Determination of some apricot seed and kernel physical and mechanical properties

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Abstract: At the duration of this study, a sample of 100 intact apricot fruits, Canino variety were selected randomly. The seeds were shelled using a nutcracker and the intact kernels were separated manually. Then, some apricot seed and kernel physical and mechanical properties were determined as relative parameters for designing the apricot seed kernels separator. The obtained results may be summarized as follows: At 7.13% (w.b.) apricot seeds moisture content, the length, width and thickness values were 18.90, 16.48 and 11.31 mm, respectively. The surface area, projected area, volume, arithmetic mean diameter, geometric mean diameter, sphericity and aspect ratio values were 727.09 mm^2, 244.60 mm^2, 1847.69 mm^3, 15.56 mm, 15.20 mm, 80.61% and 87.53%, respectively. The true and bulk density values were 0.708 and 0.354 g cm^{-3}, respectively. The porosity was 49.99%. The angle of repose was 27.29°. The static coefficient of friction values of 0.54, 0.50, 0.37, and 0.52 were recorded using viz wood, steel, glass and Canino variety apricot seeds surfaces, respectively. The mean shearing force and hardness of apricot seed were 366.3 and 396.4 N, respectively. At 9.21% (w.b.) apricot kernels moisture content, the length, width and thickness values were 14.19, 9.66 and 4.33 mm, respectively. The surface area, projected area, grain volume, arithmetic mean diameter, geometric mean diameter, sphericity and aspect ratio values were 222.00 mm^2, 107.76 mm^2, 311.92 mm^3, 9.39 mm, 8.40 mm, 59.26% and 68.20%, respectively. The true and bulk density values were 0.896 and 0.425 g cm^{-3}, respectively. The porosity was 52.61%. The angle of repose was 22.56°. The static coefficient of friction values of 0.45, 0.44, 0.29, and 0.42 were recorded using viz wood, steel, glass and canino variety apricot seeds surfaces, respectively. The mean shearing force and hardness of apricot kernel were 62.8 and 67.9 N, respectively.Finally, the obtained results provide a helpful database designing the apricot seed kernels separator.

Keywords: apricot, Canino, kernel, physical and mechanical properties.

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1 Introduction

Apricot (*Prunus armeniaca* L.) is one of the important horticultural crops in Egypt due to its export importance and several uses in many food industries. In Egypt, the apricot trees cultivated area is about 6070.28 ha, producing annually 102300 Mg fruits, which contain 7000 Mg seeds approximately (Agricultural Statistics, 2017).

Apricot kernels are rich in nutrition because they contain protein (17.38%), crude oil (48.70%), Na (3.68%), P (1.06 mg kg^{-1}), K (0.58 mg kg^{-1}), Ca (0.11 mg kg^{-1}), Mg (0.24 mg kg^{-1}), Fe (42.8 mg kg^{-1}), Zn (42.35 mg kg^{-1}), Mn (1.10 mg kg^{-1}), Cu (2.09 mg kg^{-1}) and A, C and B_{17} vitamins (Hazbavi, 2013).

Apricot kernel is used in oil production, medicine, cosmetics, and active - carbon. In addition, the supposed waste of the cake serves as an ingredient for livestock feeding (Yildirim and Tarhan, 2016).

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The apricot kernel is encapsulated by its hard shell. Apricot shell is very hard and tough to break. On the other hand, kernel is very soft, fragile, and easy to break (Kate et al., 2015).

So, the manual separating of apricot seeds is an exhausted and tedious work, costly and consuming more time. The manual separating of one kg apricot seeds consumed about 0.67 -0.75 h. Also, the manual apricot seeds separating increases the kernel damage with about 30% -40%, resulting in more losses in oil production (Dixit et al., 2010). So, it is an important issue to design a machine for separating the apricot seed kernels. To achieve this issue, it is essential to determine the physical and mechanical apricot seed kernel properties.

There are some studies were carried out to determine the apricot seed kernel properties such as Gezer et al. (2002), Fathollahzadeh et al. (2009), Hassan-Beygi et al. (2009), Hazbavi (2013) and Kate et al. (2015). The previous studies did not determine the apricot kernel properties that concern the mechanical separating of apricot seed kernels such as shearing force and hardness. Consequently, there is a lack in the data of these properties.

The objective of this study is to determine some apricot seed and kernel physical and mechanical properties as relative parameters for designing the apricot seed kernels separator.

2 Materials and methods

To fulfill the study objective, the experiments were carried out of 2018 at Agricultural Research Station, Kafer El-Hamam Village, El-Sharkia Governorate, Egypt, which is located at 30°35'15.65"N latitude and 31°30'7.20" E longitude.

