PROCESS ENGINEERING

A STUDY OF SOME PHYSICAL AND MECHANICAL PROPERTIES OF SEED MELON SEED

R. Abu Shieshaa[1], R. Kholief[1], A. A. El Meseery[2]

ABSTRAT

The present study was carried to evaluate the effect of moisture content on some physical and mechanical properties of seed melon seeds and their kernel. The average length, width, thickness, mass and hardness of 100 seeds were 12.42, 7.80, 2.37 mm, 0.097g and 64.8 N, respectively, at a seed moisture content of 9.53% (w.b.) corresponding values of kernel, were 10.5, 6.50, 1.64mm, 0.061g and 14.0 N. The increase of seed moisture content from 9.53 to 24.08% leads to increase the bulk density of seed and kernel from 490 to 600 and 510 to 640 kg/m³, respectively. However, the true density of seed was decreased from 1160 to 1000kg/m³. Meanwhile, it increased from 1015 to 1150 kg/m³ for kernel. The porosity decreased from 58 to 41 and 50 to 40% for seed and kernel, respectively. The highest values of terminal velocity were 6.4, 4.67 and 3.94 for seed, kernel and hull, respectively, at seed moisture content of 24.08%. In the same manner the same increase in seed moisture content increased the static coefficient of friction of seed from 0,24 to 0.65, 0.23 to 0.80 and 0.34 to 0.90 for galvanized metal, stainless steel and plywood, respectively. While, the corresponding values of static coefficient of friction of kernels were 0.23 to 0.68, 0.27 to 0.75 and 0.33 to 0.80 for the same mentioned above surfaces. The angle of repose increased from (27 to 43 deg) for seeds and (31 to 41) deg for kernels with an increase in moisture content 9.53 to 24.08 (w.b.).

INTRODUCTION

Seed melon (*Colocynthis citrullus*), belong to the Cucurbitaceae-family is cultivated in the arid and semi-arid areas of northern half of the Nile Delta in Egypt, such as Kafr El-Sheikh Governorate, and newly reclaimed lands.

[1]Senior researcher, Ag. Eng. Res. Inst., A.R.C., El-Dokki, El-Giza. Egypt.
[2] Assoc. Prof., Ag. Eng. Dept., Fac. of Ag., Azhar Univ., Cairo, Egypt.

Seed melon seeds are strategic vegetable products in Egypt that can be exported to several Arab countries. According to *Egyptian Ministry of Agriculture and Land Reclamation Report (2005),* the total area of seed melon is about 170.000 Fed. with an average yield of 470 kg/fed.

The seeds from the seed melon mature fruit are used in the form of roasted and salted food items. There is considerable interest in seed melon seeds because of their high nutritional quality, mainly in terms of protein and oil content. Acknowledge of the physical and mechanical properties of seed melon seeds is considered to be necessary to design the separating, hulling and handling equipment and other processing techniques. *Theotia and Ramakrishna (1989)* reported that the size of the seed wad considered being an important parameter in processing; the bulk sample of the seeds was classified into three categories, namely large, medium and small, based on their length, for melon seeds.

The increase in bulk density of karingda seeds and their kernels with increase in mass owing to moisture gain in the sample is greater than the accompanying volumetric expansion of the bulk *(Suthar and Das, 1996; Joshi et al., 1993) and Hsu et al., 1981).*

The decreasing and increasing trends of the true densities of karingda seed its kernel, respectively, may be attributed to the higher volumetric expansion of the seed as compared with the kernel alone on moisture gain. Similar trends were reported for pumpking seed *(Joshi et al,. 1993)* and other grains *(Brusewitz, 1975; Shepherd and Bhardwaj 1986).* Up to a moisture content of 18.0% (d.b.), the seed had a true density higher than that of kernel. However, beyond this moisture content, the true density for kernel remained higher.

The estimated porosity of both karingda seed and kernel was found to decrease with increase in moisture content. The porosity values for karingda seed and kernel are found to be lower than that of pumpkin seed and kernel *(Joshi et al., 1993)* and higher than that of melon seeds *(Teotia and Ramakrishna, 1989).*

The terminal velocity of the karingda seed was found to increase from of 4.5 to 6.5, 3.5 to 4.8 and 2.0 to 4.1 m/s for seed, kernel and hull respectively, in the moisture range of 5 to 40% (d.b.). The individual terminal velocities of seed, kernel and hull are linearly related to moisture

content as reported earlier for pumpkin seed and its fractions (**Joshi *et al*., 1993**). The static coefficient of friction of both karingda seed and kernel increased linearly with moisture content irrespective of surfaces employed. The coefficients for kernel for both plywood and mild steel became lower than that of seed beyond moisture content of about 29 and 22% (d.b.), respectively, *(Joshi et al., 1993).* A linear increase of angle of repose was observed for both karingda seed and kernel for moisture range of 5 to 22% (d.b) with higher values for the latter-to-rad (31 to 43°deg) than the former-to-rad (28 to 42°deg) *(Joshi, et al., 1993).*

