A STUDY ON SEPARATION AND CLEANING OF PEANUT SEEDS

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ABSTRACT

The present study was conducted to investigate some engineering parameters affecting separating and cleaning efficiencies for improving sieve unit to be more appropriate for the Egyptian varieties of peanut seed. To achieve this goal, experimental unit was fabricated and constructed in the workshop of Agric. Eng. Dep., Fac. of Agric., Suez Canal Univ., Ismailia, Egypt. Some physical and mechanical properties of seeds such as (length, width, thickness and coefficient of friction) were investigated. Four sieve oscillations (250, 275, 300 and 325 cpm), six sieve inclination angles (4°, 2° upward, zero, 2°, 4° and 6° downward) and four feed rates (15, 20, 25 and 30 kg/hr.cm) were studied under aeromechanical separation. The obtained results inducted that, the minimum separation and cleaning efficiencies were 30.0 and 92.5%, respectively at sieve oscillation of 250 cpm, feed rate of 30 kg/h.cm under sieve inclination angle of 4° upward with no seed loss. Meanwhile the maximum separation and cleaning efficiencies were 95.0 and 96.8%, respectively at sieve oscillation of 325 cpm, feed rate of 15 kg/h.cm under sieve inclination angle 6° downward with high seed loss of about 13.8%. To keep seed loss less than 0.5% with adequate separation and cleaning efficiencies about 90.9, 95.8% respectively, prefer to sieve oscillation of 300 cpm with zero inclination angle, and feed rate of 15 kg/h.cm.

Keywords: *Seeds and shell peanut; Physical and mechanical properties; Aeromechanical separation; Sieve oscillation; Sieve inclination angle; Feed rate; Seed losses; Separation and cleaning efficiency.*

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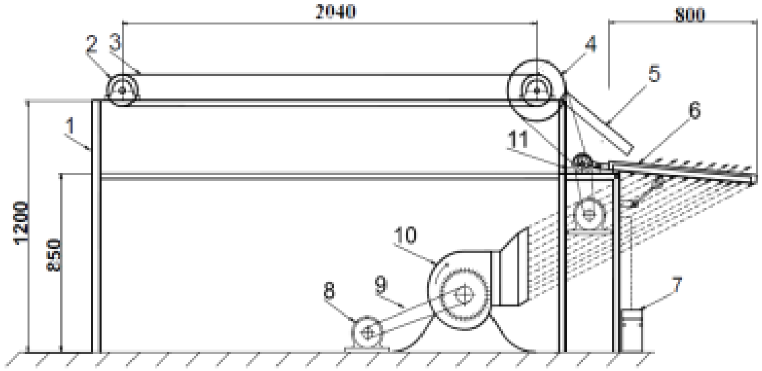
INTRODUCTION

In Egypt, peanut ranked second place in terms of relative importance of total oil crop production after cotton seed, it produces about 205 thousand tons of peanut pods from149 thousand feddans. Ismailia is ranked the third Governorate with 14 thousand feddan, which yielded 22 thousand tons **(CAPMAS, 2014)**. Separating and cleaning of peanut seeds are considered the most important post harvest process for reducing the problems during planting, cultivating, seed storage, drying and food processing. **El Fawal *et al.* (2009)** and **Nikku *et al.* (2014)** reported that, the shape and size of seed are considered in selecting type and dimension of the screen perforation (mechanical separation). **El Gamal (2009)** found that the shape and size of peanut seeds were affected by seed moisture content**.** The coefficients of friction (μ) between shelling component and sieve surface is very helpful in predicting critical sieve oscillation at which the relative movement of the particle begins as **(Fouda, 2011)**. **Chakraverty *et al.* (2003)** mentioned that, in aero-mechanical cleaning mechanisms, the assistance of air is mainly utilized: to remove light materials, to assist in moving the particles on the perforated sieves, and to move the particles caught in the opening of perforated sieves during the oscillation process. **El-Sayed *et al.* (2001)** conducted an experiment to record preliminary information on the aerodynamic properties of peanut shelled components of the Egyptian variety (Giza-5) in order to develop a suitable separation device able to separate seeds from shells with minimum loss. They concluded that the terminal velocity value of shells is lower than that of seeds and the terminal velocity value of 5.9 m.s^{-1} sufficient to remove all shells from the peanut seeds without loss and 7.4 m.s^{-1} with only a 1.8% loss of intact and split seeds at seed moisture content 8% (w.b.). **Sabbah (2007)** studied various aperture size and various aperture shape to separation peanut seed (Giza 5) from shell and recommended that sieve with round aperture of 14 mm is properly to separate peanut seeds from shells without any losses of seeds. For modern cleaning sieve the amplitude of oscillation is ranged between 17-38 mm and screen oscillation ranged between 4.3 to 6 Hz (258 – 360 cpm) cycles per minute **(Kutzbach and Quick, 1999)**. **Sahay and Singh (1994)** recommended that, to precision seed cleaner and adequate cleaning capacity, sieve inclination angle must be ranged from 4 to 12°. **Werby (2010)** stated that, as increasing sieve oscillation and inclination purity of clover seed. This increase may be due to increased movement of threshed material fast on the sieve giving less chance for straw and impurities to pass through the grain spout by increasing sieve oscillation and inclination, in the same time this increase in sieve oscillation and inclination aim to increase in losses of seed behind sieve, this losses increased for the last same reason. **Sahay and Singh (1994)** reported that, the length of screen should be between 2 to 3 times its widths. In additional, increasing the length of the screen will increase screening efficiency by improve the probability of under size particles in the stratified top layer approaching the screen surface and pass through aperture (**Gupta and Yan, 2006**). **Hanna *et al.* (2010)** studied some parameters affecting cleaning of fennel seeds at inclined sieve oscillation. And they found that by increased feed rate from 6 to 24 kg/ h. per cm of sieve width the seed cleanliness decreased by 4.93% at crank speed 250 rpm, sieve angle 8.5 degrees and amplitude 20 mm. In cleaning unit airflow should be even across the width of the sieve and decrease strongly from front to rear of the sieve. In addition of that the airflow should ideally be angled as steeply as possible, i.e., 30 degree in the winnowing **(Kutzbach and Quick, 1999)**. The objective of this study was to investigate some operation parameters in order to develop a suitable separation and cleaning unit to be more appropriate for the Egyptian varieties of peanut seed.

