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DEVELOPMENT OF A LOCAL MACHINE FOR WINNOWING AND GRADING FLAX SEEDS

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ABSTRACT

The aim of this investigation is to improve seed cleaner for better clean and grade by using physical and mechanical properties of flax seeds (Sakha 2 -variety). The developed machine was constructed and tested at a private workshop in Kalubia Governorate to clean and grad flax seeds. The performance of the cleaning and grading machine was carried out to investigate some engineering parameters such as: three different feed rates of 1000, 1200 and 1400 kg/h., four different mesh hole sizes of 0.5, 1.1, 2.5 and 3.0 mm and four different vibration frequencies of 40, 70, 100 and 130 Hz. physical and mechanical properties of fax seeds under study, purity and grading efficiency were studied to evaluate the performance of developed cleaning and grading machine.

The main results in the present study can be summarized as follows:-

- Physical properties of flax seeds: length (L), width (W), and thickness (T) were 4.38, 2.2, and 0.72 mm, respectively , volume (V) 3.631 mm^3, geometric diameter (Dg) 1.906 mm, arithmetic diameter (Da) 2.44 mm, percentage of sphericity (S) 43.52 %, bulk density (Bd) 0.640 kg/m^3, flat surface area (A_f)7.56 mm^2 transverse surface area (A_t) 1.24mm^2 mass of 1000-seeds (Km)10 g and optimum moisture content (M.C) of 12.5 % for flax seeds .

- Mechanical properties of flax seeds: the friction angle (Ψ) between stainless, metal and wood surface and flax seeds was 22, 34, and 40 degree, respectively, coefficient of friction for stainless, metal, and wood surface was 0.404, 0.675, and 0.839, respectively, the angle of repose (θ) was 30 degree, the terminal velocity (T_v) value to suspended flax grain (Sakha 2 – variety) was 22 m/s. and hardness of flax seeds was11.02 N.

- The higher seed purity was 99.33 % and higher grading efficiency was 99.69 % were reached using vibration frequency of 130 Hz, mesh hole size of 3 mm, feed rate of 1400 kg/h and moisture content of 12.5 %.

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INTRODUCTION

Flax had been cultivated by ancient Egyptians science 5000 years ago. Flax considers the most important economic oil and fiber crops in the world as well as in Egypt. The flax plays an important role in natural economy due to export and local industry. Flax is usually grown as a dual purposes crop, for the production of fiber extracted from straw and oil obtained from seeds. In Egypt, flax cultivated area was about 35700 feddans* yearly, each feddan produced about 4 ton straw and 825 kg seeds, **(Statistical year book,2003).** The physical and mechanical properties of flax seeds play an important role in problems associated with design or development of sieve unit, a specific machine, handling, cleaning and storage. Cleaning and grading of flax seeds are considered the most important topic of flax post harvest. Cleaning and grading are the most important operations, cleaning operation is to separate flax seeds from straw, chaff, broken and weed seed, while grading operation is classifying seeds into uniform categories having the similar properties. It is also reducing the problems during planting, cultivating, seed storage and drying. **Harmond et al. (1965)** reported that the size of an object determines how much space can be occupied and it can be described in terms of length, width and thickness. They added also that the size is also important in selection or design of disks for precision planting and in proper adjustment of clearances and screen openings in combining. **Mohsenin (1986)** mentioned that the physical properties of material such as shape, size, volume, and surface area, are important in many problems associated with design or development of specific machine, analysis of the behavior of the product in handling of the material, stress distribution in the material under load, electrostatic separation of grain, light reflectance and color evaluation. One of the important design parameters in conveying of solid materials by air or water in the assumption for the shape of the materials. Accurate estimates of the frontal area and the related diameters are essential for the determination of terminal velocity, drag coefficient, and Reynold number. **Awady and EL-Sayed (1994)** stated that when air stream is used for separation of product from its associated foreign materials, a knowledge of terminal

*1 fed.= 0.42 ha.

velocity of all the particles is involved. For these reasons, terminal velocity has been used as an important aerodynamic characteristic of materials in such applications an pneumatic conveying and separation from foreign materials. **Soliman (1994)** studied the effect of moisture content on angle of repose of paddy rice. He mentioned that the dynamic angle of repose is one of the mechanical properties needed for the design of material handling system and storage facilities for rice products. **Nigrini et al. (1994)** mentioned that the vibratory seed cleaner is considered as an efficient apparatus to achieve clean and grader small seeds of higher quality. **Abd El-Ghany (2001)** mentioned that increasing feed rate for oil crop from 1200, 1400, 1600 and 1800 kg/h. decreased the stripping efficiency from 97.31, 95.76, 93.94 and 92.23 % respectively, at drum speed of 300 rpm. (4.39 m/s) and moisture content of 13.15 %. Increasing feed rate from 1200, 1400, 1600 and 1800 kg/h increased the percentage of machine capacity from 70.05, 97.31, 98.48 and 99.75 % respectively, at moisture content of 13.15 %.**El-Ashary et al. (2003)** cleared that the unthreshed flax seed losses decreased by decreasing seed moisture content. Decreasing flax seeds moisture content from18.15 to 12.05 % tends to increase threshing capacity from2.23 to 3.06 t/h. from 2.95 to 6.87 t/h. and from 0.19 to 0.48 t/h. for complete, partial mechanized and conventional system, respectively. Also the energy requirements decreased by decreasing seed moisture content. **Amin (2003)** said that the sieving time, cell shape, and oscillating speed were the main factors that affected the separation efficiency. This efficiency increased by increasing sieving times and oscillating speed rpm. **El-Gayar (2005)** mentioned that there was insignificant differences between the mesh hole size level, the seed moisture content levels, the initial sample weight levels, the vibration frequency and the interaction between these factors level due to purity and grading.