The seeds are symmetrically arranged all around the central septum and are concentrated more within the central portion of the fruit than at the ends. On average, the seeds constitute 3.5% of the fruit by weight *(Nwosu, 1988).Mohsenin (1986)* concluded that friction is the result of shearing and deforming asperities, adhesion and cohesion friction of agricultural products against machine parts is one of the main causes of mechanical injuries to fruits and vegetables during handling. Knowledge of the friction coefficient is also important in the design of machines and equipment and in storage structures. He concluded investigations over the years on various agricultural products have added to the knowledge of friction properties. *Matouk et al. (1999)* evaluated the effect of some mechanical parameters on handling characteristics of spherical crops. They showed that the best ever handling result was obtained at 0.2 m/s speed of fruit feeding chain, 200 rpm sieve rocking speed and rad (15 degree) of sieve slope angle during fruits handling using rectangular cell shape. *Waziri and Mittal (1983)* stated that the angle of repose is an angle with the horizontal at which the material will stand when piled. The size contact surface and orientation of product material influence the angle of repose of a placed material. *Sitkei (1986)* studied the rolling angle of some agriculture products. He concluded that deform able product resting without movement on a slope always lies on a part of its own surface which will be impressed relative to original under formed spherical surface. Therefore, a relatively large slope angle is required to initial rolling. *Nwosu (1988)* pointed that it is a fleshy fruit, which is generally green in color, through some varieties have their green color streaked with white. The external surface of the fruit is relatively hard and smooth.

The majority of the fruits are nearly spherical in shape but some are ellipsoids having slightly elongated head-tail axial dimensions.

The objectives of the present study were to find out the principal dimensions, densities, terminal velocity, coefficient of friction, and angle of repose of seed melon seeds and its kernel at different moisture contents.

MATERIALS AND METHODS

Five bulk samples each massing 5kg of seed melon seeds (Giza-5) were produced from Kafr El-Sheikh Governorate during the harvest season of 2005. The samples were mixed and the initial moisture content of the seeds was determined by oven drying at K (105 °c) for 24h. The samples were cleaned to remove foreign matter, broken and immature seeds. To obtain the intact kernels; the seeds were manually dehulled, seeds and kernels were packed in bags.

1- Measurement of size and mass of seed melon seeds:

To determine the size and shape of the seed, three samples each massing 0.5kg, were taken from the bulk, of each sample, 200 seeds were picked out and 600 seeds thus obtained and were mixed; then, 100 seeds were randomly selected and labeled.

This method of random sampling is similar to that followed by *Dutta et al. (1988).* For each individual seed and kernel, the three principal dimensions, namely: length, width and thickness were measured using a digital vernier, (with an accuracy of about 0.01mm). Fig. 1 illustrates the main dimensions of seed melon seeds and kernel. To obtain the mass, each seed and kernel were 0.079 and 0.061 g, They separately massed on and electronic balance (accuracy of 0.01 g)

Since size of the seed was considered to be an important parameter in processing, the bulk sample of seed was classified into three categories, namely, large, medium and small, based on their length, similar to the method used by *Ramakrisha (1989)* for seed melons. The frequency distributions of seeds by the number of each size in the sample were estimated.

2- Sample preparation:

To investigate the effect of moisture content on physical and mechanical properties of seed melon seeds and kernel, the required quantity of each

was soaked separately in tap water for 60 min. to attain a moisture content of about (40%). The samples were lightly dabbed with blotting paper to remove surface water before they were allowed to be equilibrating for about 24h. This was followed by drying and it was continued for different period to achieve the desired moisture content in samples.
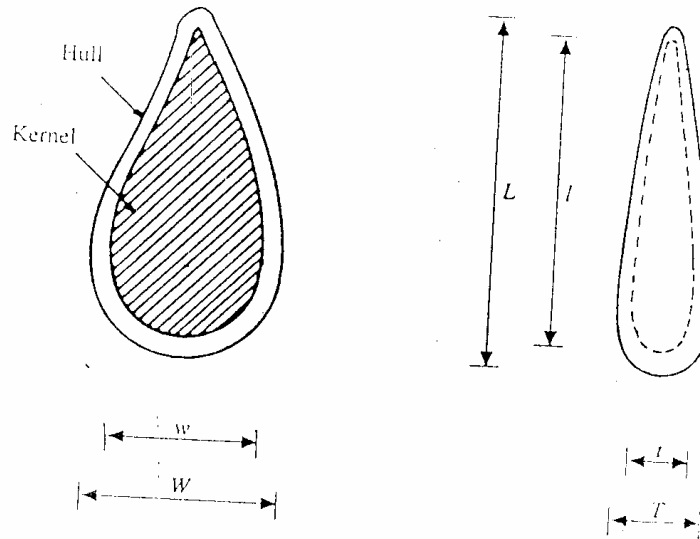

Fig. 1: Characteristic dimensions of Seed melon seed and kernel

3- Physical properties of seed and kernel for seed melon:

a- Bulk and real densities of seed and kernel:

The bulk and real densities of seed and kernel were determined at different moisture contents. The bulk density was calculated by dividing

$$p_b = \frac{M_b}{V_b} \quad ....(1)$$

the mass of bulk of seeds by its volume, which was measured by using a constant volume cylinder.

