J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 7 (7): 441 – 445,2016

Some Physical and Mechanical Properties of Pomegranate Seeds

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ABSTRACT

The present study aimed to determine and recognize the physical and mechanical properties as an important role in designing and developing of specific machines and their operations such as planting, harvesting and grading. The physical and mechanical characteristics of Pomegranate seeds were obtained for one variety of *Punica granatum.* For each of the dimensions, the Pomegranate seeds gave the highest value in width of 13.8± 0.53 mm and lowest value in height of 8.0 ± 0.59mm. The highest value of repose angle was 32.5º for ply wood while the lowest value was 25º for galvanized sheet. The Pomegranate seeds gave the lowest value of static coefficient of friction of 0.29 for ply wood while the highest value was 0.44 for glass.

INTRODUCTION

Data on physical properties of agro-food materials are valuable because: they are needed an input to models predicting the quality and behavior of produce in sowing, handling, pre-harvest, harvest, and post-harvest situations; and aid the understanding of food processing.

Nesvadba, et al. (2004) and Ismail *et al*. (2010) mentioned that physical properties of the material such as shape, size, volume, density, surface area and coefficient of friction are important and essential engineering data in design of machine structures, and controls, in analyzing and determining the efficiency of a machine or an operation. And in evaluating and retaining the quality of the final product (Mohsenin, 1986).

Matthews (1991) reported that for determining gain size from grain weight, the density of individual grain is required. This can be measured by mean of picnometer or fluid displacement techniques. The void ratio can be determined in terms of the bulk density and grain surface area is very important in term of determining the volumetric and gravimetric heat transfer coefficients for heat transfer applications.

Ibrahim (1992) indicated that the processed materials vary considerably in their physical properties such as size, shape, density, volume, specific gravity and surface texture. These characteristics are very important in many problems associated with design or development of specific machine, analysis of the behavior of the product and handling. Generally, the physical properties of grains are essential for the design of equipment for handling, harvesting, aeration, drying, storing, dehulling and processing. These properties are affected by numerous factors such as size, form, superficial characteristics and moisture content of the grain (Baumler, et.al. 2005) Many authors {Ismail Z. E. (1988),Akubuo and Odigboh (1999), Abou-Elmagd, et al. (2002), Awady et al. (2004), El Sayed et al. (2009) and Yehia et al. (2009)} mentioned that the knowledge of the physical and mechanical characteristics of agricultural products is important in the design, of agricultural machines and equipment. They studied the physical properties and characteristics of some agricultural crops and fruits, which can be used in the design and development of equipment

The aim of this investigation was establishing the physical and mechanical characteristics related to sowing, handling and storage as a function of material surfaces and painting for one variety of Egyptian Pomegranate seeds.

MATERIALS AND METHODS

Raw Materials

The Pomegranate samples obtained from a local market, Mansoura, Daqahlia Governorate**.** Pomegranate was peeled and extracts the seeds manually to be ready for direct measurements as in Fig. (1).

(a) (b)

Fig. (1): Pomegranate fruit (a) and Pomegranate seeds (b)

All experiments and procedures were done in the laboratory of physical properties at Faculty of Agricultural Engineering, Al-Azhar University.

Tests procedures

Dimensional Characteristics

Random samples of one hundred seeds were taken out from the variety of *Punica granatum*. The two major dimensions, height (parallel with the longitudinal axle "h"), Width (perpendicular on the longitudinal axle "W") Fig. (2), of each seed were recorded, while the seed thickness is neglected because of it have tiny dimension. Height and width (mm) were measured by using digital dial caliber (accuracy of 0.01).

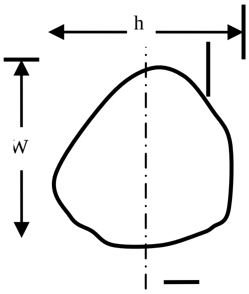


Fig. (2): Longitudinal and lateral positions of the individual Pomegranate seed.

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 processes, and it is also useful for describing the re-hydration process. The following relation was used for calculating the flat surface area (A_f) in (mm^2), according to (Matthews, 1991) as:

$$A_f = \frac{\pi}{4}(a.b) \text{ mm}^2 \quad \ldots\ldots (1)$$

Mass of one thousand seeds

A random sample of one thousand seeds was taken by seed counter and weighed by an electric digital balance, Sartorius: 1413-MP8-1, manufactured in Germany with capacities 500g and 5000g at accuracies 0.001g and 0.01g respectively. The mass of each treatment was replicated three times.