Samples preparation:

A sample of 100 intact apricot fruits, Canino variety were selected randomly. The seeds were shelled using a nutcracker. Then, the intact kernels were separated manually. Some seed and kernel physical and mechanical properties were determined as follows:

Size:

As shown in Figures 1 and 2, the seed and kernel size is determined by measuring the dimensions of the principal axes, namely: length (L), width (W) and thickness (T) using a digital Vernier caliper with an accuracy of 0.01 mm.

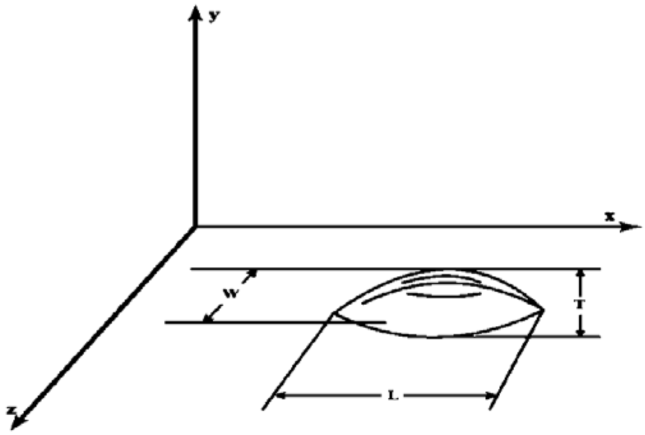

Figure 1 Apricot seed principle axes

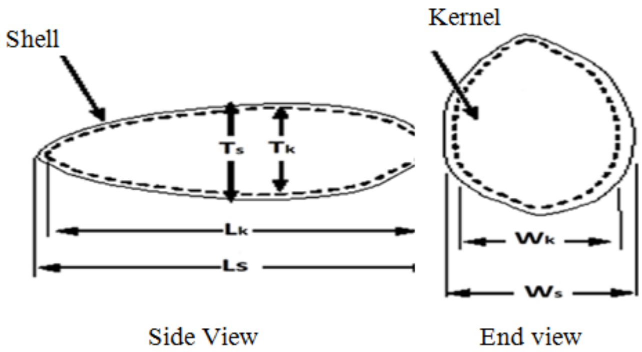

Figure 2 Dimensions for apricot seed and kernel.

Mass:

It is measured using a digital balance of with an accuracy of 0.0001 g. Seed mass (M_S) of randomly selected 100 seeds were determined gravimetrically.

The arithmetic mean diameter and geometric mean diameter:

The arithmetic mean diameter (D_a) and geometric mean diameter (D_g) are calculated according to Bahnasawy (2007) as follows:

$$D_a(mm) = \frac{L+W+T}{3} \quad (1)$$

$$D_g(mm) = (L\,.\,W\,.\,T)^{1/3} \quad (2)$$

Where: D_a is the arithmetic mean diameter of the sample, (mm); D_g is the geometric mean diameter of the sample, (mm); L is the length of the sample, (mm); W is the width of the sample, (mm); T is the thickness of the sample, (mm).

The three principal dimensions were used to calculate the geometric mean diameter (D_g) and surface area (S_a) of individual grains by assuming that the seeds were ellipsoid.

Sphericity:

Sphericity (S) is calculated as cited by Fathollahzadeh et al. (2008) as follows:

$$S(\%) = \frac{D_g}{L} \times 100 \tag{3}$$

Where: S is the phericity of the sample, (%); D_g is the geometric mean diameter of the sample, (mm); L is the length of the sample, (mm).

Aspect ratio:

Aspect ratio (R_a) is calculated as outlined by Seifi and Alimardani (2010) as follows:

$$R_a\ (\%) = \frac{W}{L} \times 100 \tag{4}$$

Where: R_a is the aspect ratio of the sample, (%); W is the width of the sample, (mm); L is the length of the sample, (mm).

Surface area and projected area:

Surface area (S_a), and the projected area (A_p) are calculated according to Goyal et al. (2007) and Perez et al. (2007) as follows:

$$S_a\ (mm^2) = \pi\ .\ (D_g)^2 \tag{5}$$

$$A_p\ (mm^2) = \pi\ .\ (\frac{L\,.\,W}{4}) \tag{6}$$

Where: S_a is the surface area of the sample, (mm^2); D_g is the geometric mean diameter of the sample, (mm); A_p is the projected area of the sample, (mm^2); L is the length of the sample, (mm); W is the width of the sample, (mm).

Volume:

It is determined as the procedure of Vursavuş and Özguven (2004) as follows:

$$V(mm^3) = \frac{\pi}{6}\ L\,.\,W\,.\,T \tag{7}$$

Where: V is the volume of the sample, (mm^3); L is the length of the sample, (mm); W is the width of the sample, (mm); T is the thickness of the sample, (mm).