Where:

P_b = the bulk density of seed, g/cm^3;

M_b = mass of the certain quantity of seeds, g and

V_b = volume of the same quantity of seeds, cm^3

The real density was defined as the ratio of a given mass of sample to its real volume which was measured as the increase in 5 ml sodium nitrate solution subjected in a small graduate cylinder of 5 cm^3 with accuracy of 0.1 cm^3 when the particle was put in the solution *(El-Raie et al., 1996).*

b- Porosity of seed and kernel:

The porosity (ε) of the bulk is the ratio of the volume of internal pores in the particle to its bulk volume and was determined as,

Where:

ε = the porosity of seed melon seeds, % and

$$\varepsilon = (1 - P_b / P_r) \, 100 \dots\dots\dots\dots\dots\dots\dots\dots(2)$$

P_r = real density of seed melon seeds, g/cm^3

4- Mechanical properties of seed and kernel:

a- Terminal velocity:

The terminal velocities of seed melon seed and kernel at different moisture contents were measured using the terminal velocity apparatus Fig. 2, according to *Awady and El-Sayed (1994).* The air flowed upwards in the tube from the bottom to top and the air velocity at which the major fraction of sample remained suspended was recorded by using an anemometer. Ten replicates were undertaken for each sample.

b- Static friction coefficient and angle of repose:

The static friction coefficient in terms of the repose angle was examined by using the digital apparatus that, designed and fabricated at the Rice Mechanization, Center. The static friction coefficient (SFC) for seed and kernel was calculated by using the following formula.

$$\text{SFC} = \tan \theta \dots\dots\dots\dots\dots\dots\dots(3)$$

Where:

SFC = static friction coefficient

θ = repose angle, degree

Three different friction surfaces of galvanized metal, stainless steel and plywood were tested, for both seed and kernel.

c- Hardness of seed and kernel:

The hardness of seed and kernel was tested using rigidity tester (model #174886 Kiya Seisakysho LTD).
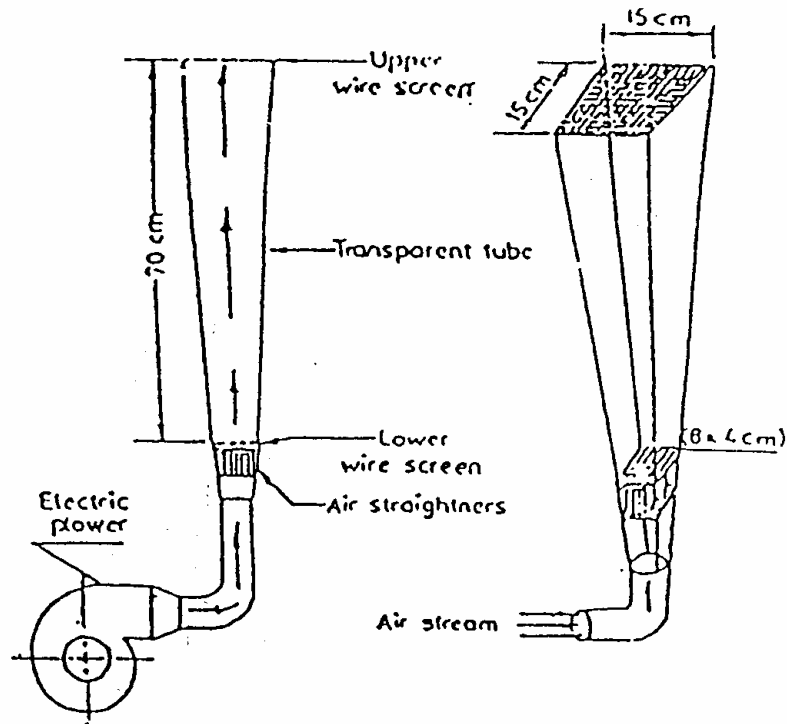
Fig. 2: Terminal velocity setup (Awady and El-Sayed 1994).

