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SOME PHYSICAL AND MECHANICAL PROPERTIES OF SESAME SEEDS CONCERNING THE SELECTION OF SEPARTION UNIT

Arafa, G. K.

ABSTRACT

The aim of this investigation to study the main physical and mechanical properties of sesame seeds (Giza 32 -variety). Also, some parameters for cleaning unit such as diameter of holes, coefficient of live area of the flat sieves and rpm. of crank of screening unit were studied and recommended. The main results in this study can be summarized as follows:- Physical properties of sesame seeds: length (L), width (W), and thickness (T) was 2.5, 1.65, and 0.94 mm respectively , volume (V) 2.03 mm3, geometric diameter (Dg) 1.57 mm, arithmetic diameter (Da) 1.29 mm, percentage of sphericity (S) 62.84 %, bulk density (Bd) 0.640 kg/m3, flat surface area (A_f) 3.24 mm2 transverse surface area (A_t)1.22 mm2 mass of 1000-seeds (Km)10 g and optimum moisture content (M.C) of 14 % for sesame seeds. Mechanical properties of sesame seeds: the friction angle (Ψ) between sesame seeds and stainless, metal and wood surface 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 sesame grain (Giza 32 – variety) was 35 m/s. and hardness of sesame seeds was11.02 N.

Relationship were written between length, width, and thickness.

Relationship were written between the terms length, width, and thickness and volume, flat surface area, transverse surface area, geometric diameter and arithmetic diameter.

From the study, the principally parameters of sieve unit, the diameters of round sieve hole was 3 mm for sesame seeds. Maximum live area was 0.3 and the holes on the sieve 0.99/1 m^2 for the total area of the sieve.

Researcher, Ag. Eng. Res. Inst., Agric. Res. Center, Giza, Dokki, Egypt.

INTRODUCTION

Sesame considers the most important economic oil, protein, calcium and fesfore in the world as well as in Egypt. The sesame plays an important role in natural economy due to export and local industry. Sesame is usually grown as a dual purposes crop, for the production of oil extracted from seeds. In Egypt, sesame cultivated area was about 70426 feddans yearly producing about 1.054 ton/feddan and 37382 ton/year, (Statistical year book,2005). The physical and mechanical properties of sesame seeds play an important role in problems associated with design or development of sieve unit, a specific machine, handling, cleaning and storage.

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. **Gorial and Callaghan (1990)** stated that the drag coefficient of a wide range of grains and straws were measured experimentally by finding the suspension velocities of particles in an air stream. Representation of shape is discussed and vol. shape factors are proposed for non-spherical particles. The effect of nodes on the orientation of straws in a vertical air stream is examined. Drag coefficients. were correlated for different seeds and straws as a function of Reynolds number by grouping the particles within the limits of a sphere and a cylinder. **Kaleem et al. (1993)** reported that the angle of repose is very important in determining the inclination angle of the machine hopper tank. **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 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. **Pearson *et al.* (1994)** said that the hull friction factor was measured using a V-shaped, polished stainless steel inclined through apparatus. The nut was placed in the through and the through was inclined until the nut started to slide. The angle of inclination of the trough with the horizontal was recorded and the coefficient of static fraction factor was calculated using the through angle. **Soliman (1994)** studied that 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 and rice products. **Nimkar and hattopadhyay. (2001)** Various physical properties of green gram were evaluated as a function of moisture content in the range of 8.39 to 33.40 % d.b. The average length, width, thickness and thousand grain mass were 4.21 mm, 3.17 mm, 3.08 mm and 28.19 g at moisture content of 8.39 % d.b. The geometric mean diameter increased from 3.45 to 3.77 mm, whereas sphericity decreased from 0.840 to 0.815. Studies on rewetted grains showed that the bulk and true densities decreased from 807 to 708 kg m-3 and 1363 to 1292 kg m-3 , respectively, whereas the corresponding bulk porosity increased from 10.1 to 12.1 m.s-1. The static coefficient of friction varied from 0.344 to 0.625 over different material surfaces, while angel of repose varied from 26.6 to 31 deg within the studied moisture range. **El-Ashary et al. (2003)** cleared that the unthreshed sesame seed losses decreased by decreasing seed moisture content. Decreasing sesame seeds moisture content from18.15 to 12.05 % tends to increasing 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.