MATERIALS AND METHODS

Experimental unit:

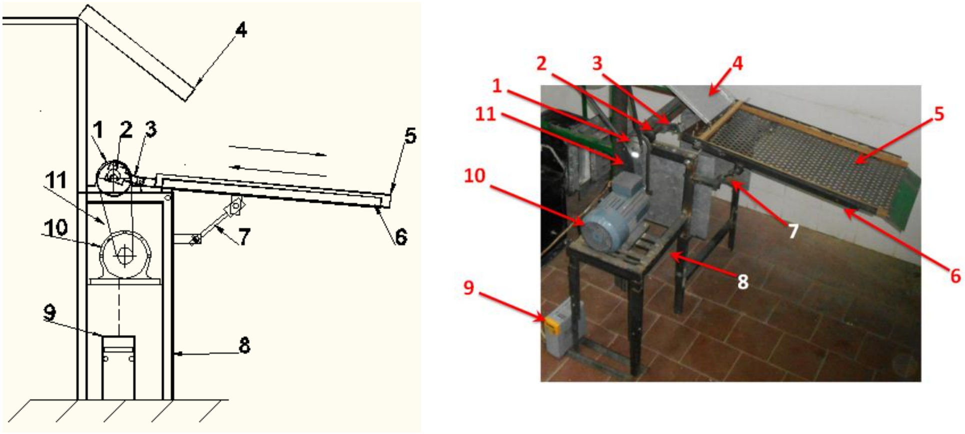
The experimental unit was fabricated and constructed in the workshop of the Department of Agricultural Engineering, Faculty of Agriculture, Suez Canal University as shown in **Fig. (1)**. The unit consisted of three main parts; conveyor belt, sieve and air blower. The conveyor belt was constructed to control the feed rate of shelling product components of peanut to the sieve surface. The conveyor frame was manufactured from steel with dimensions of (2260 x 650 x 1200 mm) for length, width and height, respectively. Feeding slot with width of 260 mm was fitted with angle of 30° in-front and below the feed conveyor to deliver the shelling components to screen surface.



1.Frame 2.Sprocket 3.Feeding conveyor belt
4. Pulley 5.Feeding slot 6.Sieve
7.Speed controller 8.Electric motor 9.Belt
10.Air blower 11.Crank oscillator

Fig. (1): Schematic diagram of separation unit.

The sieving unit consists of a single sieve with 14 mm round aperture. The sieve net length and width are 720x360 mm, respectively. The sieve was fitted on changeable inclined frame which connected to sieve frame by bolts to change the angle of sieve inclination as shown in **Fig. (2)**. This sieve inclination angle was measured by digital angle meter with accuracy (±0.1°) and range (0-360°). The sieve is coupled to a crank joint to affect the reciprocating motion of the sieve; the amplitude of the sieve is about 17.5 mm. This eccentric shaft is driven by an electric motor 2 hp (1.5 kW). The speed of the crank shaft was adjusted and controlled by an electric speed controller (650 G, Parker Co., England). The crank rotation speed was measured by a digital tachometer with accuracy (± 0.1 rpm). The air stream is supplied by a centrifugal fan which was fitted below the sieve, this fan delivers air beneath and up through the sieve. It is driven by a single phase electric motor 2 hp (1.5 kW). At the outlet of air blower there is a flow straightener to improve air velocity distribution and air deflectors placed on angle 30° with horizontal. To determine air velocity out from air blower by the air velocity meter (Model, TM-414).



(a) Schematic diagram of sieving unit. (b): Configuration of sieving unit.