Bulk density, real density and void ratio

The bulk density (ρ_b , kg/m^3) was determined using a graduated cylinder of 1000 ml, the volume was determined by pouring one thousand seeds in the pervious graduated cylinder Boumans (1985) Kaleemullah (1992). Each test was done in three replicates. The bulk density was calculated for the seeds by dividing the mass of quantity of seeds (M_b, kg) on its volume (V_b, m^3).

$$\rho_b = \frac{M_b}{V_b} \quad \ldots\ldots (2)$$

The real density (ρ_r , kg/m^3) was determined by measuring the actual volume of a known mass of a random seeds sample. The actual volume of the seeds was determined by water displacement method in a graduated measuring cylinder of 250 ml, the immersion time was about 10 second which was too small to absorb water. The real density is calculated by finding the ratio of mass (M_r, kg) to volume (V_r, m^3) of displaced water. The real density for each variety was replicated three times.

$$\rho_r = \frac{M_r}{V_r} \quad \ldots\ldots (3)$$

The void ratio (ε, %) was achieved by the following equation:

$$\varepsilon = 1 - \frac{\rho_b}{\rho_r} \times 100 \quad \ldots\ldots (4)$$

ρ_b : Bulk density of seeds, (kg/m^3) and

ρ_r : Real density of seeds, (kg/m^3).

Moisture content of seeds

The moisture content was determined for seeds using (AOAC, 19
Moisture content "*M.C*" as wet basis, (%):

$$M.C = \frac{W_m}{W_m + W_d} \times 100 \quad \ldots\ldots (5)$$

Moisture content "*M*" as dry basis, (%):

$$M = \frac{W_m}{W_d} \times 100 \quad \ldots\ldots (6)$$

Where:

W_m: Mass of moisture in sample, (g); and

W_d: Mass of bone-dry material, (g).

Repose angle

The angle of repose was measured between the horizontal and the natural slope of the seeds heap. The different material surfaces namely: plywood, glass and galvanaized sheet were used for measuring it. The height of the heap was measured and angle of repose was calculated by the following equation Ismail (1988),Kaleemullah (1992) and Soliman (1994)

$$\alpha = \tan^{-1}\left(\frac{2H}{Dp}\right) \quad \ldots\ldots (7)$$

Where: α = dynamic angle of repose, degree.

H = heap height, mm and

Dp = The wide platform distance, mm.

Static friction coefficient

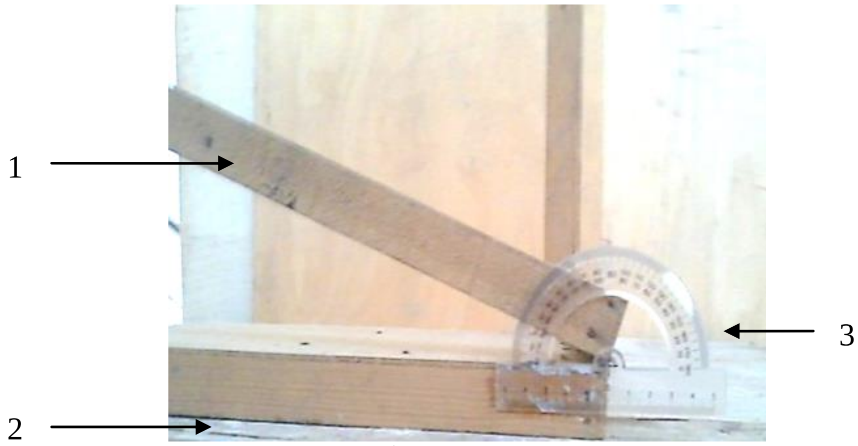
The test procedure started by leveling the apparatus that was fabricated in the workshop of Agricultural Engineering Faculty, Al-Azhar University, Nasr city, Cairo, Egypt. As shown in fig. (3). The apparatus was used to measure the angle of static friction for the different material surfaces, namely: plywood, glass and mild steel sheet. The Static coefficient of friction was determined using the following equation Mohsenin (1986).

Static Coefficient of friction = tan θ ………….. (8)

Where:

θ= the tilt angle between the surface and the horizontal.

The angle of friction (θ) was measured three times for each selected materials for seeds.



1. Revolving plate for changing their inclination angle.
2. Fixed plane. 3. Protractor.

Fig. (3): Friction angle apparatus.

