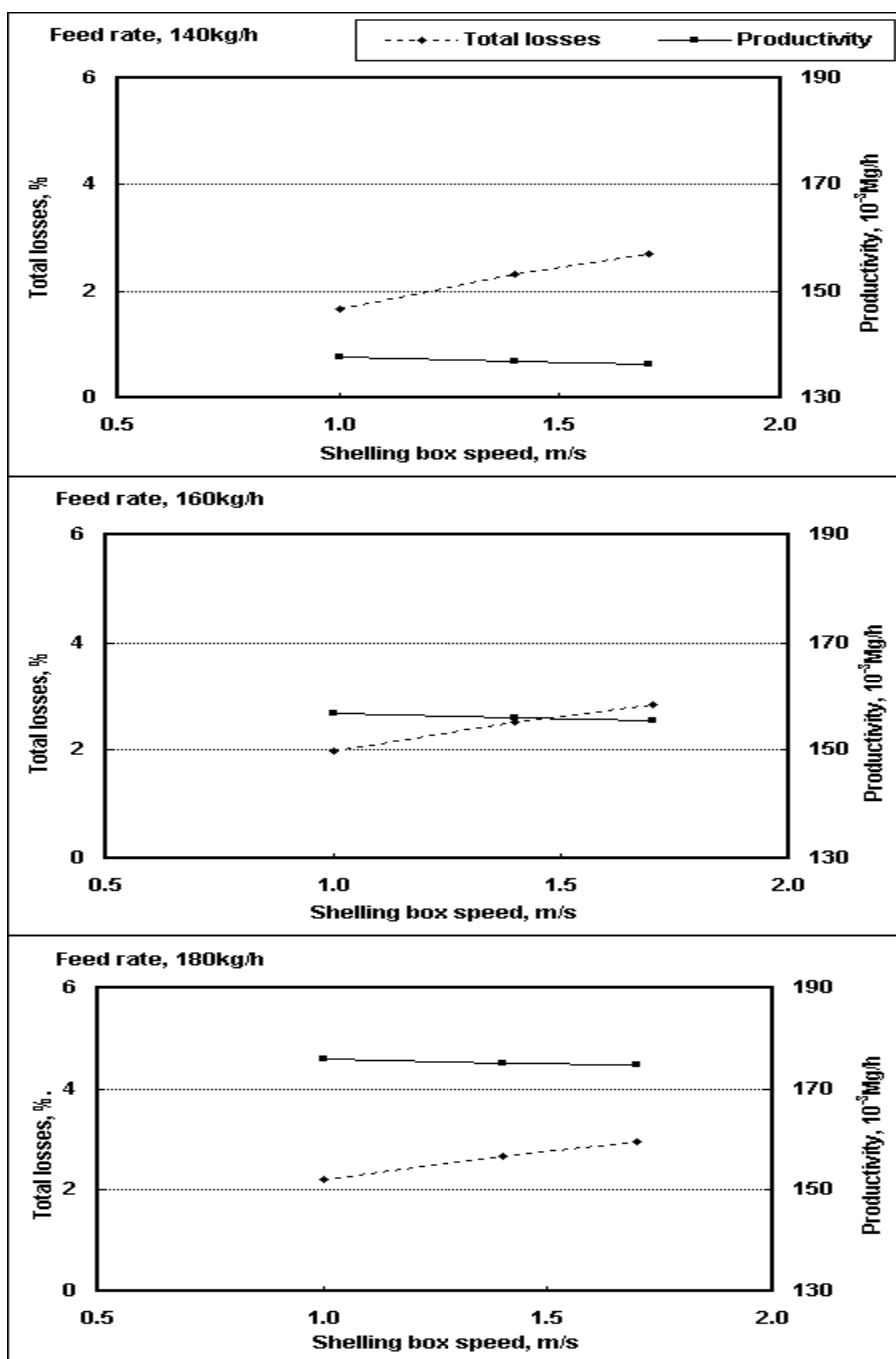


Fig. 4: Effect of shelling box speed on total losses and productivity after modification at pods moisture content about 17.12%d.b. and various feeding rates.