1. Pulley 2.Crank oscillator 3.Connecting rode
4.Feeding slot 5.Sieve 6. Sieve slider track
7. Sieve inclination control 8.Main frame 9. Speed controller
10. Electric motor 11.Belt

Fig. (2): Sieving unit.

Physical and mechanical properties of peanut seeds:

Peanut pods variety (Giza-5) used in this study were provided by Ismailia Agricultural Research Station, Ismailia, Egypt. Moisture content of seed was 12% (w.b.) and of shell was 17% (w.b.). Physical properties of peanut seeds were measured to know sieve type and aperture size suitable for separation of peanut. A random sample of 200 seed with moisture content (12% w.b.) was taken randomly from shelled peanut and were measured by digital caliper with accuracy 0.01 mm, three main dimensions of the seeds were measured the major diameter (L), the intermediate diameter (W) and the minor diameter (T) as shown in Table (1). The minor diameter was taken perpendicular to the intermediate and major diameter. The following formula was used to calculate the percent of sphercity of an individual seed according to **Mohsenin (1987**):

$$\text{Sphericity} = \frac{(\text{abc})^{1/3}}{\text{a}} \qquad (1)$$

Where:

a : longest intercept (mm);
b : longest intercept normal to a (mm) and
c : longest intercept normal to a and b (mm).

Table (1): Some physical properties of peanut seeds (variety Giza-5).

Physical properties	Range		Average	SD	CV
	Min.	Max.			
Length (L), mm.	14.54	23.30	19.10	1.64	8.60
Width (W), mm.	6.17	11.98	9.24	1.09	11.77
Thickness (T), mm.	5.23	9.91	8.36	0.87	10.38
Mass (M), gm.	0.20	1.20	0.79	0.18	22.91
Sphercity, (S),%	49.42	71.67	59.65	4.14	6.93

Friction coefficients of peanut shelling components under study were measured using a laboratory slope-meter apparatus to determine suitable operation parameters for seed separation. The percentage of open area was taken into consideration. The angle of tilt was recorded by a digital angle meter. The coefficient of friction was calculated by the following formula:

$$\mu = \tan\varphi \qquad (2)$$

Where:

μ: coefficient of friction and
φ: angle of friction (degree).

Operation parameters

The following operation parameters were studied: four levels of sieve oscillation (250, 275, 300 and 325 cpm), four specific feed rates (15, 20, 25 and 30 kg.h^{-1}.cm^{-1}) and six sieve inclination angles (2, 4, 6° downward, Zero, 2 and 4° upward). A sample of peanut pods was shelled in shelling machine which was constructed by **El-Sayed (1992)** and developed by **Abd El-Kader (1998)** and the output of shelling product was collected and spread uniformly on the surface of conveyor belt. The feed rate was controlled by changing the quantity of mixture over conveyor belt. The sieve oscillation and sieve inclination angle was adjusted, then the experiment was started by operating the fan for a few seconds till stable air blower rotation, then the motor of unit (sieve oscillation and conveyor belt) was switched on to keep a machine under working condition for period time (1 min.). The seed and shell screened through sieve aperture were caught in a wooden collector positioned below the sieve to collect the material from different regions of the sieve. The seed and shell in each box were collected manually separately then weighted by electronic balances with accuracy ±0.005 gm and weighted to 150 gm. The height of fall, 500 mm from the sieve to collector was such that enough resident time in the air stream is achieved for peanut shelling components interaction with the air stream. The rejected material and material remain over sieve surface, which consists of shell and amount of seed were collected, separated and determined. The cleaning efficiency and grain losses were calculated according to **Simonyan and Yiljep (2008)** by the following formula, respectively:

$$\eta = \frac{G_0}{G_0 + G_{cg}} \times 100 \qquad (3)$$

$$C_L = \frac{G_i}{G_w} \times 100 \qquad (4)$$

Where:

η : cleaning efficiency (%);
G_0 : pure grain (kg);
G_{cg}: contaminant with cleaned grain (kg);
C_L : grain losses (%);
G_i : grain at shell outlet (kg) and
G_w: grain at input (kg).

The separation efficiency was calculated according to **Panasiewicz *et al.* (2012)** on the basis of the following formula:

$$\eta_{index} = \frac{b}{b_0} \times 100 \qquad (5)$$

Where:

η_{index} :separation effectiveness index (%);
b :the content of contaminant in the fraction collected at the end of the sieve (kg) and
b_0 :the content of contaminant in the input material (kg).