Rigidity force

A digital force gauge (Shimpo, DF-5.0 series) with accuracy of ± 0.2 % was used for measuring the rigidity force with maximum capacity of 2200g. The rigidity force was recording of each Pomegranate seed in two surface positions (vertical and horizontal) after installing the Vee sensing head in the digital force gage. The rigidity force was recording three replicates for each seed.

RESULTS AND DISCUSSION

Physical and mechanical characteristics of Pomegranate seeds under study were conducted in the lab., of Physical Properties at Faculty of Agricultural Engineering, Al-azhar University.

The two- Major dimensions

Averages of one hundred seeds for the two-major dimensions are shown in table (1). The measurements of height (a) and width (b) in (mm) of hundred seeds, randomly selected, were conducted. The highest value of seed height and width were 10.7 and 13.8 mm respectively, while the lowest value of seed height and width were 8.0 and 11.5 mm respectively.

Fig. (4 and 5) showed that the highest frequencies of seed height and width were 37 and 37 % at (9.2 – 9.7 mm) and (12.5 – 12.9 mm) respectively. Dimensions are important to design the cleaning, sizing and grading machines.

Table (1): The two - Major dimensions of Pomegranate seeds.

Two-major dimensions	Max.	Min.	Ave.	S.D	C.V %
Height (mm)	10.7	8.0	9.2	0.59	0.06
Width (mm)	13.8	11.5	12.6	0.53	0.04

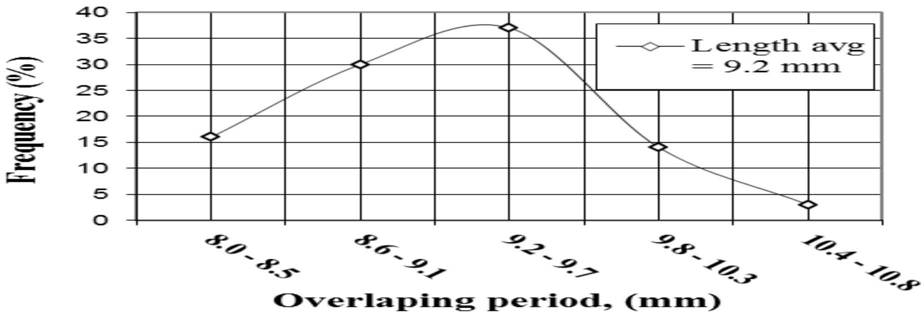


Fig. (4): Length of Pomegranate seeds

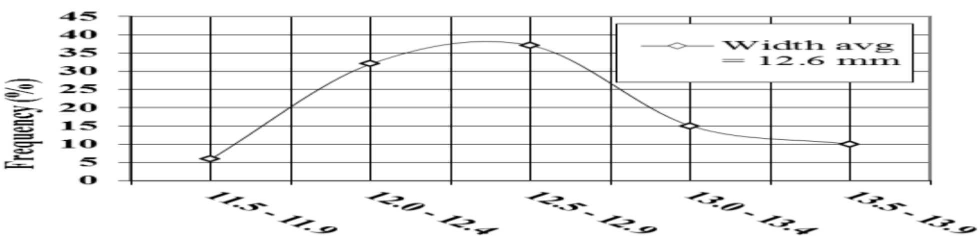


Fig. (5): Width of Pomegranate seeds

Seed surface area

Table (2) shows the flat surface area of seeds. The maximum value of flat surface area is 116.0 mm^2, while the minimum value is 72.3 mm^2. Fig. (6) shows that the highest frequency of seed flat surface area was 32 % at (89.9 – 98.6 mm^2).

Table (2) Flat surface area of Pomegranate seeds.

Seed surface area	Max.	Min.	Ave.	S.D	C.V %
Flat surface area (mm^2)	116.0	72.3	91.84	9.67	0.11

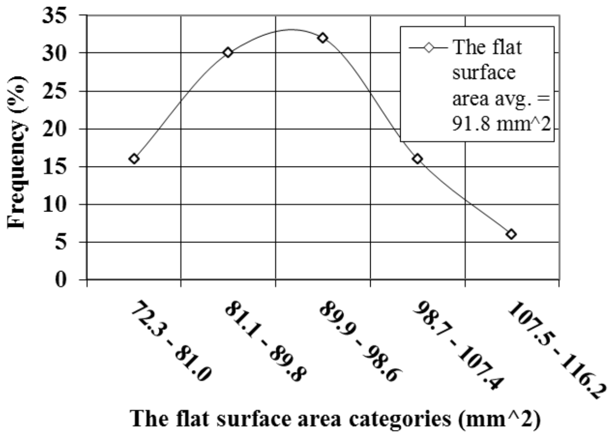


Fig. (6):The flat surface area (mm^2) of individual Pomegranate seed

Mass of 1000 seeds, bulk & real density, void ratio and moisture content

The measurements of mass of one thousand seeds of Pomegranate under study, bulk and real density. Also, void ratio and moisture content were conducted in three replicates.