The aim of this study was to investigate measure the physical and mechanical properties of the sesame seeds which affect on designing and developing of precision planting, handling system, storage, cleaning, separation and threshing machines.

MATERIALS AND METHODS

Physical and mechanical properties of sesame seeds were measured and evaluated during this study in 2005 at Agricultural Engineering Research Institute, Egypt, to determine the physical and mechanical properties of sesame seeds (Giza 32 – variety). In respect the sieve unit selection, and study also some parameters for separation unit such as diameter of holes, coefficient of live area of the flat sieves and rpm. of crankshaft of screening unit were studied and recommended.

A)Sesame seeds used in investigation:

500 sesame seeds (Giza 32 – variety) were taken to determine the physical and mechanical properties. Plant height, about 121 cm. Total percentage of oil 55-60 %, and protein of 15-25 %(Statistical year book,2005).

B)Instrumentation:

Digital dial caliper: Dimension (Length, width, and thickness) of sesame seeds were determined considering the three axes xx, yy, and zz. A digital caliper reading up to 15 cm was used. Its accuracy is 0.05mm.

Moisture content meter: A moisture content meter (Wile 35 Moisture Meter) as used for measuring the seeds moisture-content on wet basis. The measurement was by electrical sensitive.

Electronic balance: An electronic balance (made by Japan) was used for weighing samples .Its scale ranged from 0 to 5 kg max., with accuracy of 0.2 g,

Digital instrument for measuring coefficient of friction: Lifting unit: Motor, source of power: Electricity, 220 V, AC., mass of instrument, kg: 3.5, Instrument system: Digital, and accuracy, degree: 0.01. The digital measuring device was designed and constructed in Meet El-Dieba at Kafr El-Sheikh Governorate at laboratory of Rice Mechanization Center (RMC), Agricultural Engineering Research Institute (AEnRI). It was used to measure the friction angle on stainless, metal and wood surface and angle of repose with dimensions 14 x 31.5 cm.

Floating apparatus specification: It is used for measuring the terminal velocity. Source of manufacture in Japan, Electricity source of power, Work theory by vacuum, Maximum measuring in 20 m/s and accuracy 0.1 m/s.

Anemometer instrument: An anemometer instrument was used for measuring the air speed, temperature, and pressure. It is made in Japan by SATAKE CO., and ranged from 0 to 50 m/s. The measurement theory depends on the declination of the sensor inside the instrument. The movement of the air pushes the sensor then voltage indicates the variation of the air speed. the source of power is battery.

Rigidity force: A digital force of accuracy was used for measuring the rigidity force. Maximum reading of 2200 g., so a lever construction was used for amplifying the force reading, reactions due to lever weight was accounted.

Angle of repose: The friction of the grain was studied indirectly by determining their angle of repose. A rectangular vlar open – top box (10.3 cm wide * 12.8 deep * 10.1 cm high) was employed for this purpose. Grain was poured (from a triangular tray held about 5cm above) into the box and the top levelled with a blunt-edged stroker. The front wall was then flicked open, allowing excess grain to fall at the front. The resulting angle of the grain mass surface line formed with the horizontal would be read directly from angles etched on the two side walls.

C)Physical properties of sesame seeds:

Dimensions like length (L), width (W), and thickness (T) mm, volume mm^3, geometric diameter mm, arithmetic diameter mm, percentage of sphericity %, bulk density kg/m^3, transverse surface area (A_t), flat surface area (A_f) in mm^2 mass of 1000-seeds g and moisture content % for sesame seeds reported as follows.