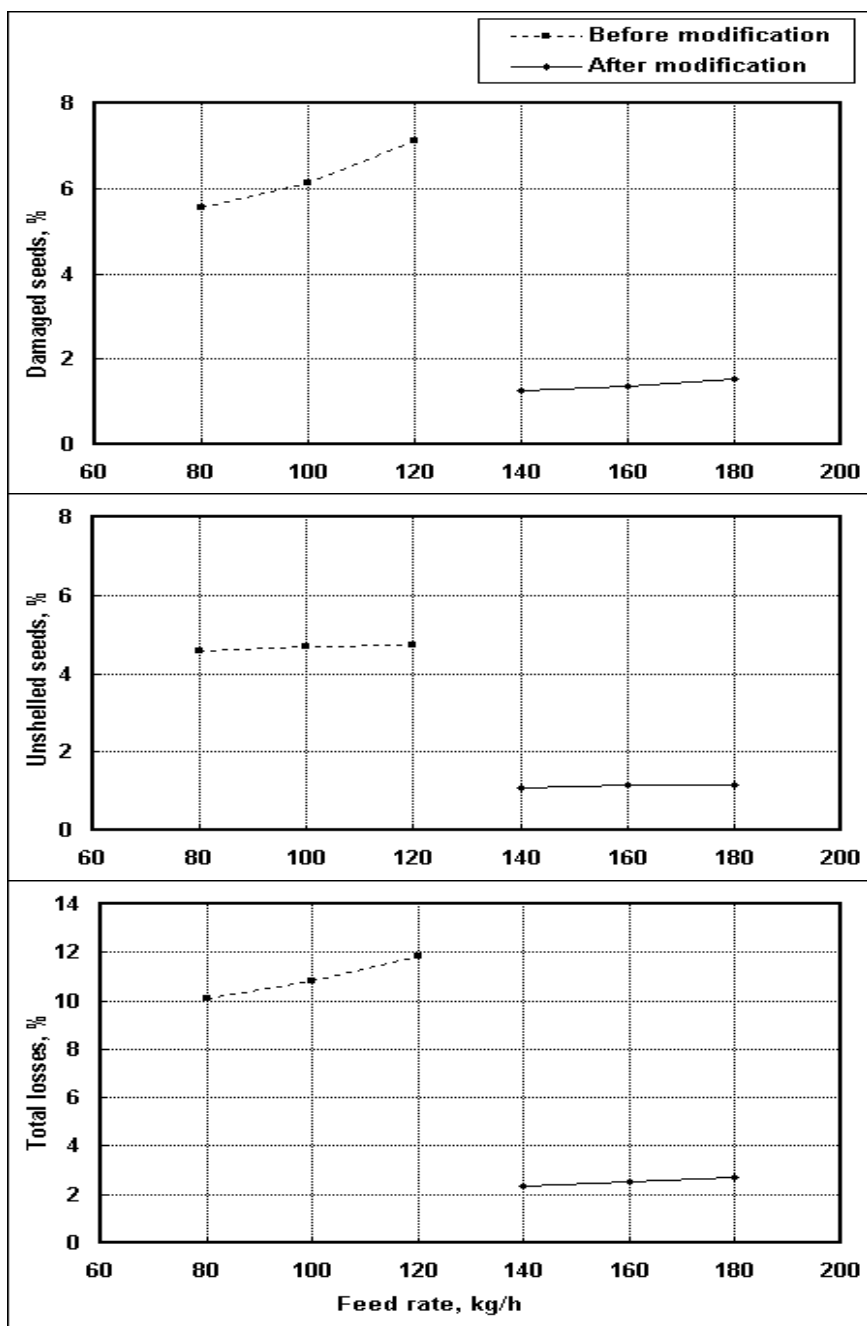


Fig. 5: Effect of feeding rate on damaged, unshelled seeds and total losses for the sheller before and after modification at pods moisture content about 17.12%d.b. and shelling box speed of 1.4m/s.

95.27 and 98.92-98.86% at feed rate ranges of 80-120 and 140-180kg/h at box speed of 1.4m/s and moisture content about 17.12%d.b. for the sheller before and after modification respectively (Fig. 6). Increase of shelling efficiency after modification can be attributed to the existing of the conveyor belt, which increases the chance of pods to stay more time on the box strips as result shelling efficiency increase and increasing the friction area of shelling box.