Bulk density:

It is determined according to Aydin (2007) as follows:

$$\rho_b(g\,cm^{-3}) = \frac{M_s}{V} \tag{8}$$

Where: ρ_b is the bulk density of the sample, (g cm^{-3}); M_s is the mass of the sample, (g); V is the volume of the sample, (cm^3).

True density:

It is determined according to Altuntas and Erkol (2010) and Payman et al. (2011) as follows:

$$\rho_s(g\,cm^{-3}) = \frac{M_s}{V_t} \tag{9}$$

Where: ρ_s is the bulk density of the sample, (g cm^{-3}); M_s is the mass of the sample, (g); V_t is the true volume of the seed (cm^3).

Porosity:

It is determined as pointed out by Davies (2009) as follows:

$$\varepsilon\ (\%) = (1 - \frac{\rho_b}{\rho s}) \times 100 \tag{10}$$

Where: ε is the porosity of the sample, (%); ρ_b is the bulk density of the sample, (g cm^{-3}); ρ_s is the bulk density of the sample, (g cm^{-3}).

Mechanical properties:

Angle of repose:

To determine the repose angle, a polyvinyl cylindrical pipe of 30 mm in diameter and 50 mm in height was placed on a clean surface and filled with seed samples. A cone shape of apricot seed samples was obtained by raising slowly and removing the cylinder. The radius and height of the cone were measured. The angle of repose (α) was calculated according to Yildirim and Tarhan (2016) as follows:

$$\alpha = tan^{-1}(\frac{L}{R}) \tag{11}$$

Where: L is the cone height (mm); R is the cone radius (mm).

Coefficient of static friction:

The coefficient of static friction of the date seed was determined using the inclined plane method on four surfaces (wood, steel, glass, and a surface of the same variety of seeds). The end of the friction surface (inclined plane) was attached to an endless screw. The date seeds arranged in a topless and bottomless cubic with dimensions of 20 × 20 × 10 cm^3 and then the cubic was placed on the surfaces (as shown in Figure 3). The cubic was slowly lifted up to avoid friction between the cubic and surfaces. The friction surfaces were gradually raised by the screw when the samples started sliding over the surfaces. Both horizontal and vertical height values were measured by a ruler and, using the tangent of that angle, the coefficient of static friction was calculated according to Fadavi et al. (2013) as follows:

$$\mu_s = tan\,\theta \tag{12}$$

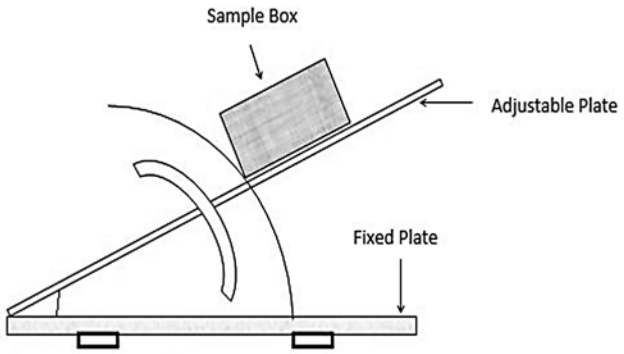

Figure 3 Determination of static angle of friction.

Where: μs is the static coefficient of friction; ϴ is the angle between the inclined surface and the horizontal at which

samples just start to slide down (o).

Shearing force and hardness:

The shearing force and hardness values of seeds were measured by Force digital gauge with a range up to 2000 N, accuracy ± 0.2% of maximum load and its weight 450 g. It used for measuring the force required to separate kernel from seeds. The results from the compression tests should be considered the maximum force and deformation that shell of the apricot seed can withstand prior to cracking and rupture.

Data analysis:

Data were analyzed statistically using spreadsheet software (Microsoft EXCEL 2016) and SPSS (statistical package for the social science, Chicago, IL, version 24) for descriptive statistics. Comparison of means, and standard deviation (SD) were conducted on the properties for Canino apricot seeds and kernel.

3 Results and discussion

A summary of the results of the physical and mechanical properties of Canino apricot seeds and kernel measured is presented in Tables 1-3 for the dimensional, gravimetric and frictional properties respectively. The mean moisture content was calculated as 7.13% (w.b.) for seed and 9.21% (w.b.) for kernel and all the other experiments were conducted at this moisture content. The moisture content is very important as it influences the size, shape, and angle of repose of the seeds; which in turn determine the hopper capacity and the free flow of the seeds.