RESULTS AND DISCUSSION

Physical properties of peanut seeds:

The average of (L), (W) and (T) were 19.10, 9.24 and 8.36 mm, respectively and their frequency distribution curves were presented in **Fig. (3)**. The seed shape is useful in chose appropriate sieve aperture shape for separation seed from shell. The results showed that, the peanut seed shape is oblong due to the sphercity of 99% of seeds under study are less than 70% as shown in **Fig. (4)**, therefore the round aperture sieve is more appropriate for separation peanut seed from shell **(Vaughan *et al.*, 1968).** The aperture diameter should be more than maximum seed width by 10% as **(Kepner *et al.*, 1980)** recommended. The result showed that, to separate peanut seeds from shells without any losses of seeds the suitable aperture diameter must be about 13.20 mm. In addition of that the seed dimensions are useful in determine sieve motion type (oscillation or vibration). The oscillation motion is more appropriate for sieve motion due to that the aperture diameter is more than half of maximum seed length according to **Beunder and Rem (1999).**

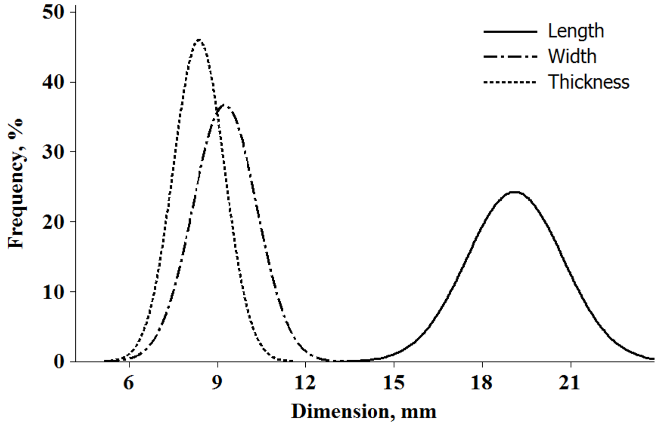


Fig. (3): Frequency distribution of peanut seeds dimension.

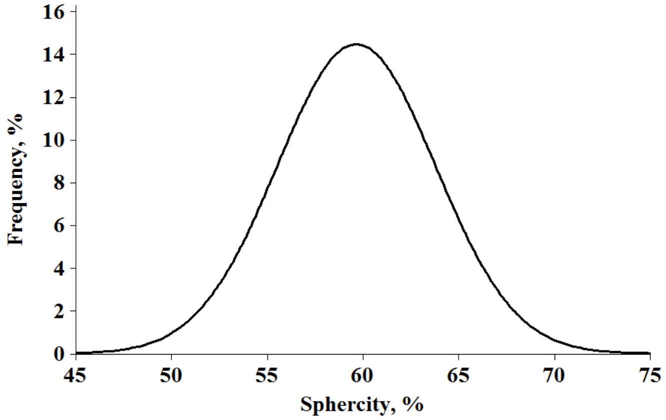


Fig. (4): Frequency distribution of peanut seeds sphercity.

Table (2) presented the static friction coefficients of the peanut shelling product (seed, shell and pods) on different stainless steel perforated surfaces type with apertures size (14, 10, 8; 6 mm for round aperture and 10x21, 8x20, 7x27; 5x20 mm for oblong aperture).

Table (2): Coefficient of friction (µ) as mean ± standard division of shelling component against different round and oblong sieve aperture size.

Aperture size, (mm)	Open area, (%)	Aperture direction	Coefficient of friction (µ)		
			Peanut shelling component		
			pods	seed	shell
Round aperture					
14	34.00	-	0.68±0.02	0.45±0.04	1.04±0.09
10	46.00	-	0.72±0.03	0.71±0.04	1.47±0.16
8	27.16	-	0.61±0.04	0.44±0.03	1.02±0.08
6	38.00	-	0.68±0.04	0.51±0.03	1.07±0.06
Oblong aperture					
10×21	40.27	Parallel	0.67±0.03	0.64±0.03	0.92±0.02
		Perpendicular	1.13±0.10	0.64±0.03	1.13±0.08
8×20	39.70	Parallel	0.60±0.03	0.57±0.04	0.91±0.03
		Perpendicular	0.81±0.06	0.78±0.07	1.05±0.04
7×27	33.00	Parallel	0.58±0.03	0.50±0.03	0.90±0.17
		Perpendicular	0.77±0.06	0.55±0.03	1.06±0.07
5×20	21.00	Parallel	0.37±0.03	0.41±0.03	0.88±0.08
		Perpendicular	0.44±0.02	0.41±0.01	0.85±0.07

Table (2) showed that when open area percentage decreased the friction coefficient of shelling component against sieve surface decreased. In addition of that at all sieve oblong aperture; the friction coefficient of shelling component against sieve surface with perpendicular oblong aperture is more than parallel aperture.

Separation and cleaning of peanut seed:

Feed rate

The percentage of seed loss increased as feed rate increased from 15 to 30 kg/h.cm at all sieve oscillations and all sieve inclination angles as presented in **Fig. (5)**. Generally when the sieve oscillations increase the effect of feed rates on percentage of seed loss increased. The lowest seed losses were at the inclination angle 4° upward and they were increased to 0.1, 0.3 and 0.9% when the feed rate increased from 15 to 30 kg/h.cm at 275, 300 and 325 cpm, respectively. The highest seed losses were at the inclination angle 6° downward and they were increased to 4.4, 6.0, 20.4 and 22.4% when the feed rate increased from 15 to 30 kg/h.cm at 250, 275, 300 and 325 cpm, respectively. Generally the effect of feed rate on seed losses increased when sieve inclination angle decreased from 4° upward to 6° downward. At sieve oscillation of 325 the percentage of seed losses increased from 0.5 to 0.9, from 1.7 to 2.7, from 2.7 to 7.6, from 5.8 to 9.6, from 9.8 to 11.0 and from 13.8 to 22.3% when the feed rate increased from 15 to 30 kg/h.cm at sieve inclination angles 4°, 2° upward, zero, 2°, 4° and 6° downward, respectively. This result may be due to at the high feed rates, segregation of shell and seed was not evident; the material seemed more compacted and seed loss with shell at the end of the sieve. These results agree with **(Hershbarger, 2008).**