RESULTS AND DISCUSSION

1- Physical properties of seed and kernel for seed melon:

a- Dimensions of seed and kernel:

Table 1 presents the mean values of the parameters for both seed melon seed and kernel, which classified into three categories. Results indicated that 81.83% of the seeds were medium (length ranged between 10.5 to 13.5 mm), meanwhile about 12.25% were in large (grade length larger than 13.5mm) and the small length was lesser than 10.5 mm and represented 5.92%. The smaller seeds were thinner, narrower and lighter as compared with the medium and larger size seeds. Also, the results indicated in the same table, showed that the kernel length, width, thickness and mass were closely correlate with its grade whereas the large grade gave the highest values of these parameters as compared with the other two categories.
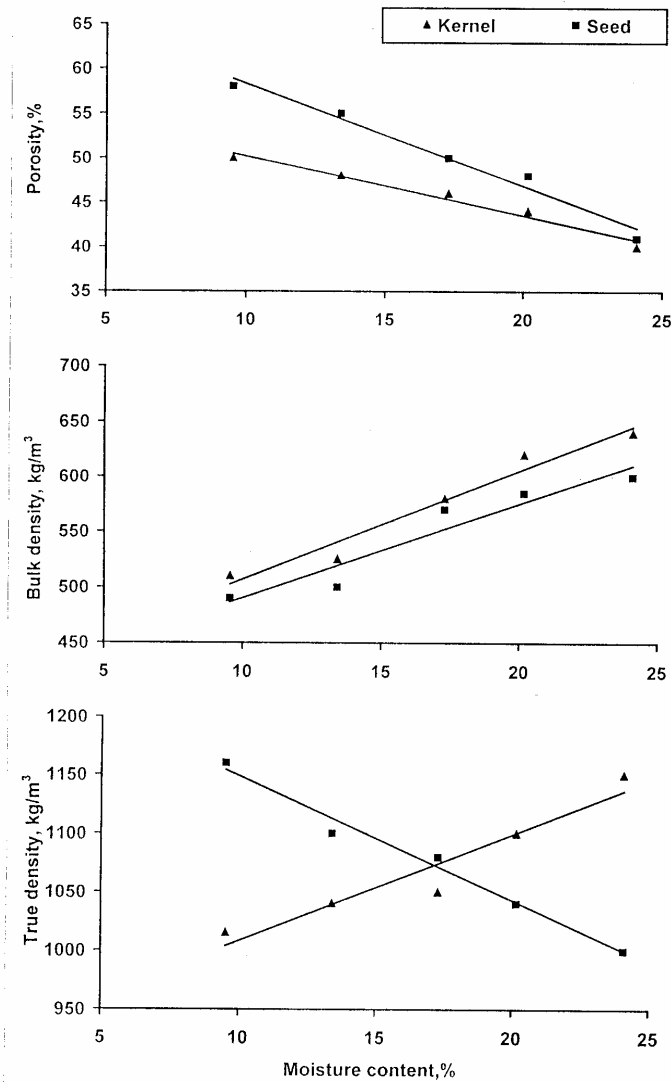
Fig. 3: Effect of moisture content on true density, bulk density and porosity of seed and kernel melons.

Results in Table 2 show that the L/W ratio gave the lowest value of standard deviation as compared with L/T and L/M ratios. This means that length of the seed is closely related to its width but less associated with the thickness and mass. The same results were obtained for the kernel and the lowest values of the standard deviation were obtained for l/w ratio.

b- Bulk and real densities:

Figure 3 shows that the bulk density of seed melon seed and its kernel were increased from 490 to 600 and 510 to 640 kg/m³, respectively, as the moisture content increased from 9.53 to 24.08%. It is obvious also that the bulk density of seeds was loss than that under the same conditions of grain moisture content. This is due to the presence of the relatively lighter hull, which reduces the total mass per unit volume occupied by the seed. However, the increase in bulk density of both seed and kernel with increase is mass owing to moisture gain in the sample is greater than accompanying volumetric expansion of the bulk. These results agreed with that reported by *(Suthar and Das, 1996).* An equation to explain the relationships between the bulk densities (P_b) and moisture content (MC) of seed and kernel were obtained and derived as follows:

$$P_{bk} = 408.6 + 9.85\,Mc \dots\dots\dots\dots\dots\dots\dots\dots\dots 4 \qquad (r^2 = 0.96)$$

$$P_{bs} = 405.07 + 8.52\,Mc \dots\dots\dots\dots\dots\dots\dots 5 \qquad (r^2 = 0.92)$$

Where:

   k: kernels and s: seeds

   Pbk: kernel bulk density, Kg/m³

   Pbs: seed bulk density Kg/ m³

Figure 3 illustrates the effect of seed moisture content on true density of seed and kernel. Results showed that the true density was found to be decreased from 1160 to 1000 kg/m³ for seed and increase from 1015 to 1150 kg/m³ for kernel by increasing the seed moisture content from 9.5³ to 24.08%. The decreasing and increasing trends of the true densities of seed melon seed and its kernel, respectively, may be attributed to the higher volumetric expansion of seed as compared with the kernel alone on moisture gain.