Seeds dimensions: This dimensions like (length, width, and thickness mm) was measured by using digital dial caliper. These physical characteristics can be utilized effectively in design or development of devices and their operations or in analyzing of the behavior of product in handling and sieving operations. The following relations can be used for calculating the geometric diameter (D_g) mm, arithmetic diameter (D_a) mm, percentage of sphericity (S) %' and volume (V) mm^3 of an individual seed according to El-Raie et al. (1996).

$$Dg= (L*W*T)^{1/3} \text{ mm} \text{-------------------------------}(1)$$

$$Da= (L+W+T)/3 \text{ mm} \text{-------------------------------}(2)$$

$$S= 100*(L*W*T)^{1/3} /L \ \% \text{-------------------------}(3)$$

$$V= \pi/6 (L*W*T), mm^3 \text{-----------------------------}(4)$$

1- **seed surface area:** The surface area of seeds is very important characteristic in determining both volumetric and gravimetric heat transfer coefficients and in analyzing heat and moisture transfer during drying and frying processes, and it is also useful for describing the re-hydration process. The following relations was used for calculating the transverse surface area (A_t), and the flat surface area (A_f) in mm^2 , according to El-Raie et al. (1996).

$$A_t = \pi/4 (W*T), mm^2 \text{-----------------------------}(5)$$

$$A_f = \pi/4 (L*W), mm^2 \text{----------------------------}(6)$$

2- **Bulk density of seed (Bd):** It was calculated for the seeds by dividing the mass of a quantity of seeds on its volume, which was measured by using a constant volume cylinder.

$$Bd = Wb / Vb \text{-------------------------------------}(7)$$

Where:-

Bd: Bulk density of seeds, kg/m^3,

Wb: Mass of the same quantity of seeds, kg and,

Vb: Volume of the same quantity of seeds, m^3.

3- **Mass of 1000-seeds (Km):** The mass of 1000- seeds was weighing by electronic balance.

D)Mechanical properties of sesame seeds:

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:-

1- Friction angle, degree (Ψ): It was measured between seeds and stainless, metal, and wood surface. 1000 sample of sesame seeds was used.

2- 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:-

$$\tan \theta = L / 0.5\, x \text{-------------------------------(8)}$$

3-Terminal velocity m/s (V_t): The terminal velocity for seeds was determined by using floating apparatus. The terminal velocity of the air stream at which the body remains suspended is know as the terminal velocity of critical velocity.

$$\text{Suspended seed velocity} = (2\, Mg/cap)^{1/2}$$

Where;-

M: mass, g: acceleration, c:drag coefficient,

A: seed area and p: air density.

<u>RESULTS AND DISCUSSION</u>

This section determine physical and mechanical properties of sesame seeds as follows:-

1- Physical properties of sesame seeds:

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 sesame seeds.

Table (1): Physical properties of sesame seeds.

Seed parameter	Mean	S.D	C.V %
L	2.5	0.16	0.04
W	1.65	0.13	0.02
T	0.94	0.07	0.004
V	2.03	0.45	0.19
S	62.84	1.98	4.75
Dg	1.57	0.089	0.011
Da	1.29	0.087	0.010
A_f	3.24	0.84	0.718
A_t	1.22	0.150	0.016
Km	10	-	-
Bd	0.640	-	-
M.C	14	-	-

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 %

1-1- Dimensions of sesame seeds:

Seed dimensions used in the experiments are shown in fig. 1. Mean dimensions of sesame seeds are as follows:-

length (L) = 2.5 mm, width (W) = 1.65 mm, and thickness (T) = 0.94 mm.

Fig. (1) data indicates that the percentage of frequency is 60 % at mean grain length of about 2.5 mm, for mean grain width of about 1.7 mm with the percentage of frequency is 49 %, and for mean grains thickness of about 0.9 mm with the percentage of frequency is 85 %.