ENERGY REQUIREMENTS:

Unit energy values were increased by increasing feed rate for the sheller before and after modification. The unit energy ranges were 3.36-3.68 and 2.71-2.95kW.h/Mg at feed rate ranges of 80-120 and 140-180kg/h at box speed of 1.4m/s and sheller moisture content about 17.12%d.b. before and after modification respectively (Fig. 7). The reduction in sheller unit energy values after modification can be attributed to the increase of sheller productivity.

CLEANING EFFICIENCY:

Cleaning efficiency was decreased by increasing feed rate for the sheller before and after modification. The cleaning efficiency ranged from 99.01 to 98.79 and 99.17 to 98.93% at feed rate ranged from 80 to 120 and 140 to 180kg/h at box speed of 1.4m/s, air velocity of 8.37m/s and moisture content about 17.12%d.b. for the sheller before and after modification respectively (Fig. 8). Increase of sheller cleaning efficiency after modification may be due to uniformity of feeding rate by using conveyor belt.

COST ANALYSIS:

Table 1 summarizes the economical cost for producing one megagram of peanut seeds. The total cost was deduced to determine the cheapest operating conditions. It can be concluded that the lowest value of total cost of 84.93LE/Mg for the sheller before modification was obtained at feed rate of 100kg/h, box speed of 1.4m/s and moisture content about 17.12%d.b. While after modification, the lowest value of total cost of 42.17 LE/Mg was obtained at feed rate of 160kg/h under the same operating conditions.

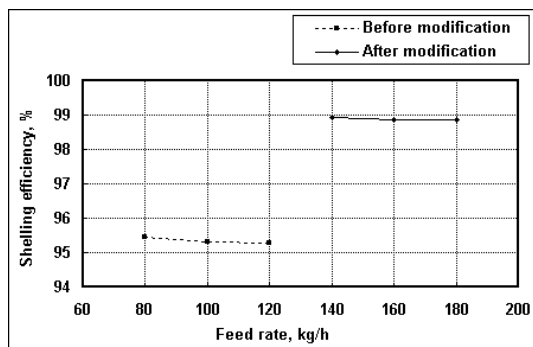


Fig. 6: Effect of feeding rate on shelling efficiency at pods moisture content about 17.12%d.b. and shelling box speed of 1.4m/s.

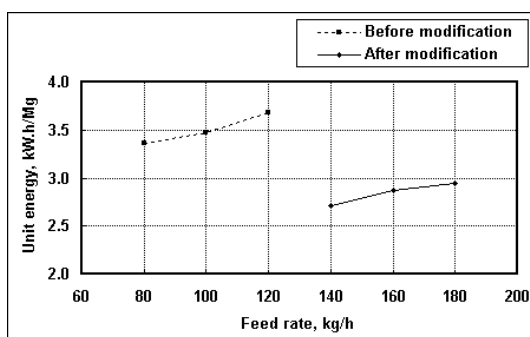


Fig. 7: Effect of feeding rate on unit energy at pods moisture content about 17.12%d.b. and shelling box speed of 1.4m/s.

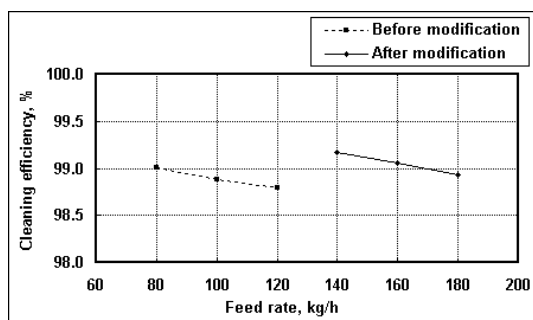


Fig. 8: Effect of feeding rate on cleaning efficiency at pods moisture content about 17.12%d.b., shelling box speed of 1.4m/s and air velocity of 8.37m/s.