Table (3) shows the other physical characteristics for the mass, real& bulk density, void ratio and moisture content. It shows that the seeds gave values of 527.90 (g), 1.07 (g/cm^3), 0.66 (g/cm^3), 38.32 % and 84.10 % w.b & 528.80 % d.b for mass, real, bulk density, void ratio and moisture content after a week of harvest respectively. Mass of one thousand seeds is major considerations in designing containers, silos and hoppers. Estimating the mass of seed is necessary to assess the required mass of seed for planting a limited area and number of seed in each hole. Bulk and real density are major considerations in designing the sowing, converting, drying, aeration and storage systems, bulk density is also considered for determination of paging capacity, designing seed hopper dimensions in seed planters and cleaning and grading equipment.

Table (3): The mass , real& bulk density of one thousand seeds, void ratio and moisture content.

Seeds	Mass (g)	Real density (g/cm^3)	Bulk density (g/cm^3)	Void ratio (%)	Moisture content (%)	
	527.90	1.07± 0.03	0.66 ± 0.07	38.32	84.10 w.b	528.80 d.b

Angle of repose and static friction coefficient

The angle of repose for Pomegranate seeds of the investigated variety was 32.5°, 29.8° and 25°for plywood, glass and galvanized sheet respectively.

It is clear that angle of repose of seeds was decreased when the surface of seeds becomes more smooth. The previous data can be utilized to assess the optimum side's inclination of seed hopper in planting machines, silos and storage containers to allow an easily sliding. Coefficient of friction is the tangent of dynamic angle of repose. The repose angle for Pomegranate seeds of the investigated variety on the selected material surfaces including plywood, glass and galvanized sheet are shown in Fig (7).

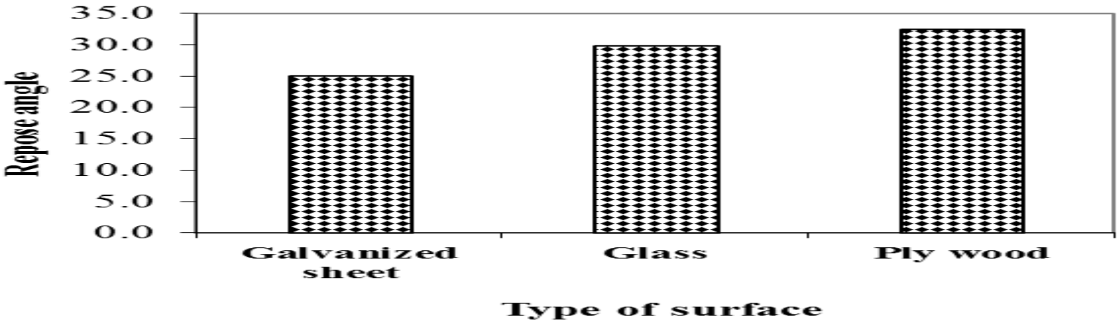


Fig. (7): Angle of repose for Pomegranate seeds on different material surface

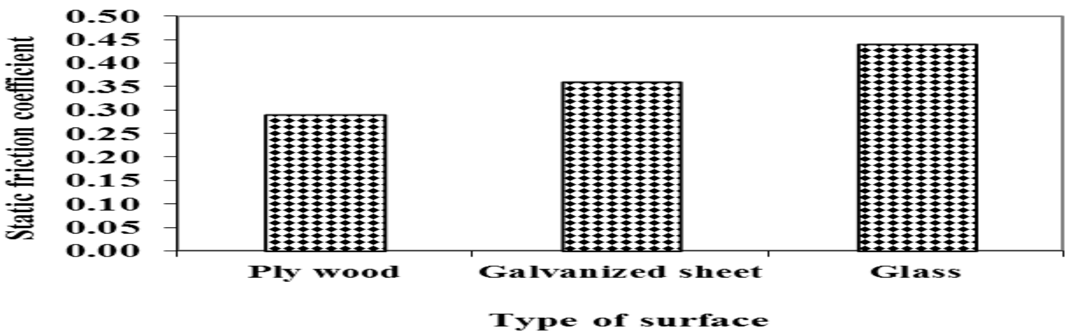


Fig. (8): Static friction coefficient for Pomegranate seeds on different material surface

The lowest values of static coefficient of friction were on plywood followed by galvanized sheet, and the highest glass, (0.29, 0.36 and 0.44) for the Pomegranate variety respectively. It is recommended to use this material in the structure of seed hopper in planters, silos and storage containers. The static coefficient of friction for Pomegranate seeds of the investigated variety on the selected material surfaces including plywood, galvanized sheet shown in Fig (8).