Similar results were reported by *(Joshi, et al., 1993).* The variations in true density (P_t) with moisture content (Mc) for seed and kernel may be indicated as follows:

$$P_k = 916.98 + 9.12\,Mc \dots\dots\dots\dots\dots\dots\dots\dots 6 \ (r^2 = 0.92)$$

$$P_s = 1254.9 - 10.59\,Mc \dots\dots\dots\dots\dots\dots\dots 7 \ (r^2 = 0.98)$$

Where:

   K: kernel and s: seeds

Table 1: Size distribution of seeds at moisture content of 9.53% (w.b.)

Particulars	Size category			
	Ungraded	Large	Medium	Small
Length of seed, mm	9.43 to 16.27	>13.5	10.5 to 13.5	<10.5
Percentage of sample by massing	100	12.25	81.83	5.92
Average dimension **Seed:**				
Length (L),mm	12.42	14.52	12.45	10.32
Width (W),mm	7.80	9.47	7.63	6.12
Thickness(T),mm	2.37	2.67	2.32	2.05
Mass (M),mm	0.097	0.126	0.089	0.065
Hardness (T),N	66.58	52.56	65.79	74.18
Kernel:				
Length (L),mm	10.57	12.17	10.78	8.92
Width (W),mm	6.50	8.01	6.34	4.83
Thickness (T),mm	1.64	1.85	1.60	1.26
Mass (M),mm	0.061	0.091	0.067	0.043
Hardness (T),N	14.70	6.12	13.41	21.73

Average of three replications.

c- Porosity of seed and kernel:

Dealing with the effect of moisture content on the estimated porosity, it was noticed that the estimated porosity for both seed and kernel found to decrease with the increase of moisture content (Fig. 3). The observed reduction in seed and kernel porosity with the increase in moisture content could be attributed to the increase in principal dimensions of seed and the resulted reduction in void area between seed. Similar results were obtained by *(Matouk et al., 2004).* Two equations to explain the relation between the porosity (ε) and the moisture content (Mc) for kernels and seeds are indicated as follows:

$$\varepsilon_k = 56.89 - 0.67 \, Mc \quad \text{…………............8 } (r^2 = 0.97)$$
$$\varepsilon_s = 69.75 - 1.15 \, Mc \quad \text{…………...............9 } (r2 = 0.98)$$

Where:

k: kernels and s: seeds

Table 2: Seed and kernel dimension ratio at 9.53% moisture content w.b.

Particulars	Ratio			Standard deviation
	Mean value	Min. value	Max. value	
L/W	1.59	1.53	2.42	0.133
L/T	5.24	4.49	5.89	0.457
L/M	128.04	97.57	162.26	20.491
l/w	1.63	1.41	2.53	0.124
l/t	6.45	3.38	7.43	0.635
l/m	173.28	112.78	219.18	25.059
L/l	1.18	1.05	2.30	0.158
W/w	1.20	1.03	2.24	0.194
T/t	1.45	1.09	1.98	0.168
M/m	1.59	1.86	1.46	0.016

2- Mechanical properties of seed and kernel:

a- Terminal velocity:

The variation velocity of seed melon seed and its fractions with moisture content are presented in Fig. 4. The terminal velocity was found to be increasing from 4.55 to 6.4, 3.50 to 4.67 and 2.10 to 3.94 m/s for seed, kernel and hull respectively by increasing the moisture content 9.53 to 24.08 % (w.b.). The divergent between the terminal velocities of seed and kernel with the increase in their moisture contents suggests better separability of these two fractions at higher moisture contents. On the other hand, the terminal velocities of kernel and hull tend to converge with the increase in moisture contents, which would make separation more difficult. These results agreed with that reported by *(Joshi et al., 1993).*

Three equations to explain the relation between the moisture content and the terminal velocity (Tv) and moisture content (Mc) for hull, kernel and seed were obtained and indicated.

$$T.V_h = 0.82 + 0.12Mc \dots\dots\dots\dots\dots\dots\dots\dots\dots 10 \ (r^2 = 0.95)$$

$$T.V_k = 2.62 + 0.08Mc \dots\dots\dots\dots\dots\dots\dots\dots\dots 11 \ (r^2 = 0.94)$$

$$T.V_s = 3.12 + 0.14Mc \dots\dots\dots\dots\dots\dots\dots\dots\dots 12 \ (r^2 = 0.97)$$

Where:

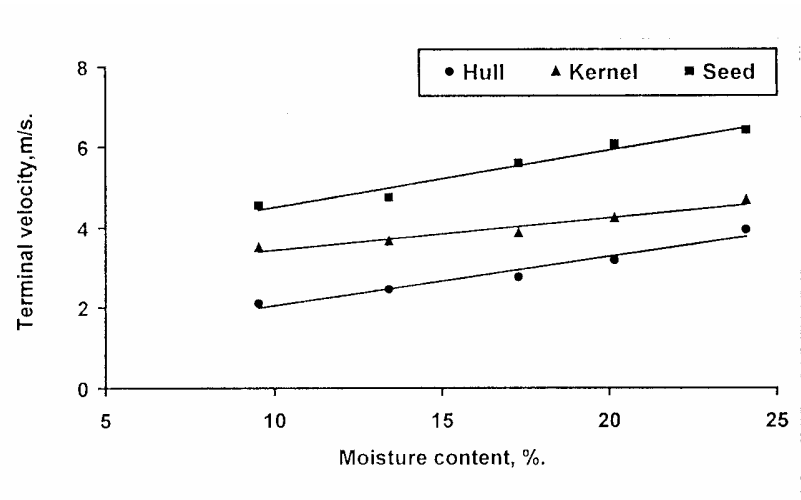　h: hulls, k: kernels and s: seeds

Fig. 4: Effect of moisture content on terminal velosity
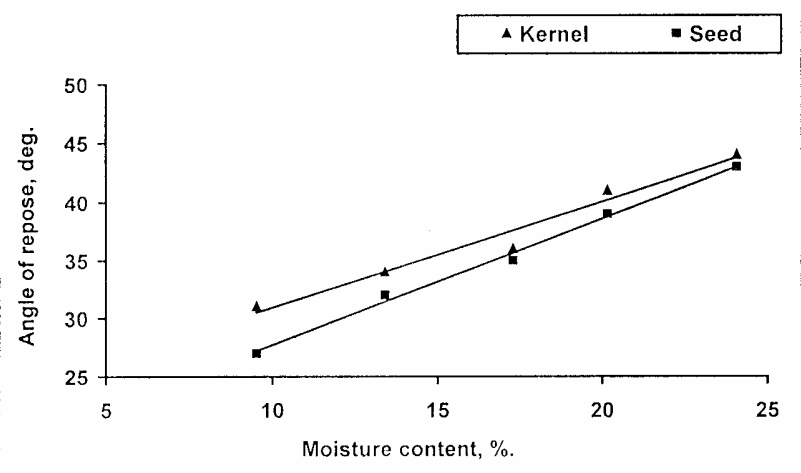of seed melons and its fractions.

Fig. 5: Effect of moisture content on angle of repose of seed
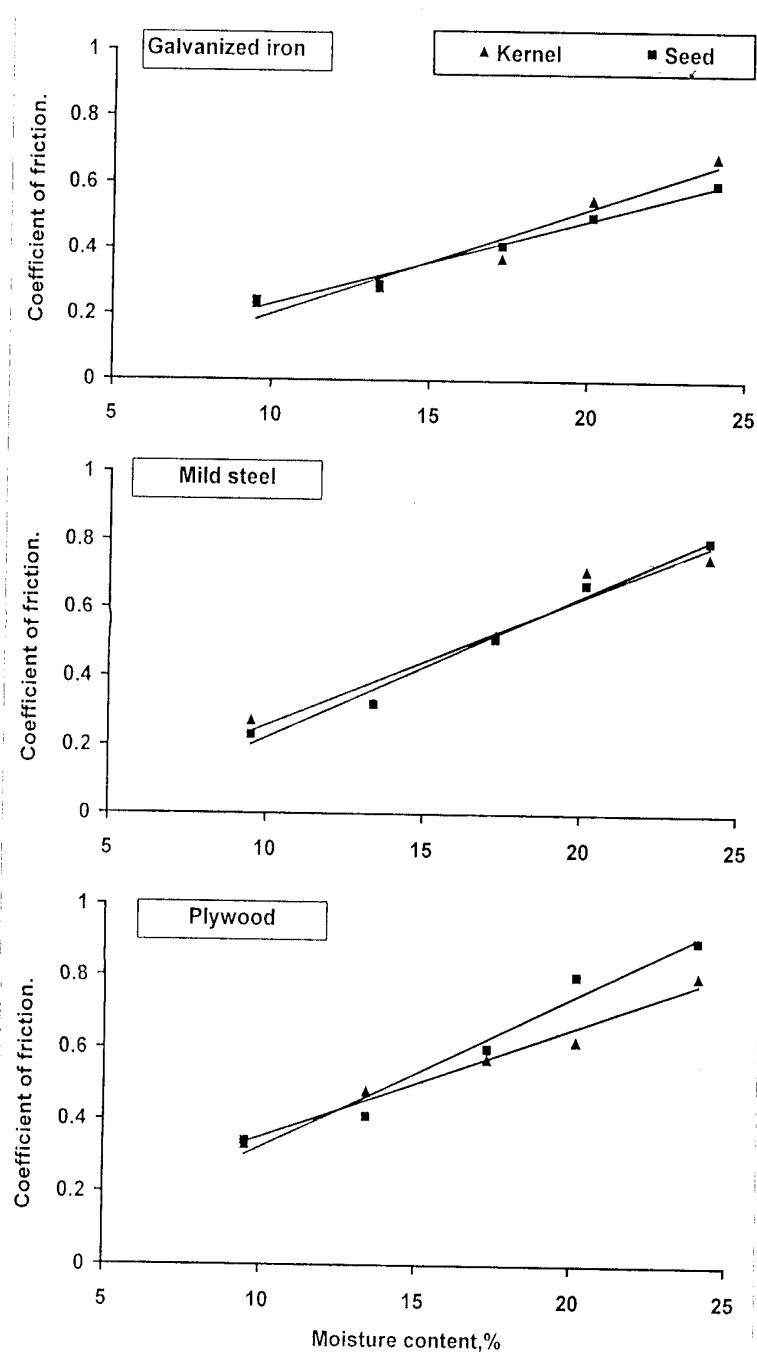and kernel melons.