In Egypt the methods of threshing flax are done manually and threshed seeds have weed seeds, undesired seeds, fungal bodies, green leaves, chaff, straw and dust. Then the winnowed of flax seeds is necessary for cleaning by winnowing machine.

So the aim of this study is:

1- To study the physical and mechanical properties of Egyptian variety of flax seeds (v. Sakha 2), these properties provide data base, consequently it can be used as a guide in seed production and post harvesting operation.

2- To obtain the engineering parameters of the suitable separation and grading machine from physical and mechanical properties of the threshed materials.

MATERIAL AND METHODS

In the present study, the winnowing machine was modified and tested at a private workshop in Kalubia Governorate for cleaning and grading flax seeds. The developed machine consists of frame, hopper, electric motor and oscillating dual-screen assembly as shown in Fig. (1). The frame was supported on four legs. Power transfer from the electric motor to oscillating screen. General specifications of machine are: overall (length 1428 mm, width 570 mm, height 1210 mm), power of 0.3 hp (0.225 kW), labor requirement 1-2 man, easy operation, minimum adjustments, reduced repairs and maintenance problems. Construction includes 1 mm sheet metal and 30x30x3 angle iron.

1- Machine specifications and description:

Frame: Made of angle steel sections 30x30x3 mm

Hopper: Made of steel metal of 1 mm thickness and angle iron steel section 30x30x3 mm.

Sieves: Made of steel metal of 1.5 mm thickness. They consists of four wire mesh holes having of 0.5, 1.1, 2.5 and 3.0 mm were located in screen assembly to remove impurities to pass underneath (the shape and dimensions of the used mesh were chosen according to the pervious measured physical and mechanical properties of flax seeds).

Electric motor: An electric motor power of 0.3 hp (0.225 kW) was used at 1500 r.p.m.

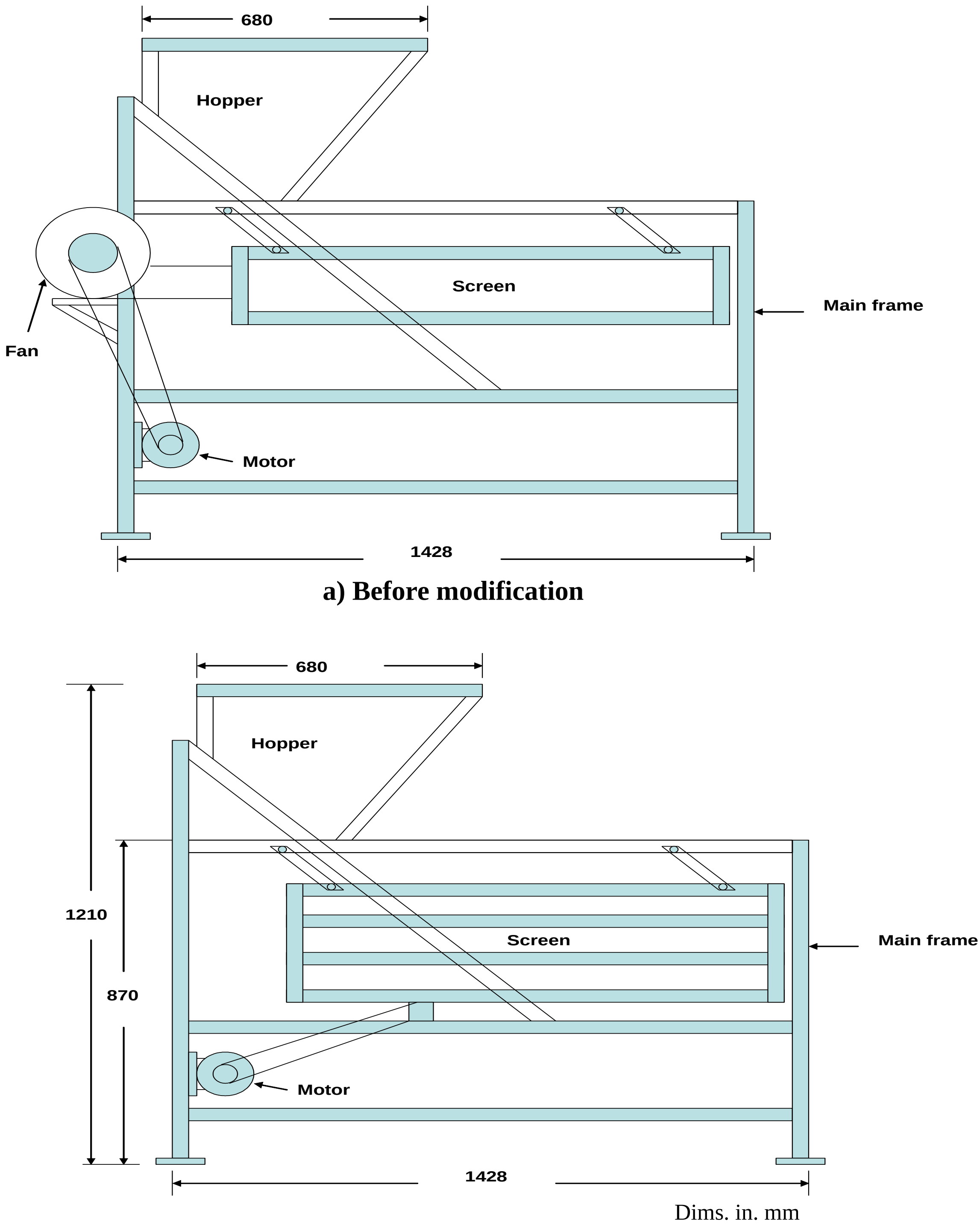
2- Modification recommendation:

- To use machine in cleaning: it was used as it is (before modification).

- To use machine in winnowing and grading: 1- Remove fan

2- Increase the number of screen from two to four screens.

3- Increase the execentric speed to suit cleaning and grading process.



a) Before modification

b) After modification

Fig. (1): Sketch of modified winnowing and grading machine.

3- Determination of physical and mechanical properties of flax seeds used in investigation:

500 flax seeds (v. Sakha 2) were taken to in random determine the physical and mechanical properties. Average plant height, was 121 cm. Fiber represent 19.5 %, and oil in seeds 42.5 %, producing about 4 ton/feddan from straw and 825 kg/feddan from seeds, and capsules diameter 0.92 cm. (**Statistical year book,2003).** All treatments were replicated five times to give more reliable average. Table (1) shows the mean, standard deviation, and coefficient of variance of length, width, thickness, mass of 1000-seeds, volume, percentage of sphericity, geometric diameter, arithmetic diameter, flat surface area transverse surface area, bulk density, and moisture content for flax seeds.

Table 1: Physical properties of flax seeds.

Seed parameter	Mean	S.D	C.V %
L	4.38	0.28	0.071
W	2.2	0.22	0.04
T	0.72	0.09	0.006
V	3.631	0.51	0.25
S	43.52	2.40	5.38
Dg	1.906	0.109	0.011
Da	2.44	0.108	0.010
A_f	7.56	0.94	0.817
A_t	1.24	0.167	0.026
Km	10	-	-
Bd	0.640	-	-
M.C	12.5	-	-

Where:-

S.D = standard deviation, C.V = coefficient of variance %

L = length, mm W = width, mm

T = thickness mm, Km = mass of 1000-seeds, g

V = volume mm^3, S = percentage of sphericity %,

Dg = geometric diameter mm, Da = arithmetic diameter mm

A_t= transverse surface area mm^2 A_f = flat surface area mm^2

Bd = bulk density kg/m^3, and M.C. = moisture content %.

The following relations were used according to **El-Raie et al. (1996).**

$Dg = (L*W*T)^{1/3}$ mm----------------------------(1)
$Da = (L+W+T)/3$ mm----------------------------(2)
$S = 100*(L*W*T)^{1/3}/L$ %---------------------(3)
$V = \pi/6\ (L*W*T)$, mm^3 -------------------------(4)
$A_t = \pi/4\ (W*T)$, mm^2 ---------------------------(5)
$A_f = \pi/4\ (L*W)$, mm^2 ---------------------------(6)
$Bd = Wb / Vb$ -------------------------------------(7)

Using the mean values, the following general equations can be written to express the relationship between, length, width, and thickness:-

Flax seeds (v. Sakha 2) $L = 1.99\ W = 6.1\ T$.-------------(8)

One of the most common and accurate methods being the prediction of these values from the measurements of length, width, and thickness of the product. In the present study, the formulae (1), (2), (4), (5), and (6) were used to determine these values for all seeds of samples. The results were analyzed statistically, and the following general equations can be written to express the relationships between the terms L, W, T and V, A_f, A_t, Dg, Da for flax seeds (Sakha 2 – variety).