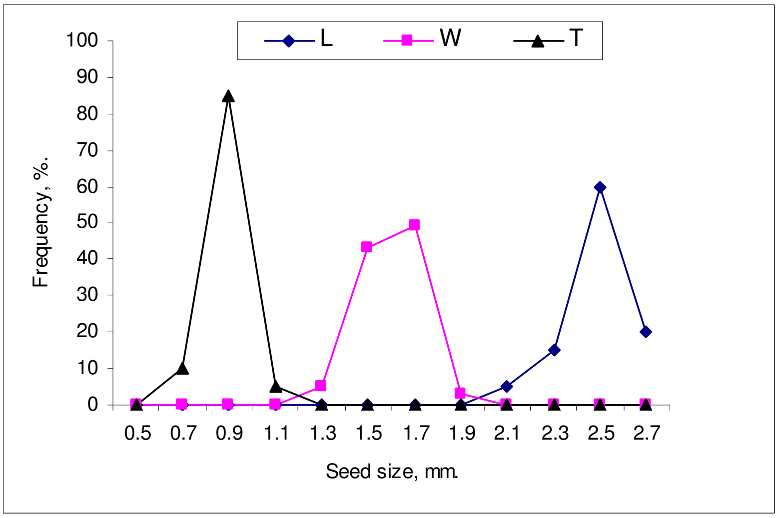


Fig. (1): Frequency of 3 dimensions of sesame seeds (Giza 32-variety).

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

Sesame seeds (Sakha 2 variety) L = 1.52 W = 2.66 T---(9)

1-2- Mass, sphericity and volume of sesame seeds:

Table (1) shows that the mass of-1000 seeds and sphericity is 10 g. and 62.84 % respectively.

1-3- Diameter of sesame seeds:

Seed diameter used in the experiments are shown in table (1) Maximum diameter of sesame seeds are as follows:- geometric diameter (D_g) = 1057 mm and, arithmetic diameter (D_a) = 1.29 mm.

1-4- Surface area of sesame seeds:

Table (1) shows that the flat surface area and transverse surface area is 3.24 and 1.22 mm^2 respectively.

1-5- Volume, flat surface area, transverse surface area, geometric diameter, and arithmetic diameter as a function of length, width, and thickness:

The volume (V), flat surface area (A_f), transverse surface area, (A_t) geometric diameter (Dg), and arithmetic diameter (Da) of sesame seeds, as also with other similar agricultural products, are useful values which are usually difficult and cumbersome to determine rapidly or by a direct measurement. 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 formula (4), (5), (6), (1), and (2) were used to determine these values for all seed 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 sesame seeds (Giza 32 – variety).

$$V = 0.129 L^3 = 0.451 W^3 = 2.44 T^3 \text{ ------------------(10)}$$
$$A_t = 0.195 L^2 = 0.45 W^2 = 1.38 T^2 \text{ --------------------(11)}$$
$$A_f = 0.52 L^2 = 1.19 W^2 = 3.67 T^2 \text{ --------------------(12)}$$
$$Dg = 0.628 L = 0.95 W = 1.67 T \text{ ----------------------(13)}$$
$$Da = 0.516 L = 0.78 W = 1.37 T \text{ ----------------------(14)}$$

The main advantage of the equations (10) to (14) 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.

2- Mechanical properties of sesame seeds:

2-1- Terminal velocity:

The terminal velocity of sesame seeds (Sakha2-variety) was ranged between 30 –40 m/s., and the average value was 35 m/s.

2-2- Friction, repose of angle and hardness:

Also friction angle, coefficient of friction, angle of repose, and hardness for sesame seeds reported are shown in table (2).

Table (2): Mechanical properties of sesame seeds.

Mechanical properties	Sesame 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.

From table (2) found that the friction angles between stainless surface and sesame seeds is less than friction angle between metal and wood surface and sesame seeds it were 22, 34, and 40 degree for stainless, metal, and wood surface respectively, coefficient of friction for stainless, metal, and wood surface was 0.404, 0.675, and 0.839 respectively, the angle of repose for was 30 degree, and hardness of sesame seeds was11.02 N.

3- Parameters affecting selection of screen:-

-Productivity of sieve used in the cleaning and sorting process was calculated as follows according to El-Raie (1981):-

$$\mathbf{Q = q_F \cdot F = q_F \cdot B \cdot L = q_B \cdot B} \text{-------------------------------------} \mathbf{(15)}$$

Where:

Q : productivity of sieve (kg/h),

q_F: specific load of unit area of the sieve per unit time $\frac{kg/h}{dm2}$

F : total surface area of screen, dm^2,

B : width of the screen, dm,

L : length of the screen, dm and

q_B: specific loading per unit width of the sieve $\frac{kg/h}{dm}$.

Take Q = 800 kg/h. F = 110 x 30 cm^2.