3.1 Apricot seed and kernel physical properties

Size:

The mean apricot seed length, width, and thickness were found to be 18.90 ±1.10 mm, 16.48 ± 0.96 mm and 11.31 ± 0.72 mm, respectively (as shown in Table 1 and Figure 4). Reported values for the length, width and thickness (in that order) of seeds were29.72 ± 1.25 mm, 20.82 ± 1.24 mm and 13.07 ± 0.94 mm for apricot seed (Ordubad cultivar) (Hassan-Beygi et al., 2009) and 22.86 ± 1.8 mm, 14.23 ± 1.25 mm and 9.6 ± 0.88 mm for apricot seed (“Hacıhaliloglu” Turkey variety) (Yildirim and Tarhan, 2016).

The mean apricot kernel length, width, and thickness were found to be 14.19 ± 0.70 mm, 9.66 ± 0.56 mm and 4.33 ± 0.35 mm, respectively (as shown in Table 1 and Figure 5). Reported values for the length, width and thickness (in that order) of seeds were 17.81 ± 0.83 mm, 12.08 ± 0.55 mm and 8.28 ± 0.89 mm, respectively, for apricot kernel (Ordubad cultivar) (Hassan-Beygi et al., 2009).

Surface area, projected area, and volume:

The mean value of the seed surface area was found about 3.3 times of kernel surface area. The large dimensions of the seed are the reason for the higher values surface area of seed than the kernel. The mean surface areas of Canino apricot seeds and kernels were 727.09 ± 57.57 and 222.00 ± 19.89 mm^2, respectively (as shown in Table 1).

As the results, the projected area which was perpendicular to the thickness of seed and kernel was the greatest and that of perpendicular to length was the smallest. The mean of projected areas of the seed and the mean of projected areas of the seed was about 2.3 times of kernel, which were contributed to the dimensions of the fruit, seed, and kernel. The mean projected areas of Canino apricot seeds and kernels were 244.60 ± 18.61 and 107.76 ± 9.51 mm^2, respectively. Reported value for the projected area (in that order) of seeds was256.42 ± 36.72 mm^2 for apricot seed (“Hacıhaliloglu” Turkey variety) (Yildirim and Tarhan, 2016).

The grain volumes of apricot seeds and apricot kernel varied between 1847.69 ± 218.03 and 311.92 ± 42.03 mm^3, respectively.

Table 1 Dimensional properties of Canino apricot seeds and kernels

Parameter	Seeds				Kernels			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Length (L), mm	17.35	20.99	18.90	1.10	12.62	15.38	14.19	0.70
Width (W), mm	14.71	18.27	16.48	0.96	8.86	10.49	9.66	0.56
Thickness (T), mm	9.81	13.37	11.31	0.72	3.67	5.10	4.33	0.35
Seed shell Thickness (T_{sh}), mm	1.35	2.99	2.21	0.38	-	-	-	-
Surface area (S_a), mm^2	620.38	825.17	727.09	57.57	193.27	255.43	222.00	19.89
Projected area (A_p), mm^2	217.66	277.44	244.60	18.61	93.64	122.92	107.76	9.51
Volume (V), mm^3	1452.98	2228.88	1847.69	218.03	252.65	383.86	311.92	42.03
Arithmetic diameter (D_a), mm	14.54	16.50	15.56	0.60	8.80	9.93	9.39	0.39
Geometric diameter (D_g), mm	14.05	16.21	15.20	0.61	7.84	9.02	8.40	0.38
Percent of Sphericity (S), %	73.08	87.62	80.61	4.40	55.18	65.82	59.26	2.49
Aspect ratio (R_a), %	74.56	101.27	87.53	7.55	61.44	76.09	68.20	4.21