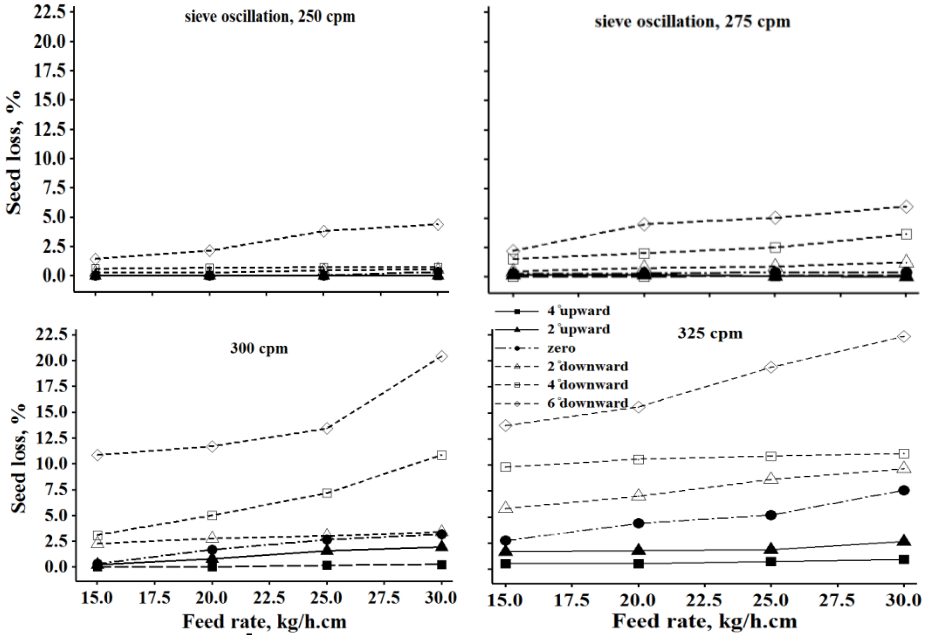


Fig. (5): Relationship between feed rate and seed loss at different levels of sieve inclination angle and sieve oscillation.

Figure (6) showed that, the percentage of separation efficiency decrease when feed rates increase from 15 to 30 kg/h.cm at different levels of sieve oscillation and sieve inclination angle. The highest separation efficiency was at the inclination angle 6° downward and they were decreased from 90.6 to 88.4, from 92.7 to 90.5, from 93.5 to 90.9 and 95.0 to 91.4% when the feed rate increased from 15 to 30 kg/h.cm at 250, 275, 300 and 325 cpm, respectively. Meanwhile, The lowest separation efficiency was at the inclination angle 4° upward and they were decreased from 77.2 to 30.0, from 80.9 to 33.8, from 83.2 to 40.7 and from 91.6 to 77.5% when the feed rate increased from 15 to 30 kg/h.cm at 250, 275, 300 and 325 cpm, respectively in addition of that sieve inclination angles 2° upward and zero take the same trend.

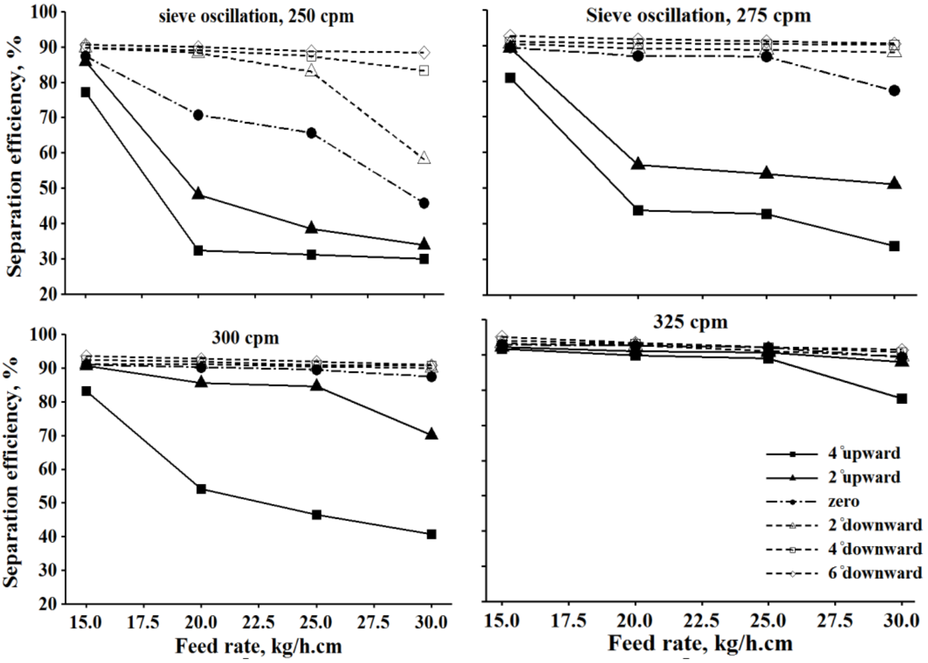


Fig. (6): Relationship between feed rate and separation efficiency at different levels of sieve inclination angle and sieve oscillation.