From equation 15:

$$\therefore q_F = 24 \frac{kg/h}{dm2}$$

$$\text{and } q_B = 266 \frac{kg/h}{dm}$$

B = 3dm = 300 mm (500 mm > B > 130 mm),

L 1000 mm (600 mm > L > 2500 mm),

L/B = 1000/300 = 3 (1.0 > L/B > 3.0)

-The rpm (n) of crankshaft of screening unit was calculated from the following formula according to El-Raie 1981:

$n = 30/\pi \{ g/r \cdot \tan(\Psi - \beta) \}^{1/2}$ ---------------------------------(16)

Where:

r :is the radius of rotation of crankshaft of screening unit in m,

g: gravitational acceleration in m/sec^2,

Ψ: angle of friction between seed and screen, degree and

β: slope angle of the sieve toward horizontal plane, degree .

Take $r = 17.5$ mm = 0.0175 m $\beta = 5^o$

From table (2)

Ψ = 22 for stainless sheet, 34 for metal sheet and 40 degree for wood sheet.

$\therefore$n = 125.07 rpm for stainless sheet 168.41 rpm for metal sheet and 189.28 rpm for wood sheet respectively,

- The ideal distribution of holes may be evaluated by coefficient of live area (μ) according to El-Raie 1981 as follows:-

$\mu = F_o / F$---(17)

Where: -

F_o : is the total area of the holes on the sieve and

F : total area of the sieve sheet

Take $F_0 = 990$ and $F = 3300$

From equation 17 $\therefore$ $\mu = 0.3$

For round hole

$\mu = \pi r^2 / 2 (3)^{1/2} (r + m)^2$ --(18)

Where:

2r = d = diameter of the hole,

2m = distance between two neghbouring holes

$(0.9 < (d)^{1/2}\ 2m < 1.2\ (2r)^{1/2})$,

From table (1)

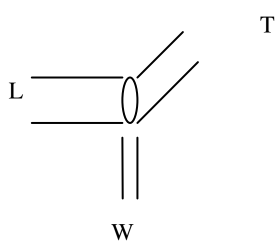
For sesame: L = 2.5 $\therefore$ d = 3 mm $\therefore$ r = 1.5 mm,

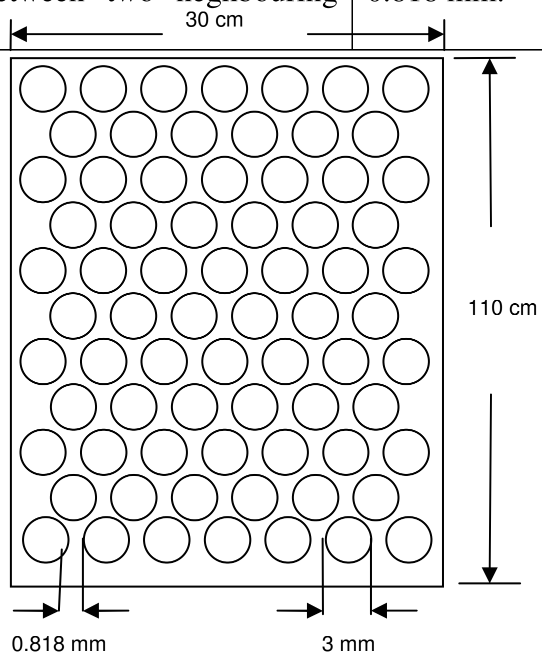
From equation 18 $\therefore$ m=0.818 mm

4- Sieve specification suggested:

Item	Specification
Q : productivity of sieve (kg/h)	800
F : total surface area of screening, dm^2,	110 x 30
β: slope angle of the sieve toward horizontal plane, degree .	5^o

Ψ: angle of friction between seed and screen, degree	22 for stainless sheet, 34 for metal sheet and 40 degree for wood sheet.
The rpm (n) of crankshaft of screening unit	125.07 rpm for stainless sheet 168.41 rpm for metal sheet and 189.28 rpm for wood sheet respectively,
(μ): ideal distribution of holes may be evaluated by coefficient of live area	0.3
L: Length of grain	2.5 mm
D: diameter of hole	3 mm
m:distance between two neghbouring holes	0.818 mm.