$V = 0.043\ L^3 = 0.34\ W^3 = 9.73\ T^3$ ---------------------(9)
$A_t = 0.065\ L^2 = 0.26\ W^2 = 2.39\ T^2$ ---------------------(10)
$A_f = 0.39\ L^2 = 1.56\ W^2 = 14.58\ T^2$ --------------------(11)
$Dg = 0.44\ L = 0.87\ W = 2.65\ T$ --------------------------(12)
$Da = 0.56\ L = 1.11\ W = 3.39\ T$ -------------------------(13)

The main advantage of the equations (9) to (13) is that, the volume or the flat or transverse surface area or geometric or arithmetic diameter of a seed can be predicted with reasonable accuracy from a measurement of any one of the three principal dimensions of L, W, T.
Also friction angle, coefficient of friction, angle of repose, and hardness for flax seeds reported are shown in table 2.

Table 2: Mechanical properties of flax seeds.

Mechanical properties	Flax seeds
- Friction angle Ψ for stainless surface for metal surface for wood surface	 22 degree 34 degree 40 degree
- Coefficient of friction for stainless surface for metal surface for wood surface	 0.404 0.675 0.839
Angle of repose θ	30 degree.
Hardness	11.02 N.

Friction angle (degree), coefficient of friction, angle of repose (degree), hardness (N), and terminal velocity (m/s) was measured to determine the mechanical properties as follows:-

A) Friction angle, degree (Ψ).

It was measured between seeds and stainless, metal, and wood surfaces. 1000 sample of flax seeds were used.

B) Angle of repose, degree (θ).

It is the angle between the horizontal base and the inclined side of the formed cone due to free fall of seeds sample. The horizontal base of the cone (x) and its height (L) were measured by a ruler and the repose angle can be calculated as follows:-

$$\tan \theta = L / 0.5\, x \text{--(14)}$$

C) Terminal velocity (V_t) m/s.

The terminal velocity for seeds was determined by using floating apparatus (Source of manufacture in Japan, Electricity source of power, Work theory by vacuum, Maximum measuring in 25 m/s and accuracy 0.1 m/s). The terminal velocity of the air stream at which the body remains suspended is know as the terminal velocity of critical velocity.

4- Factors effect on cleaning and grading effectiveness for machine:

The following parameters were considered during the cleaning and grading machine testing.

A) Feed rate: Three different feeding rates were tested 1000, 1200 and 1400 kg/h.

B)Vibration frequency: Four different vibration frequencies of 40, 70, 100 and 130 Hz.

C) Mesh hole size: Four different mesh hole sizes of 0.5, 1.1, 2.5 and 3.0 mm.

5- Calculations:

A) Purity (P):

$$P = \frac{Weight\,of\ cleaned\,seeds}{Total\,weight\,of\ sample} x\,100 \quad \% \text{ ---------------------------(15)}$$

B) Grading efficiency (Ge):

The following relation was used according to **El-Gayar (2005)**

$$Ge = \frac{Wa}{Wa+Wc} x\,100 \quad \% \text{--------------------------(16)}$$

Where:- Wa: Weight of seed recovered in product, kg and

Wc: Weight of seed in the reject, kg.

RESULTS AND DISCUSSION

1- Dimensions of flax seeds:

Grain dimensions used in the experiments are shown in fig. 2. Mean dimensions of flax seeds are as follows:-

length (L) = 4.38 mm, width (W) = 2.2 mm, and thickness (T) = 0.72 mm.

Fig. 2. data indicates that the percentage of frequency is 60 % at mean grain length of about 4.4 mm, for mean grain width of about 2.0 mm with the percentage of frequency is 49 %, and for mean grains thickness of about 0.8 mm with the percentage of frequency is 85 %.

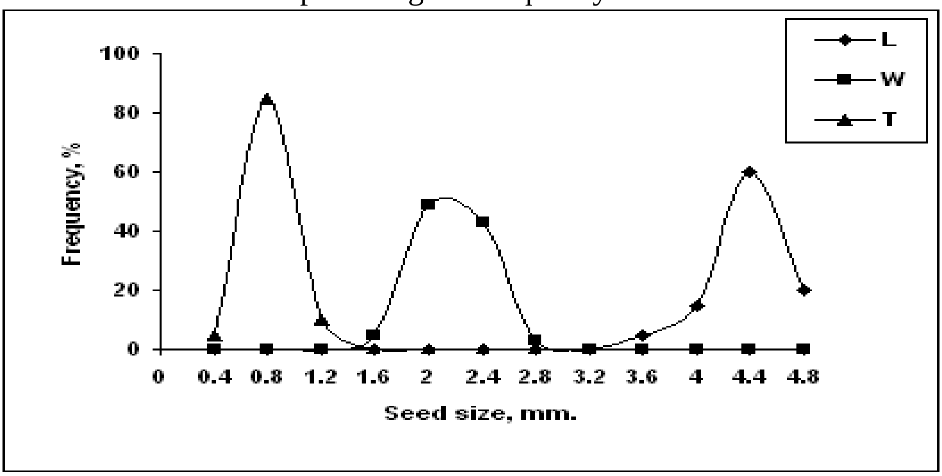


Fig. 2: Frequency of 3 dimensions of flax seeds (v. Sakha 2).

2- Factors affecting purity.