Figure (7) showed the relationship between feed rate and separation efficiency at different levels of sieve inclination angle and sieve oscillation. The effect of feed rate on cleaning efficiency was very slightly this may be due to that the main factor affecting on cleaning efficiency was air stream. The highest percentages of cleaning efficiency were 96.9, 96.4, 96.0 and 95.4% at sieve oscillation 325 cpm and at feed rates 15, 20, 25 and 30 kg/h.cm, respectively at sieve inclination angle 6° downward. On the other hand, the lowest percentages of cleaning efficiency were 94.8, 94.1, 93.0 and 92.5% at sieve oscillation 250 cpm and feed rates 15, 20, 25 and 30 kg/h.cm, respectively at sieve inclination angle 4° upward. Higher feed rates creates a thick layer of material on sieves, which causes low separation and cleaning efficiency because the fan cannot supply enough air to the sieve to ensure complete separation of shell, these results agree with **Hanna *et al.* (2010)**. The best feed rate was 15 kg/h.cm.

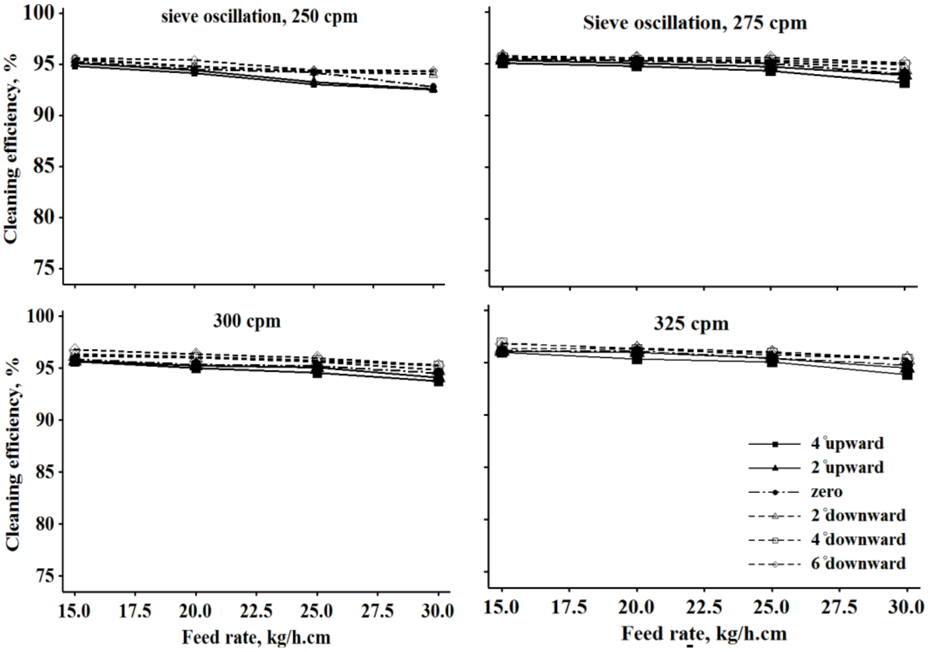


Fig. (7): Relationship between feed rate and cleaning efficiency at different levels of sieve inclination angle and sieve oscillation.

Sieve oscillation

As shown in **Fig. (8a)** the percentage of seed loss increased when sieve oscillation increased at feed rate 15 kg/h.cm and all sieve inclination angles. Increasing sieve oscillations from 250 to 325 cpm had non to very slightly affect on percentage of seed loss at feed rate 15 kg/h.cm and at sieve inclination angles 4°, 2° upward and zero. At other sieve inclination angles there were gradually increase in seed loss when sieve oscillation increased from 250 to 325 cpm at all feed rates. The seed losses were increased from 0.0 to 0.9, 0.0 to 1.7, 0.0 to 2.7%, 0.3 to 5.8, 0.6 to 9.8 and from 1.4 to 13.8 at sieve inclination angles 4°, 2° upward, zero, 2°, 4° and 6° downward respectively when the sieve oscillations increased from 250 to 325 cpm at feed rate 15 kg/h.cm. The reason of increasing seed losses when sieve oscillation increased was at high oscillation the seed have sufficient momentum to jump over and not pass through the aperture, then go away with shell at the end of sieve, these results agree with **(Arafa *et al.*, 2009)**.