Fig. 6: Effect of moisture content on coefficient of friction
of seed and kernel melons.

b- Angle of repose:

Fig. 5 shows the relation between the angle of repose of seed melon seed and its kernel at various moisture contents. It increased from (27 to 43) and from (31 to 44° degree) for kernel as the moisture content increased from 9.53 to 25.08% (w.b.). The angle of repose for both seed and kernel was found to be linear relationship with respect to moisture content (Mc) as given by the following equations:

$$\theta_s = 16.85 + 1.09 \ Mc \quad \dots\dots\dots\dots\dots\dots\dots\dots 13 \ (r^2 = 0.99)$$
$$\theta_k = 21.78 + 0.91 \ Mc \quad \dots\dots\dots\dots\dots\dots\dots 14 \ (r^2 = 0.97)$$

Where:

  s: seeds and k: kernels

c- Static coefficient of friction:

The static coefficients of friction of seed melon seed and kernel with respect to three surfaces (galvanized steel, stainless steel and plywood) showed a direct proportion with the moisture content as shown in Fig. 6. Data also, showed that the coefficients of friction of seed and kernel vary linearly with the moisture content of the tested sample irrespective of the surfaces under test. It is clear that lower moisture content gave the lowest values of static coefficients of friction (CF) or all tested surfaces. However, the increase in seed moisture content gives higher values of coefficients of friction. These results reveal that, seed and kernel counters more resistance to sliding for plywood than the other two surfaces. The relationships between the static coefficients of friction against the three different surfaces with the moisture content (Mc) are indicated as follows:

$$C.F_{gk} = -0.12 + 0.03 \ Mc \quad \dots\dots\dots\dots\dots\dots \ 15 \ (r^2 = 0.94)$$
$$C.F_{gs} = -0.03 + 0.03 \ Mc \quad \dots\dots\dots\dots\dots\dots \ 16 \ (r^2 = 0.98)$$
$$C.F_{sk} = -0.12 + 0.04 \ Mc \quad \dots\dots\dots\dots\dots\dots \ 17 \ (r^2 = 0.93)$$
$$C.F_{ss} = -0.19 + 0.04 \ Mc \quad \dots\dots\dots\dots\dots\dots \ 18 \ (r^2 = 0.98)$$
$$C.F_{pk} = 0.05 + 0.03 \ Mc \quad \dots\dots\dots\dots\dots\dots \ ..19 \ (r^2 = 0.97)$$
$$C.F_{ps} = -0.10 + 0.04 \ Mc \quad \dots\dots\dots\dots\dots\dots\dots 20 \ (r^2 = 0.96)$$

Where:

  gk: kernel with galvanize

  gs: seed with galvanize

  sk: kernel with stainless steel

  ss: seed with stainless steel

pk: kernel with plywood

ps: seed with plywood

d- Hardness of seed and kernel:

Results illustrated in Table 1 shows that, the ungraded seed and kernels gave the lowest values where they reached 66.58 and 14.7 N. However, small seed and kernels gave the highest values of 74.18 and 21.73 N comparing with the other sizes distribution of seed.

CONCLUSION

From the obtained results the following conclusion are derived:

1- The average length, width, thickness, mass and hardness of 100 seeds were 12.42, 7.80, 2.37 mm, 0.097 g and 64.8 N, respectively, at a seed moisture content of 9.53% (w.b.) corresponding values of kernel which were found to be 10.57, 6.50, 1.64 mm, 0.061g and 14.0 N.

2- Results also showed that the physical properties of seed melon seed and kernel were dependent on the moisture content.