2-1 Feed rate

Fig. (3) shows the effect of feed rate on purity at different mesh hole sizes, vibration frequency of 130 Hz and moisture content of 12.5 %. Purity decreased by increasing feed rate.

It was found that by increasing feed rate from 1000 to 1400 kg/h. purity decreased from 96.23 to 85.35 % respectively at mesh hole size of 1.1 mm.

From fig. (3) It was found that purity affected by feed rate at mesh hole size of 0.5 and 1.1 mm, but at mesh hole size of 2.5 and 3 mm there was no effect for feed rate on purity. It refers to at big mesh hole size (2.5 and 3 mm) more seed quantities deposited up on the mesh holes, allowing more seed quantity to pass through the holes. The best feed rate was 1400 kg/h.

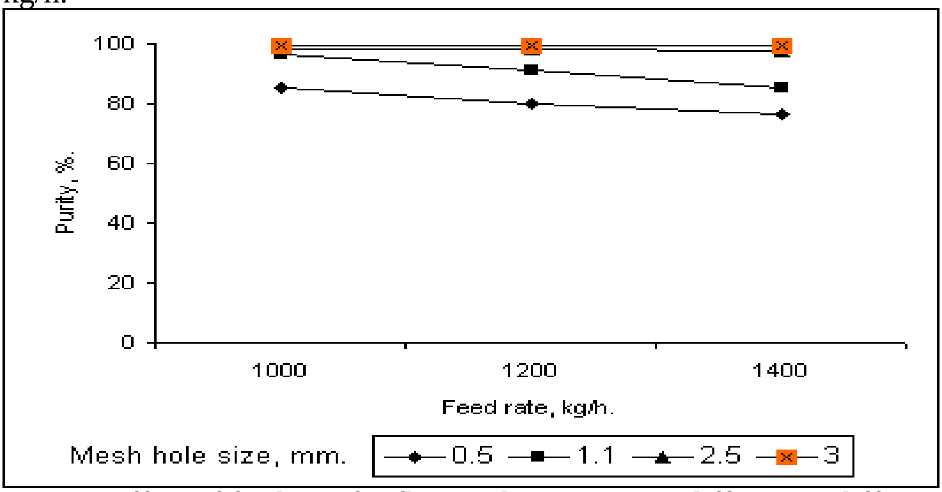


Fig. 3: Effect of feed rate for flax seeds on purity at different at different mesh hole sizes, vibration frequency of 130 Hz and moisture content of 12.5 %.

2-2 Vibration frequency.

Fig. (4) shows the effect of vibration frequency on purity at different mesh hole sizes, feed rate of 1400 kg/h and moisture content of 12.5 %. Purity increased by increasing vibration frequency.

It was found that purity increased from 79.73 to 84.51 % as the vibration frequency increased from 40 to 130 Hz, respectively at mesh hole size of 0.5 mm.

From Fig. (4) by increasing vibration frequency the movement of threshed materials on the sieve increased and there is no chance for impurities to pass thought the grain spout with grains. The best vibration frequency was 130 Hz.

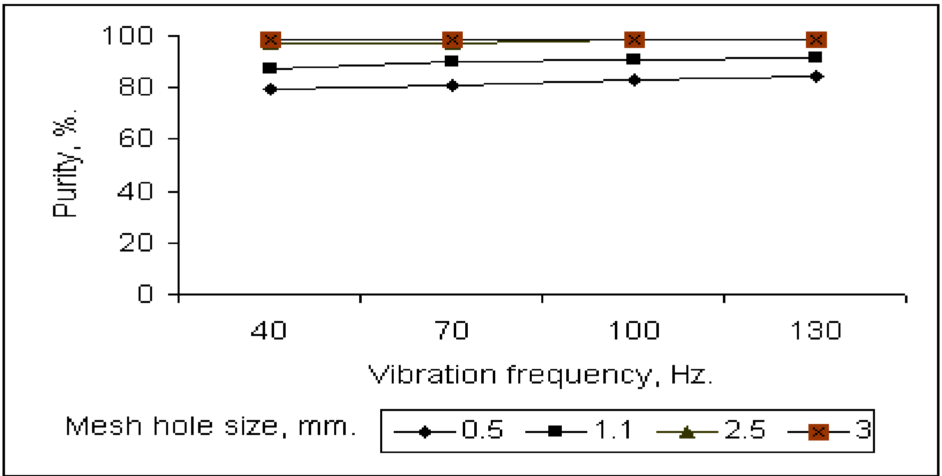


Fig. 4: Effect of vibration frequency on purity at different mesh hole sizes, feed rate of 1400 kg/h for flax seeds and moisture content of 12.5 %.

2-3Mesh hole size.

Fig. (5) shows the effect of mesh hole size on purity at different feed rate vibration frequency of 130 Hz and moisture content of 12.5 %. Purity increased by increasing mesh hole size.

It was found as the mesh hole size increased from 0.5 to 3 mm, purity increased from 76.19 to 99.33 %, respectively at feed rate of 1400 kg/h.