Figure (8b) presented that, the percentage of separation efficiency increase slightly when sieve oscillations increase at feed rate 15 kg/h.cm and different levels of sieve inclination angle. For instance the highest separation efficiency were increased from 90.6 to 95.2 at sieve inclination angle 6° downward when the sieve oscillation increased from 250 to 325 cpm at feed rate 15 kg/h.cm. Meanwhile, the lowest separation efficiency was increased from 77.2 to 91.6 at sieve inclination angle 4° upward.

Figure (8c) illustrated that, there were a slightly increase in cleaning efficiency when sieve oscillation increase at feed rate 15 kg/h.cm and different levels of sieve oscillation. The highest percentages of cleaning efficiency were 95.6, 95.7, 96.7 and 96.8% at sieve oscillations 250,275, 300 and 325 cpm, respectively at feed rate 15 kg/h.cm and sieve inclination angle 6° downward. That may be referred to by increasing sieve oscillation the movement of shelled materials on the sieve increased and there is no chance for shell to pass thought the aperture with seed. These results were in agreement with **(Arfia, 2006)**. The best sieve oscillation was 300 cpm.

Sieve inclination angles

As shown in **Fig. (8d)** the percentage of seed loss decrease as sieve inclination angle increase from 6° downward to 4° upward at all feed rates. Exception was found at feed rate 15 kg/h.cm there were no effect in percentage of seed loss when sieve inclination angles increase from zero to 4° upward. Meanwhile, when the sieve inclination angle was lowered from zero to 6° downward seed losses percentage were increased from 0.3 to about 10.8%.

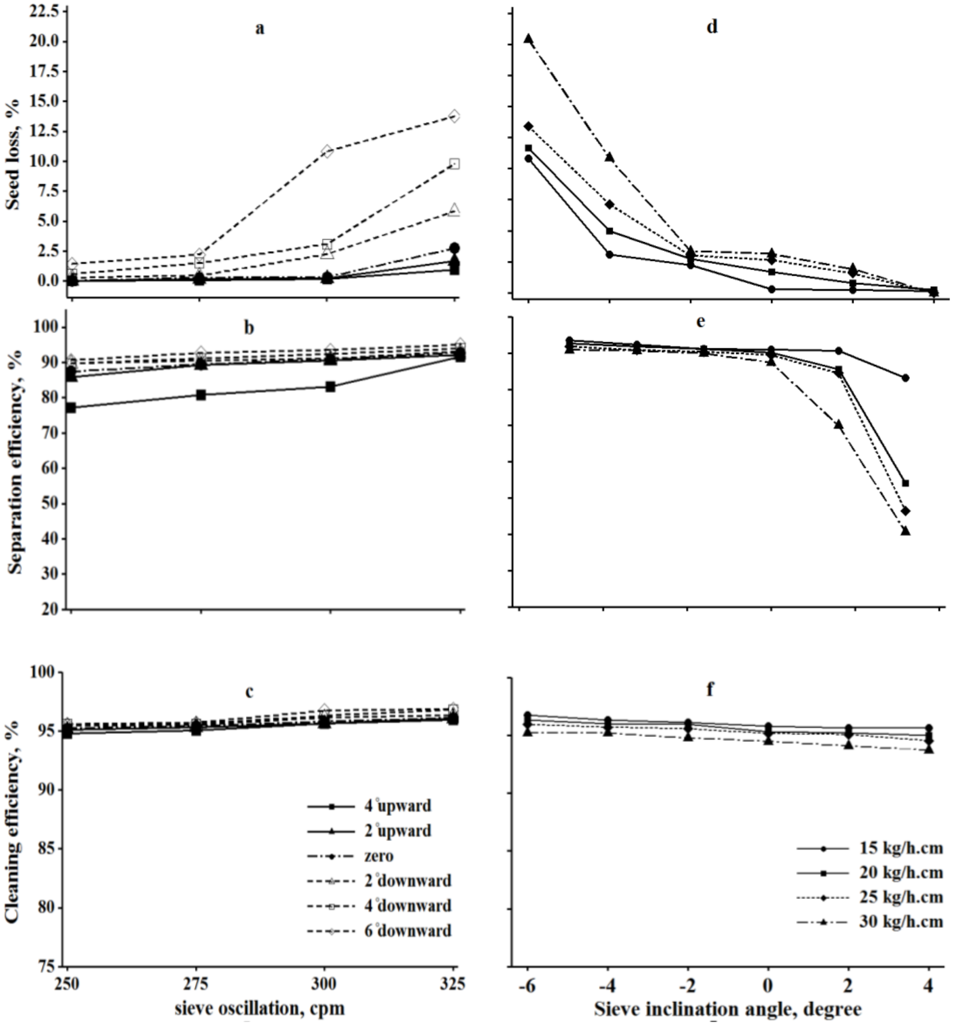


Fig. (8): Effect of sieve oscillation and sieve inclination angle on seed losses, separation efficiency and cleaning efficiency with feed rate 15 kg/hr.cm and sieve oscillation 300 cpm, respectively.