3- The highest values of bulk and true densities of seed were 600 and 1000 kg/m^3, while corresponding values for kernel were 640 and 1150 kg/m^3, respectively, at moisture content of 24.08%.

4- The porosity of seed and kernel were decreased from 58 to 41 and 50 to 40% as the moisture content increased from 9.53 to 24.08%, respectively.

5- The data revealed that the terminal velocities of seed and its components were increased as the moisture content increase and the seed gave the highest values of terminal velocities while hull gave the lowest values.

6- Results also, illustrated that plywood surface gave the highest values of coefficient of friction at all seed moisture content for seed and kernel. Meanwhile, galvanized metal gave the lowest values at the same conditions.

7- The increase of seed moisture content from 9.53 to 24.08% increased the angle of repose from (27 to 43) and (31 to 44 deg) for seed and kernel, respectively.

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<u>الملخص العربى</u>

دراسة لبعض الخواص الطبيعية والميكانيكية لبذور بطيخ اللب

رفاعى أبو شعيشع[1]   رزق خليف[1]   علاء الدين المسيرى[2]

تعتبر محاصيل الخضر من المحاصيل الاقتصادية الهامة والتي تنافس الكثير من المحاصيل الحقلية والتي تدر دخلاً كثيراً للمزارع المصري، ومنها محصول بطيخ اللب والتي انتشرت زراعته في الآونة الأخيرة في منطقة شمال الدلتا والأراضي الجديدة.

وتبلغ مساحة بطيخ اللب في مصر حوالي 170000 فداناً وبإجمال إنتاج سنوي قدره 79900 طن بمتوسط إنتاج 470 كج/فدان (كتاب الإحصاء الزراعية- وزارة الزراعةعام 2005م) ومتوسط سعر 8 جنيهات لكل كج بذور- حيث يزرع بطيخ اللب في شهر مايو ويحصد في أغسطس بغرض الحصول على البذور وكان تصنيع الآلات الزراعية وخاصة آلات ما بعد الحصاد مثل آلات الفصل والتذرية والنقل والتغليف يحتاج إلى بيانات عن الخواص الطبيعية والميكانيكية للمنتج لكي تساعد في تصميم أجزاء الآلة.

ولتحقيق هذا الهدف أمكن دراسة الخواص الطبيعية المتعلقة بهذا المحصول من خلال تأثير خمسة مستويات للمحتوى الرطوبى للبذور (9.53، 13.41، 17.29، 20.16، 24.08% على أساس رطب) على البذور ومكوناتها من خلال الكثافة الظاهرية والحقيقية، المسامية، السرعة الحرجة، معامل الاحتكاك وزاوية الراحة.

<u>ويمكن تلخيص النتائج كما يلى:-</u>

1- كان متوسط كل من الطول والعرض والسمك والكتلة لبذور البطيخ 12.42مم، 7.80مم، 2.37مم، 0.097 جم على الترتيب عند محتوى رطوبة البذور 9.53% على أساس رطب بينما كان المتوسط 10.57مم، 6.50مم، 1.64مم، 0.061ج للب البذور.

1- باحث أول – معهد بحوث الهندسة الزراعية - دقى – الجيزة – مصر.

2- أستاذ مساعد الهندسة الزراعية – كلية الزراعة جامعة الأزهر- القاهرة- مصر

2- أوضحت النتائج أن أعلى قيمة لكل من الكثافة الظاهرية والحقيقية للبذور كانت 600، 1000كجم/م^3 على الترتيب. عند محتوى رطوبى 24.08% على أساس رطب بينما كانت 640، 1150كجم/م^3 للب البذور على الترتيب.

3- انخفضت مسامية البذور ولب البذور من 58 إلى 41% ومن 50 إلى 40% على الترتيب عند زيادة المحتوى الرطوبى للبذور من 9.53 إلى 23.08% على أساس رطب.

4- زيادة المحتوى الرطوبى من 9.53 إلى 24.08% على أساس رطب أدى إلى زيادة السرعة الحرجة من 2.10 إلى 3.94 ومن 3.50 إلى 4.67 ومن 4.55 إلى 6.40 م/ثانية لكل من قشرة البذرة ولب البذرة والبذرة على الترتيب.

5- بلغت قيم معامل الاحتكاك للبذور عند أعلى محتوى رطوبى(24.08% على أساس رطب) 0.90، 0.80، 0.65 عند استخدام أسطح الخشب والحديد والصاج على الترتيب. وهذه الخاصية تعتبر من أهم الخواص المؤثرة فى حالة نقل وتداول البذور.

6- وبلغت زاوية الراحة للبذور(43 درجة) عند محتوى رطوبى 24.08% على أساس رطب وهذه الخاصية هامة جداً عند تصنيع وسائل نقل وتداول البذور.