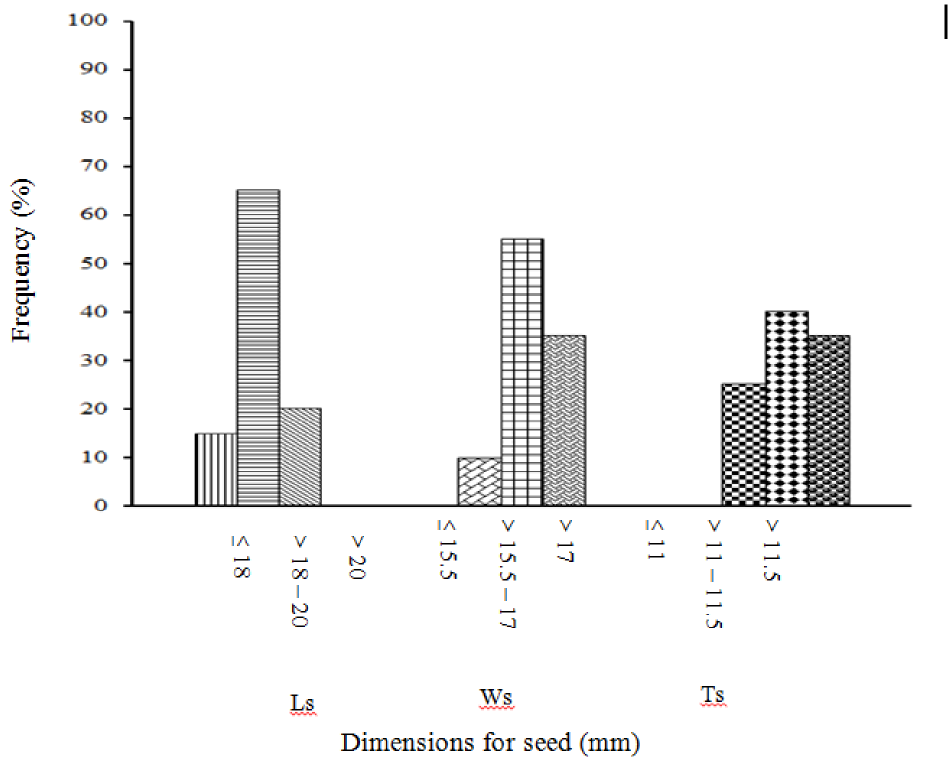

Figure 4 Frequency distribution of apricot seeds dimensions

The arithmetic mean diameter and geometric mean diameter:

In apricot seeds, the arithmetic mean diameter and geometric mean diameter were 15.56 ± 0.60 mm and 15.20 ± 0.61 mm respectively. The sphericity and aspect ratio were 0.8061 ± 4.40 (80.61%) and 0.8753 ± 7.55 (87.53%), respectively (as shown in Table 1). While kernels, the arithmetic mean diameter and geometric mean diameter 8.40 ± 0.38 mm and 9.39 ± 0.39 mm respectively. The sphericity and aspect ratio were 0.5926 ± 2.49 (59.26%) and 0.6820 ± 4.21 (68.20%), respectively. Reported values for geometric mean diameter and sphericity (in that order) of seeds were 14.59 ± 1.11 mm and 0.6395 ± 4.07 (63.95%), respectively, for apricot seed ("Hacıhaliloglu" Turkey variety) (Yildirim and Tarhan, 2016).

Mass:

The mean one thousand seed mass (apricot seeds - kernels) was found to be 1313.58 - 72.31 g, respectively (as shown in Table 2 and Figure 6). One-point worthy of note however that is the one thousand seed weight is a function of the individual mass (weight) of the seed/kernel of apricot seeds.