Table 1: The economical cost for producing one megagram of peanut seeds.

| Sheller machine | Feed rate, kg/h | Sheller productivity, Mg/h | Sheller operating cost, LE/h | Unit operating cost, LE/Mg | Total shelling losses, LE/Mg | Total cost, LE/Mg |
|---------------------|-----------------|----------------------------|------------------------------|----------------------------|------------------------------|-------------------|
| Before modification | 100 | 0.08920 | 4.14 | 46.41 | 38.52 | 84.93 |
| After modification | 160 | 0.15598 | 4.36 | 27.95 | 14.22 | 42.17 |

CONCLUSION

For the duration of the current investigation, the main results gained are concluded in the following two points:

1. The performance of a reciprocating peanut sheller after modification was better than that before modification because the productivity was increased and the total losses (damaged + unshelled seeds) were decreased.
2. The applied recommendations for operating the reciprocating peanut sheller before and after modification can be concluded in the following:

| Performance parameter | Value | | Increasing (+) or reduction (-), % |
|--|------------------------|-------------------------|------------------------------------|
| | Before modification | After modification | |
| Moisture content, %d.b. | 17.12 | 17.12 | - |
| Clearance, mm | 18 | 18 | - |
| Box speed, m/s | 1.4 | 1.4 | - |
| Air velocity, m/s | 8.37 | 8.37 | - |
| Feed rate, kg/h | 100 | 160 | +60.0 |
| Productivity, Mg/h | 89.20×10^{-3} | 155.98×10^{-3} | +74.9 |
| Damaged seeds, % | 6.12 | 1.36 | -77.8 |
| Unshelled seeds, % | 4.68 | 1.15 | -75.4 |
| Total losses (damaged +unshelled seeds), % | 10.80 | 2.51 | -76.8 |
| Shelling efficiency, % | 95.32 | 98.85 | +3.7 |
| Unit energy, kW.h/Mg | 3.47 | 2.87 | -17.3 |
| Cleaning efficiency, % | 98.88 | 99.06 | +0.18 |
| Criterion cost, LE/Mg | 84.93 | 42.17 | -50.3 |

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- نشرة وزارة الزراعة (2004).** خدمة زراعة الفول السوداني في الأراضي القديمة والجديدة، مركز البحوث الزراعية، البرنامج القومي للمحاصيل البقولية.

الملخص العربي

تعديل وتقييم أداء آلة ترددية لتقشير الفول السوداني

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يعتبر محصول الفول السوداني من المحاصيل التي تدر عائداً نقدياً سريعاً للمزارع حيث يعتبر من محاصيل التصدير الهامة حيث يستهلك حوالي 65-70٪ من الناتج محلياً ويصدر منه 30-35٪ (نشرة وزارة الزراعة ، 2004). لذلك استهدف هذا البحث إضافة تعديل على آلة ترددية لتقشير الفول السوداني مصنعة محلياً لتقليل الفاقد الكلي وزيادة إنتاجيتها وذلك بإضافة سير ناقل للتغذية وزيادة مساحة الاحتكاك لعملية التقشير وتغطية شرائح الاحتكاك الخشبية بالكاوتشوك. وكذا تم دراسة بعض العوامل المؤثرة على أداء الآلة لاختيار أنسب ظروف التشغيل قبل وبعد التعديل كالاتي:

- المحتوى الرطوبي للفول السوداني (11.6 ، 17.12 ، 23.52٪ على أساس جاف).
- سرعة صندوق التقشير قبل وبعد التعديل (1 ، 1.4 ، 1.7 م/ث).
- معدل التلقيم قبل التعديل (80 ، 100 ، 120 كج/س) وبعد التعديل (140 ، 160 ، 180 كج/س).
- سرعة هواء التنظيف قبل وبعد التعديل (6.25 ، 8.37 ، 10.11 م/ث).

وقد تم التوصل للنتائج التالية:

أداء الآلة بعد التعديل أفضل حيث ارتفعت كفاءة التقشير من 95.32 إلى 98.85٪ وكفاءة التنظيف من 98.88 إلى 99.06٪ وكذا إنتاجية الآلة من 0.0892 إلى 0.1559 ميجا جرام/ساعة ، وانخفضت قيم تلف الحبوب الميكانيكي من 6.12 إلى 1.36٪ والحبوب غير المقشورة من 4.68 إلى 1.15٪ ، كما انخفضت تكلفة إنتاج واحد ميجا جرام من حبوب الفول السوداني المقشور من 84.93 إلى 42.17 جنيهاً مصرياً وكذا قيمة وحدة الطاقة المستهلكة من 3.47 إلى 2.87 كيلووات. ساعة / ميجا جرام وذلك عند معدل تلقيم 160 كج/س وسرعة صندوق التقشير 1.4 م/ث وسرعة هواء التنظيف 8.37 م/ث ومحتوى رطوبي 17.12٪ على أساس جاف.

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