It refers to at big mesh hole size more seed quantities deposited up on the mesh holes, allowing more seed quantity to pass through the holes. But at small mesh hole size the threshed materials accumulated on the sieve gave chance to pass straw and impurities through the grain spout which drops with grain. The best mesh hole size was 3 mm.

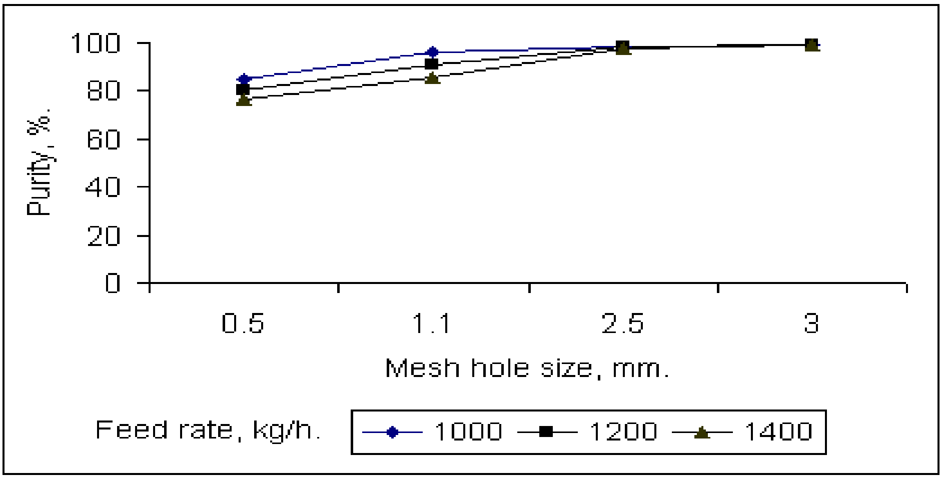


Fig.5: Effect of mesh hole size on purity at different feed rates of flax seeds vibration frequency of 130 Hz and moisture content of 12.5 % .

3- Factors affecting grading efficiency.

3-1 Feed rate

Fig. (6) shows the effect of feed rate on grading efficiency at different mesh hole sizes, vibration frequency of 130 Hz and moisture content of 12.5 %. Grading efficiency decreased by increasing feed rate.

From Fig. (6) it was found that the grading efficiency decreased from 65.11 to 20.91 % as the feed rate increased from 1000 to 1400 kg/h, respectively at mesh hole size of 2.5 mm. But grading efficiency not affected by using mesh hole size of 3 mm. It refers to at big mesh hole size more seed quantities deposited up on the mesh holes, allowing more seed quantity to pass through the holes.

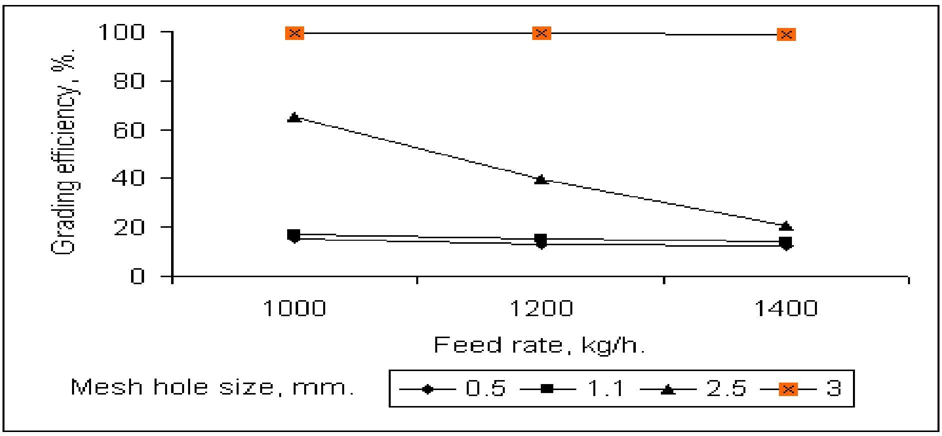


Fig. 6: Effect of feed rate of flax seeds on grading efficiency at different mesh hole sizes, vibration frequency of 130 Hz and moisture content of 12.5 %.

3-2 Vibration frequency.

Fig. (7) shows the effect of vibration frequency on grading efficiency at different mesh hole sizes, feed rate of 1400 kg/h. and moisture content of 12.5 %.

It was found that by increasing vibration frequency from 40 to 130 Hz. grading efficiency increased from 93.90 to 99.69 %, respectively at mesh hole size of 3 mm.