The suggested of original sieve for sesame seeds.

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<u>الملخص العربى</u>

بعض الخصائص الطبيعية والميكانيكية لبذور السمسم المرتبطة باختيار وحدة التنظيف

د/ جمال كمال عرفة

ويهدف هذا البحث الى 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 ، ومعامل الاحتكاك لثلاثة أسطح من الاستنلس والمعدن والخشب ، ودراسة زاوية التكويم ، والصلابة وسرعة التعليق) وكذلك أيضا تمت دراسة بعض المتغيرات المرتبطة بوحدة التنظيف مثل أقطار فتحات الغربال، ومعامل المساحة الحية للغربال، والمساحة الكلية للفتحات على الغربال.

وكانت النتائج المتحصل عليها كالتالى:

<u>**(ا) الخواص الطبيعية**</u>

ا- **أبعاد البذور :** وجد ان طول وعرض وسمك بذور السمسم هو 2.5، 1.65، 0.94 مم على الترتيب.

2- **وزن الآلف حبة وحجمها:** وجد ان وزن الآلف حبة وحجمها هى 10 ج. 2.03 مم^3.

3- **الكثافة الحقيقية :** وجد ان الكثافة الحقيقية هى 0.640 كج/م3.

4- **التكور:** وجد ان النسبة المئوية للتكور هى 62.84 %.

5- **القطر:** وجد ان القطر الهندسى والرياضى هو 1.57 ، 1.29 مم على الترتيب.

6- **مساحة السطح:** وجد ان مساحة السطح المسطح ومساحة سطح الحبة المنقولة هو 3.24 ،1.22 مم^2 على الترتيب.

7- **المحتوى الرطوبى:** وجد ان المحتوى الرطوبى الأمثل لبذور السمسم هو 14 %.

<u>**(ب) الخواص الميكانيكية.**</u>

1- **زاوية ومعامل الاحتكاك :** وجد ان متوسط زاوية الاحتكاك لبذور السمسم هى 22، 34، 40 درجة على أسطح الاستانلس ستيل، الصاج ، والخشب على الترتيب . بينما كان معامل الاحتكاك للأسطح الاستانلس ستيل، الصاج ، والخشب هو 0.404 ،0.675 ، 0.839 علي الترتيب حيث يفضل السطح الاستانلس ستيل لقلة زاوية الاحتكاك ومعامل الاحتكاك عن الأسطح الأخرى (المعدن والخشب) .

2- **زاوية التكويم:** وجد ان أقصى زاوية تكويم لبذور السمسم هى 30 درجة.

3- **صلابة الحبوب:** وجد ان متوسط مقدار تحمل حبوب السمسم لقوى الكسر هو 11.02 نيوتن.

4- **سرعة التعليق:** وجد ان السرعة المناسبة للتخلص من القش والأتربة والأجزاء الدقيقة أثناء عملية الفصل يجب ان تقل عن 35 م/ث.

باحث – معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – دقى – جيزة.

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

$$L = 1.52\ W = 2.66\ T$$

(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

$$V = 0.129\ L^3 = 0.451\ W^3 = 2.44\ T^3$$

$$A_t = 0.195\ L^2 = 0.45\ W^2 = 1.38\ T^2$$

$$A_f = 0.52\ L^2 = 1.19\ W^2 = 3.67\ T^2$$

$$Dg = 0.628\ L = 0.95\ W = 1.67\ T$$

$$Da = 0.516\ L = 0.78\ W = 1.37\ T$$

(هـ) ومن دراسة المتغيرات الأساسية لأجهزة التنظيف تم وضع مواصفات الغرابيل المناسبة والتى باستخدامها تؤدى الى رفع نسبة النظافة وهى كالتالى عند الفصل حسب اكبر بعد للحبة (الطول): قطر فتحة الغربال الدائرية 3 مم لبذور السمسم، معامل المساحة الأقصى = 0.3 ، والمساحة الكلية للفتحات على الغرابيل 0.99 / 1 م2 من السطح الكلى للغربال.