Rigidity force:

The rigidity force of each seed in two surface positions (vertical and horizontal) was 1.42 N and 0.67 N respectively as in table (4).

Table (4): The rigidity force of Pomegranate seeds.

Surface positions	Rigidity force (N) 1	2	3	Ave.
Vertical	1.30	1.40	1.56	1.42
Horizontal	0.76	0.50	0.74	0.67

CONCLUSION

The obtained results can be summarized as follows:

1- the highest value of the two major dimension was 13.80 mm for the width while the lowest value was 8.00 mm for the height.
2- The Pomegranate seeds gave the highest of flat surface area of 116.00 mm^2.
3- The values of (529.90 g, 1.07 g/cm^3, 0.66 g/cm^3 and 38.00%) were for mass of one thousand seeds, real density, bulk density and void ratio respectively.
4- The seeds gave moisture content of 84.10 % w.b and 528 % d.b.
5- The highest value in dynamic angle of repose 32.50º for ply wood while the lowest value in dynamic angle of repose 25.00º for galvanized sheet.
6- The lowest value of static coefficient of friction was 0.29 with ply wood while the highest value was 0.44 with glass.
7- The rigidity force of 1.42 N and 0.67 N in two surface position (vertical and horizontal) respectively.

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بعض الخصائص الطبيعية والميكانيكية لبذور الرمان

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*** مدرس بقسم هندسة تصنيع المنتجات الزراعية ـ كلية الهندسة الزراعية ـ جامعة الأزهر ـ القاهرة ـ مصر.**

تهدف هذه الدراسة إلى توفير قاعدة معلومات للخصائص الطبيعية لبذور الرمان لما تمثله هذه الخواص من أهمية فى عملية تداول وتنظيف بذور الرمان كمراحل أولية فى العمليات التصنيعية المختلفة, وبغرض المساهمة فى تقليل الأضرار الميكانيكية التى تتعرض لها البذور خلال عمليات التداول المختلفة. وكانت الخصائص الطبيعية المدروسة هى الخصائص البعدية, وتشمل طول وعرض البذرة (مم) والكثافة الظاهرية والحقيقية (جرام/سم^3) ونسبة الفراغات البينية ووزن الألف حبة و والمحتوى الرطوبى وزاوية المكوث ومعامل الإحتكاك الإستاتيكى للبذور على ثلاثة أسطح مختلفة وهى الخشب والزجاج والصاج وقوة الإختراق السطحية للبذور.
ويمكن تلخيص النتائج التي توصل إليها البحث فيما يلي: - الخصائص البعدية: كانت أعلى قيمة للطول (البعد الموازى للمحور الطولى للبذرة) 10,70 مم و أقل قيمة 8,00 مم, وأعلى قيمة للعرض (البعد العمودى على المحور الطولى للبذرة) 13,80 مم وأقل قيمة 11,50مم. - وزن الألف حبة: أظهرت النتائج أن وزن ألف حبة من بذور الرمان كانت 527,90 جرام. الكثافة الظاهرية : سجلت بذور الرمان كثافة ظاهرية مقدارها 0,66 جرام/سم3. الكثافة الحقيقية : سجلت بذور الرمان كثافة حقيقية مقدارها 1,07 جرام/سم3. المحتوى الرطوبى: سجلت بذور الرمان محتوى رطوبى 84,10 ٪ على أساس رطب و 528,80 ٪ على أساس جاف. زاوية المكوث الطبيعى للأسطح المختلفة: سجلت بذور الرمان فى زاوية المكوث الطبيعى الإستاتيكى 32,50° , 29,80° , 25,00° على أسطح الخشب والزجاج والصاج على التوالى. معامل الإحتكاك الإستاتيكى للأسطح المختلفة: سجلت بذور الرمان فى معامل الإحتكاك الإستاتيكى 0,29 , 0,36 , 0,44 على أسطح الخشب والصاج والزجاج على التوالى. قوت الإختراق السطحية: سجلت بذور الرمان قوة اختراق قدرها 1,42نيوتن و 0,67 نيوتن فى الوضع العمودى والأفقى على الترتيب.