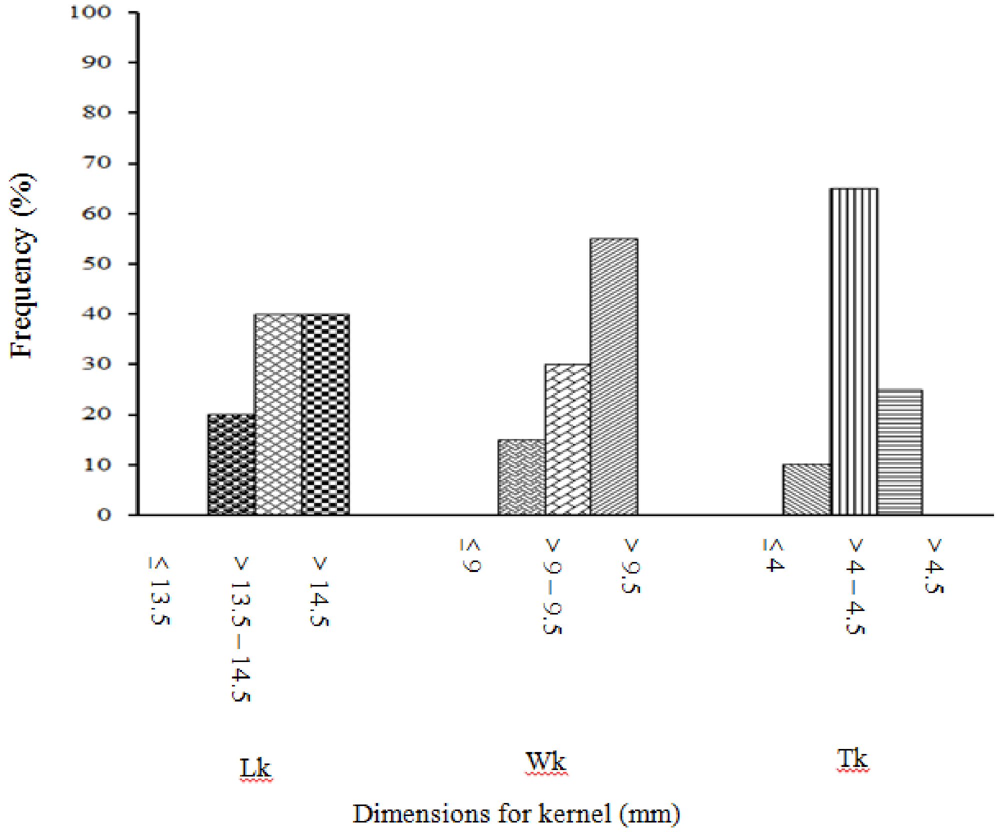

Figure 5 Frequency distribution of apricot kernel dimensions

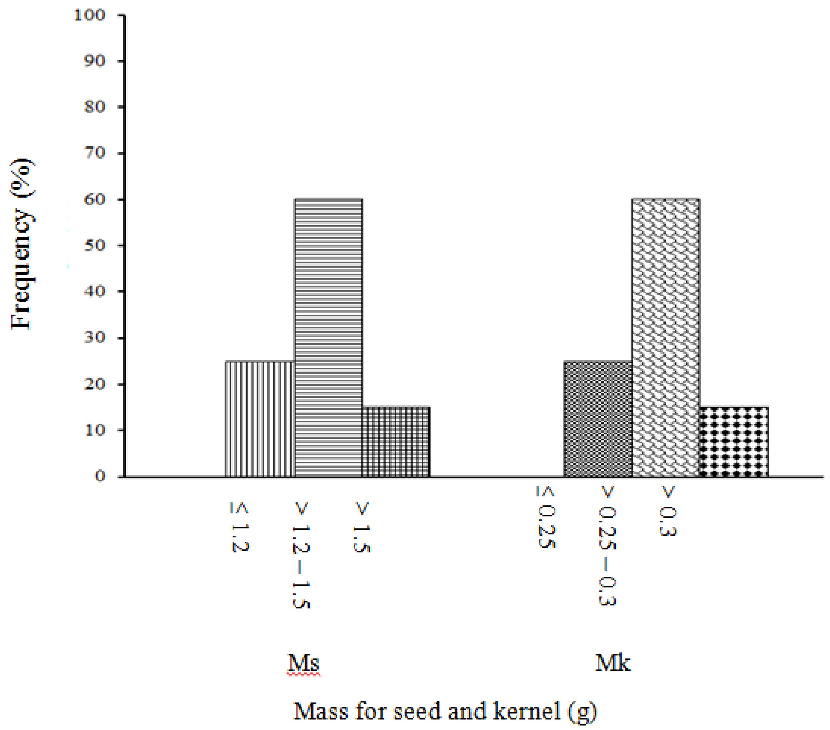

Figure 6 Frequency distribution of apricot seed and kernel mass

Bulk density, true density, and porosity:

The mean true and bulk densities (apricot seeds - kernels) were found to be 0.708 - 0.896 g cm^{-3} and 0.354 - 0.425 g cm^{-3}, respectively (as shown in Table 2) while the porosity was computed from the values of the true and bulk densities using Equation 10 as 49.99% - 52.61%. The true density of the apricot seeds showed that the seeds are slightly less dense than water and therefore will float on water.

Mechanical properties:

Angle of repose:

The mean angle of repose (α) (apricot seeds - kernels) was found to be 27.29° ± 4.18° and 22.56° ± 3.65°, respectively (as shown in Table 3). There is a similarity between these results and the studies of Gezer et al. (2002) for Turkey apricot seeds.

Table 2 Gravimetric properties of Canino apricot seeds and kernels

Parameter	Seeds				Kernels			
	Min.	Max.	Mean	SD.	Min.	Max.	Mean	SD.
Unit mass (M_1), g	0.92	1.75	1.31	0.21	0.19	0.35	0.26	0.04
Mass of 1000 (M_{1000}), g	946.34	1724.48	1313.58	217.71	62.04	81.98	72.31	5.53
Seed shell mass (M_s), g	0.74	1.40	1.05	0.16	-	-	-	-
Bulk density (ρ_b), kg m^{-3}	302.40	394.80	353.94	24.65	400.60	459.80	424.71	17.09
True density (ρ_s), kg m^{-3}	603.60	791.52	707.71	49.48	840.72	966.12	896.26	36.48
Porosity (ε), %	49.74	50.29	49.99	0.17	52.35	52.93	52.61	0.17

Table 3 Mechanical properties of Canino apricot seeds and kernels

Parameter		Seeds				Kernels			
		Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
The angle of repose (α), °		21.25	34.99	27.29	4.18	17.35	29.36	22.56	3.65
Coefficients of Static Friction (μ_s)	wood	0.49	0.61	0.54	0.05	0.41	0.53	0.45	0.04
	steel	0.38	0.64	0.50	0.09	0.32	0.57	0.44	0.09
	glass	0.27	0.51	0.37	0.07	0.20	0.43	0.29	0.07
	a surface of the same variety of seeds	0.39	0.70	0.52	0.09	0.31	0.56	0.42	0.08
Shear force, N		244.8	444.0	366.3	76.8	42.2	76.1	62.8	12.9
Hardness force, N		376.0	409.2	396.4	12.8	64.5	70.1	67.9	2.2