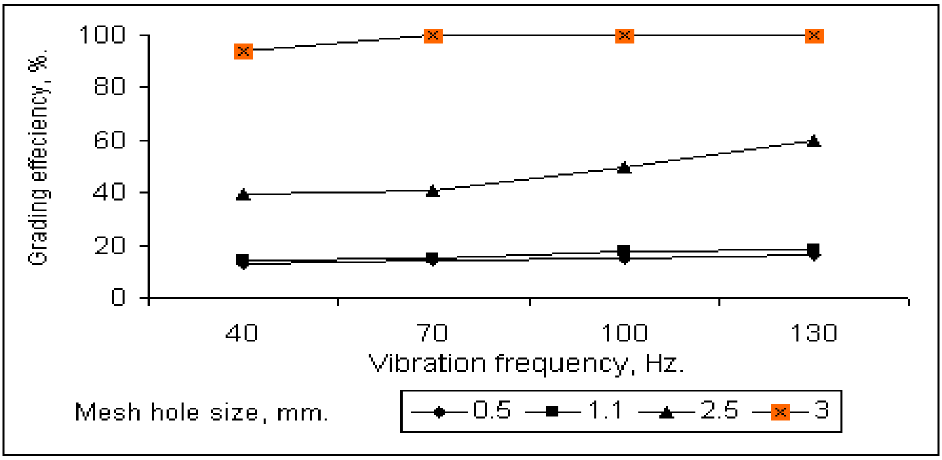


Fig. 7: Effect of vibration frequency on grading efficiency at different mesh hole sizes feed rate of 1400 kg/h for flax seeds and moisture content of 12.5 %.

3-3Mesh hole size.

Fig. (8) shows the effect of mesh hole size on grading efficiency at different, feed rates, vibration frequency of 130 Hz. and moisture content of 12.5 %.

It was found as the mesh hole size increased from 0.5 to 3 mm, grading efficiency increased from 15.20 to 99.69 %, 13.3o to 99.60 % and 12.4 to 99.10 % using feed rate of 1400 kg/h, respectively.

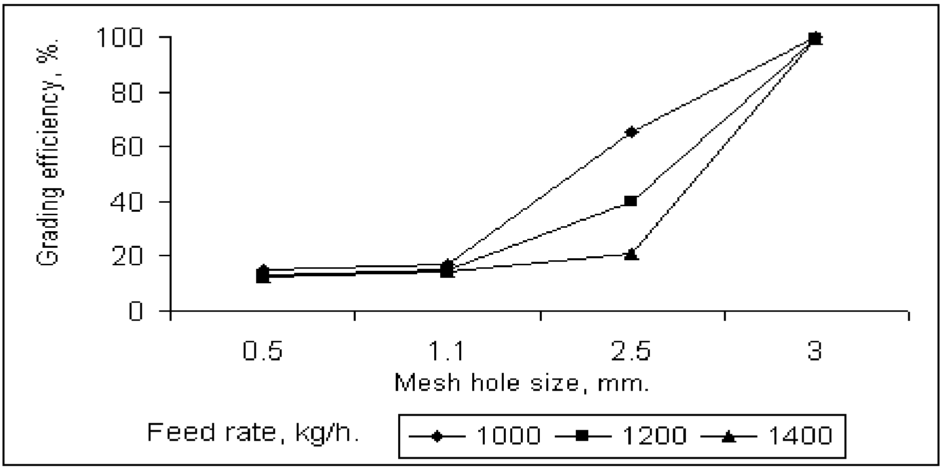


Fig. 8: Effect of mesh hole size on grading efficiency at different feed rates, vibration frequency of 130 Hz. and moisture content of 12.5 %.

CONCLUSION

The main results in this study can be summarized as follows:-

1- Physical properties of flax seeds: length (L), width (W), and thickness (T) were 4.38, 2.2, and 0.72 mm, respectively , volume (V) 3.631 mm3, geometric diameter (Dg) 1.906 mm, arithmetic diameter (Da) 2.44 mm, percentage of sphericity (S) 43.52 %, bulk density (Bd) 0.640 kg/m3, flat surface area (A_f)7.56 mm2 transverse surface area (A_t)1.24mm2 mass of 1000-seeds (Km)10 g and optimum moisture content (MC) of 12.5 % for flax seeds .

2- Mechanical properties of flax seeds: the friction angle (Ψ) between stainless, metal and wood surface and flax seeds was 22, 34, and 40 degree, respectively, coefficient of friction for stainless, metal, and wood surface was 0.404, 0.675, and 0.839, respectively, the angle of repose (θ) was 30 degree, the terminal velocity (T_v) value to suspended flax grain (v. Sakha 2) was 35 m/s. and hardness of flax seeds was11.02 N.

3- The higher seed purity was 99.33 % and higher grading efficiency was 99.69 % were reached using vibration frequency of 130 Hz, mesh hole size of 3 mm, feed rate of 1400 kg/h and moisture content of 12.5 %.