Figure (8e) showed that the percentage of separation efficiency decrease as sieve inclination angle increase from 6° downward to 4° upward at 300 cpm for all feed rates. As obvious the highest separation efficiency was obtained at 2°, 4° and 6° downward. On the other hand, the effect of sieve inclination angles on percentage of separation efficiency increased when the feed rates increase, especially at low sieve oscillations. The highest percentage of separation efficiency was achieved at feed rate 15 kg/hr.cm ranged from 83.2% at 4° upward to more than 93.5% at 6°

downward and there were slightly decrease in separation efficiency when sieve inclination angle increase from 6° downward to zero.

Figure (8f) illustrated that, there were a slightly decrease in cleaning efficiency when sieve inclination angles increase from 6° downward to 4° upward at different levels of feed rate at sieve oscillation 300 cpm. The highest percentage of cleaning efficiency was achieved at feed rate 15 kg/hr.cm ranged from 95.6% at 4° upward to more than 96.7% at 6° downward. The percentage of separation and cleaning efficiency decrease when sieve inclination angle increase from 6° downward to 4° upward, that may be refer to increase shell remaining time and lead to suitable conditions for shell penetration through the sieve aperture so reduction separation and cleaning efficiency. The above mentioned results are in agreement with **Fouda (2011)**.

CONCLUSION

1. The average of length (L), width (W) and thickness (T) of peanut seeds were 19.10, 9.24 and 8.36 mm, respectively. In addition to that, the peanut seed was oblong shape due to the average seed sphercity percentage was 59.65%.
2. The round aperture sieve with diameter 13.20 mm should be used to separate peanut seeds variety (Giza- 5) from shells without any losses.
3. The maximum separation and cleaning efficiency were 95.0 and 96.8% respectively, at sieve oscillation 325 cpm, feed rate 15 kg/h.cm and sieve inclination angle 6° downward.
4. In aeromechanical separation to keeping seed loss less than 0.5% with shell separation efficiency 90.9% and adequate cleaning efficiency about 95.8%, prefer to sieve oscillation 300 cpm with sieve amplitude 17.5 mm; at zero inclination angle (horizontal).

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الملخص العربى

دراسة عن فصل وتنظيف بذور الفول السودانى

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أُجري هذا البحث بهدف تطوير وحدة فصل وتنظيف نواتج عملية تقشير قرون الفول السوداني لتكون مناسبة للأصناف المصرية (جيزة-٥) ولتحقيق هذا الهدف تم دراسة بعض الخواص الطبيعية والميكانيكية لبذور الفول السودانى وكذلك العوامل الهندسية التى تؤثر على عمليات الفصل والتنظيف، حيث تم تصنيع وتركيب الوحدة التجريبية للفصل والتنظيف من خامات محلية بورشة قسم الهندسة الزراعية - كلية الزراعة - جامعة قناة السويس – الإسماعيلية - مصر.

تم دراسة تأثير العوامل التشغيلية التالية معدل التلقيم (١٥، ٢٠، ٢٥ و ٣٠ كجم/ س.سم)، السرعة الترددية للغربال (٢٥٠، ٢٧٥، ٣٠٠ و ٣٢٥) دورة فى الدقيقة، زوايا ميل الغربال صفر وعن الأفقى (٤°، ٢° لأعلى، ٢°، ٤° و٦° لأسفل) تحت نظام الفصل الإيروميكانيكى للحصول على أعلى كفاءة فصل وتنظيف مع أقل فواقد للبذور.

وتم التوصل إلى النتائج التالية:

١. متوسط الطول والعرض والسمك للبذور ١٩.١٠ ، ٩.٢٤ و ٨.٣٦ مم على الترتيب و البذور بيضاوية الشكل حيث كان متوسط تكور البذور ٥٩.٦٥٪.

٢. الغرابيل ذات الفتحات الدائرية والتى قطرها ١٣.٢مم هى الأنسب لفصل بذور الفول السودانى صنف (جيزة-٥) عن القشر دون أى فواقد من البذور.

٣. أقصى كفاءة فصل وتنظيف تحت نظام الفصل الإيروميكانيكى ٩٥.٠ و ٩٦.٨ ٪ على الترتيب، والتى تحققت عند سرعة ترددية للغربال ٣٢٥ دورة في الدقيقة، ومعدل التلقيم ١٥ كجم/س.سم وزاوية ميل الغربال ٦° لأسفل و كانت نسبة البذور المفقودة عالية جداً وبلغت ١٣.٨٪.

٤. لتقليل فواقد البذور أقل من ٠.٥٪ فى نظام الفصل الإيروميكانيكى مع كفاءة فصل وتنظيف ٩٠.٩و ٩٥.٨٪ على الترتيب زاوية ميل الغربال على الأفقى مساويةً للصفر وبسرعة ترددية ٣٠٠ دورة فى دقيقة مع طول مشوار ٣٥ مم ومعدل تلقيم ١٥ كجم/س.سم.

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