Coefficient of static friction:

The mean coefficients of static friction (μ_s) (apricot seeds - kernels) on four different surfaces viz wood, steel, glass and a surface of the same variety of seeds were found to be (0.54 - 0.45), (0.50 - 0.44), (0.37 - 0.29), and (0.52 - 0.42), respectively, in that order as shown in Table 3 and Figure 7. It would be observed that the static coefficient of friction was highest on wood and lowest on glass. This was in agreement with earlier reports on apricot seed and kernel of Ordubad variety by Hassan-Beygi et al. (2009). It was observed that the smoother the structural surface, the lower the coefficient of friction of the apricot seeds on the surface. The knowledge of the coefficient of friction will be useful during the calculations of the various forces required to translate and compress the seeds as well as the frictional force resulting from the screw's motion.

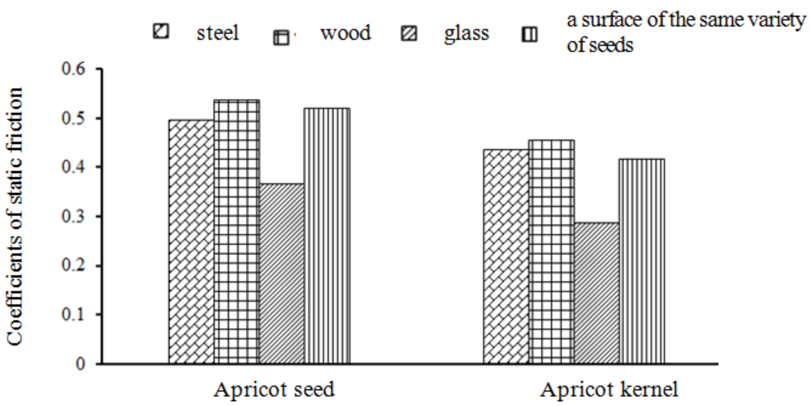

Figure 7 The mean static coefficients of friction for apricot seeds and kernels on four different surfaces.

Shearing force and hardness:

The mean shearing force of apricot seeds and kernels was found to be 366.3 ± 76.8 and 62.8 ± 12.9 N, respectively (as shown in Table 3). The mean hardness of apricot seeds and kernels was found to be 396.4 ± 12.8 and 67.9 ± 2.2 N, respectively. There is a similarity between these results and the studies of Hassan-Beygi et al. (2009) for apricot seed and kernel of Ordubad variety, and Gezer et al. (2002) for Turkey apricot seeds.

4 Conclusion

The mean moisture content was found to be 7.13% (w.b.) for apricot seed and 9.21% (w.b.) for apricot kernel. The mean length, width, and thickness of (seeds - kernels) was found to be (18.90 - 14.19), (16.48 - 9.66), and (11.31 - 4.33) mm, respectively. The mean surface area, projected area, grain volumes, arithmetic mean diameter, geometric mean diameter, sphericity and aspect ratio for apricot (seeds - kernels) were found to be (727.09 - 222.00) mm^2, (244.60 - 107.76) mm^2, (1847.69 - 311.92) mm^3, (15.56 - 9.39) mm, (15.20 - 8.40) mm, (80.61% - 59.26%) and (87.53% - 68.20%), in that order. The true density, bulk density and porosity for (seeds - kernels) were (0.708 - 0.896) g cm^{-3}, (0.354 - 0.425) g cm^{-3} and (49.99% - 52.61%), respectively. The mean angle of repose for apricot seeds and kernels was 27.29° and 22.56°, respectively. While the mean static coefficients of friction for apricot (seeds - kernels) on four different surfaces viz wood, steel, glass and a surface of the same variety of seeds were (0.54 - 0.45), (0.50 - 0.44), (0.37 - 0.29), and (0.52 - 0.42), respectively. The static coefficients of friction for apricot seeds and kernels were greatest wood followed by a surface of the same variety of seeds, steel, and glass. The mean shearing force and hardness of apricot seeds were 366.3 and 396.4 N, respectively. The mean shearing force and hardness of apricot kernel were 62.8 and 67.9 N, respectively.

The obtained apricot seed, Canino variety physical and mechanical properties provided a database for designing an apricot seed kernels separator as follows:

Apricot seed dimensions enhance to determine the hopper capacity and the clearance between drum and concave.