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الملخص العربي

تطوير ألة لتنظيف وتدريج بذور الكتان

د/ جمال كمال عرفة د/ محمد طه عبيد* د/هانى عبدالعزيز الجندى***

نظرا لأهمية عملية فصل الحبوب وتدريجها لأعدادها لمراحل التصنيع المختلفة لذا يتناول هذا البحث تعيين الخواص الطبيعية (الطول ، العرض ، السمك ، الحجم ، القطر الهندسي ، القطر الحسابي ، نسبة التكور ، والكثافة الظاهرية ، وزن الألف حبة ، ومساحة السطح المسطح ، ومساحة سطح الحبة المنقولة وذلك عند المحتوي الرطوبي الأمثل)، والميكانيكية (زاوية الاحتكاك ، معامل الاحتكاك لثلاثة أسطح من الاستنلس والمعدن والخشب ، زاوية التكويم ، الصلابة، وسرعة التعليق) وعلاقتها بتنظيف وتدريج بذور الكتان (صنف سخا ٢)، وذلك من خلال تطوير منظف الحبوب لاستخدامه فى تنظيف وتدريج بذور الكتان وذلك للخروج بتصميم يتناسب مع الظروف المحلية مع التوصيات لافضل عوامل تشغيل. وقد تم تغيير معدل التغذية فى المدى من ١٠٠٠ – ١٤٠٠ كج/س، واقطار فتحات الغرابيل ٠,٥، ١,١، ٢,٥، ٣ مم، وتردد الغربال ٤٠، ٧٠، ١٠٠، ١٣٠ هيرتز عند المحتوى الرطوبى الامثل ١٢,٥ %.

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وتم التوصل الى النتائج والتوصيات التالية للحصول على أعلى نسبة نظافة وأفضل درجة تدريج (فى ظروف هذا البحث):

(ا) الخواص الطبيعية.

١- أبعاد البذور : وجد ان طول وعرض وسمك بذور الكتان هو ٤,٣٨ ، ٢,٢ ، ٠,٧٢ على الترتيب.

٢- وزن الآلف حبة وحجمها: وجد ان وزن الآلف حبة وحجمها هى ١٠ جم. ١,٦١٨ مم٣.

٣- الكثافة الظاهرية : وجد ان الكثافة الظاهرية هى ٠,٦٤٠ كج/م٣.

٤- التكور: وجد ان النسبة المئوية للتكور هى ٤٨,٢٢ %.

٥- القطر: وجد ان القطر الهندسى والرياضى هو ١,٩٠٦ ، ١,٧ مم على الترتيب.

٦- مساحة السطح: وجد ان مساحة السطح المسطح ومساحة سطح الحبة المنقولة هو ٣,٠٣ ، ٠,٨٠ مم٢ على الترتيب.

٧- المحتوى الرطوبى: وجد ان المحتوى الرطوبى الأمثل لبذور الكتان هو ١٢,٥ %.

(ب) الخواص الميكانيكية.

١- زاوية ومعامل الاحتكاك : وجد ان متوسط زاوية الاحتكاك لبذور الكتان هى ٢٢، ٣٤، ٤٠ درجة على أسطح الاستانلس ستيل، الصاج ، والخشب على الترتيب . بينما كان معامل الاحتكاك للأسطح الاستانلس ستيل، الصاج ، والخشب هو ٠,٤٠٤ ، ٠,٦٧٥ ، ٠,٨٣٩ علي الترتيب حيث يفضل السطح الاستانلس ستيل لقلة زاوية الاحتكاك ومعامل الاحتكاك عن الأسطح الأخرى (المعدن والخشب) .

٢- زاوية التكويم: وجد ان أقصى زاوية تكويم لبذور الكتان هى ٣٠ درجة.

٣- صلابة الحبوب: وجد ان متوسط مقدار تحمل حبوب الكتان لقوى الكسر هو ١١,٠٢ نيوتن.

٤- سرعة التعليق: وجد ان السرعة المناسبة للتخلص من القش والأتربة والأجزاء الدقيقة أثناء عملية الفصل يجب ان تقل عن ٣٥ م/ث.

(ج) تم التوصل الى علاقة تربط بين الأبعاد الأساسية للبذور (الطول والعرض والسمك) وهى:

$$L = 1.99\ W = 6.1\ T$$

(د) تم التوصل الى علاقة تربط بين الحجم، ومساحة سطح الحبة المنقولة، ومساحة السطح المسطح، والقطر الهندسى، والقطر الرياضى مع الطول والعرض والسمك ويمكننا التنبؤ بحجم الحبوب، والقطر الهندسي ، والقطر الحسابي ، ومساحة السطح المسطح ، ومساحة سطح الحبة المنقولة بدلالة أبعادها الأساسية وهى

$$V = 0.043\ L3 = 0.34\ W3 = 9.73\ T3$$

$$A_t = 0.065\ L2 = 0.26\ W2 = 2.39\ T2$$

$$A_f = 0.39\ L2 = 1.56\ W2 = 14.58\ T2$$

$$Dg = 0.44\ L = 0.87\ W = 2.65\ T$$

$$Da = 0.56\ L = 1.11\ W = 3.39\ T$$

(هـ) من دراسة المتغيرات الأساسية تم الحصول على اكبر نسبة للحبوب النظيفة ٩٩,٣٣ %، واعلى درجة لكفاءة التدريج ٩٩,٦٩ % عند تردد الغربال ١٣٠ هيرتز، ومعدل تغذية ١٤٠٠ كجم/س.، وقطر فتحة الغربال ٣ مم، ومحتوى رطوبى ١٢,٥ %.