The repose angle determines the hopper slope and capacity to facilitate the free flow of the seeds.

The coefficient of static friction determines the manufacturing material of hopper and drum.

Shearing force and hardness determine the force of fracture of the outer shell from the seed

From the obtained results, it can be concluded that:

To minimize separating cost and total losses with high capacity and efficiency.

Recommendation reached is the need to prepare a database for apricot seeds and kernels physical and mechanical properties contribute to the development of machine suit separating kernel of apricot seeds.

It is recommended use the designing machine under the following conditions:

Clearance between drum and concave about 6 mm.

The hopper slope angle about 30°.

The manufacturing material of hopper and drum from steel.

The force of fracture of the outer shell from apricot seed about 350 N.

References

Agricultural Statistics. 2017. Economic Affairs Sector, Ministry of Agriculture and Land Reclamation, Cairo, Egypt.

Altuntas, E., and M. Erkol. 2010. Physical properties of shelled and kernel walnuts as affected by the moisture content. *Czech Journal of Food Sciences*, 28(6): 547-556.1

Aydin, C. 2007. Some engineering properties of peanut and kernel. *Journal of Food Engineering*, 79(3): 810-816.

Bahnasawy, A. H. 2007. Some physical and mechanical properties of garlic. *International Journal of Food Engineering*, 3(6): Article 7. DOI:10.2202/1556-3758.1136

Davies, R. M. 2009. Some physical properties of groundnut grains. *Research Journal of Applied Sciences, Engineering and Technology*, 1(2): 10-13.

Dixit, A. K., P. C. Sharma, S. K. Nanda, and S. K. Kudos. 2010. Impact of processing technology in hilly region: a study on extraction of apricot kernel oil. *Agricultural Economics Research Review*, 23(conf): 405-410.

Fadavi, A., S. R. Hassan-Beygi, and F. Karimi. 2013. Moisture dependent physical and mechanical properties of Syrjan region wild pistachio nut. *Agricultural Engineering International: CIGR Journal*, 15(2): 221-230.

Fathollahzadeh, H., H. Mobli, B. Beheshti, A. Jafari, and A. M. Borghei. 2008. Effect of moisture content on some physical properties of Apricot kernel (C.V. Sonnatim Salmas). *Agricultural Engineering International: CIGR Journal*, X: Manuscript FP 08 008.

Fathollahzadeh, H., H. Mobli, M. Tavakkoli, M. R. Ebrahimzadeh, and M. H. Tabatabaie. 2009. Some physical properties of ‘Sonnati Salmas’ apricot pit. *Agricultural Engineering International: CIGR Journal*, XI: Manuscript 1157.

Gezer, İ., H. Haciseferoğulları, and F. Demir. 2002. Some physical properties of Hacıhaliloğlu apricot pit and its kernel. *Journal of Food Engineering*, 56(1): 49-57. (In Turkish)

Goyal, R. K., A. R. P. Kingsly, P. Kumar, and H. Walia. 2007. Physical and mechanical properties of aonla fruits. *Journal of Food Engineering*, 82(4): 595-599.

Hassan-Beygi, S. R., S. M. Ghaebi, and A. Arabhosseini. 2009. Some physic-mechanical properties of apricot fruit, pit and kernel of Ordubad variety. *Agricultural Engineering International: CIGR Journal*, XI: Manuscript 1459.

Hazbavi, I. 2013. Determination of physical properties of apricot fruit and proper box height for storing and handling the apricot fruit. *Agricultural Engineering International: CIGR Journal*, 15(4): 288-292.

Kate, A. E., A. Sarkar, N. C. Shahi, and U. C. Lohani. 2015. Cracking force analysis for apricot pit decortication based on mathematical model of Hertz’s theory. *International Journal of Food Properties*, 18(11): 2528-2538.

Payman, S. H., F. R. Ajdadi, I. Bagheri, and M. R. Alizadeh. 2011. Effect of moisture content on some engineering properties of peanut varieties. *Journal of Food, Agriculture & Environment*, 9(3-4): 326-331.

Perez, E. E., G. H. Crapiste, and A. A. Carelli. 2007. Some physical and morphological properties of wild sunflower seeds. *Biosystems Engineering*, 96(1): 41-45.

Seifi, M. R., and R. Alimardani. 2010. The moisture content effect of some physical and mechanical properties of corn (*Sc 704*). *Journal of Agricultural Science*, 2(4): 125-134.

Vursavuş, K., and F. Özguven. 2004. Mechanical behaviour of apricot pit under compression loading. *Journal of Food Engineering*, 65(2): 255-261.

Yildirim, S., and S. Tarhan. 2016. Aerodynamic properties of apricot pits. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi*, 33(1): 47-55.