

Some Physical Properties of ‘Sonnati Salmas’ Apricot Pit

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ABSTRACT

In this study, some physical properties of apricot pit of cv. ‘Sonnati Salmas’ were determined at 5.11, 11.23 and 16.48 % wet base moisture contents. Physical properties such as dimensions, geometric mean diameter, sphericity, surface area, bulk density, true density, porosity, volume, weight and coefficient of static friction on various surfaces were determined as a function of pit moisture content. Length, width, thickness, geometric mean diameter and surface area of pits increased with increasing moisture content. Sphericity decreased from 72.16 to 72.10 %, 1000 grain mass and grain volume increased from 1402.43 to 1437.32 g and 1.49 to 1.51 cm³, respectively. Porosity decreased from 49.457 to 48.404 %, true density and bulk density increased from 1043.97 to 1045.51 kg/m³ and 527.65 to 539.44 kg/m³, respectively. The coefficient of static friction increased as the moisture content increased. These results are necessary for designing of equipments for processing, conveying, separating and packing apricot pit.

Key words: Physical properties, apricot, pit, moisture content

Nomenclature			
L	Length, mm	V	Volume, cm ³
W	Width, mm	Td	True density, kg/m ³
T	Thickness, mm	Bd	Bulk density, kg/m ³
D_g	Geometrical mean diameter, mm	M_{1000}	Thousand grain mass, g
Φ	Sphericity	ρ	Porosity
S	Surface area, mm ²	μ	Coefficient of static friction
m	Weight, g	MC	Moisture content, %

1. INTRODUCTION

Apricot (*Prunus armeniaca* L.) is widely cultivated in Mediterranean countries (Burgos *et al.*, 1993). Apricot trees can grow over all the five continents of the world and annual amount of production exceeds 2.8 million tons. Iran is the second apricot producer country in the world with about 280000 tons per year. In Iran, the most widely produced cultivars are 'Tabarzeh', 'Sonnati Salmas', 'Kardi Damavandi' and 'Nakhjavan'. Iran has exported more than 670 tons to different countries in 2005 (FAO, 2008). France, Spain, Italy and Greece are fresh apricot producers. Hungary, Morocco and Tunisia are important fresh apricot exporter countries. Turkey, Australia and Iran are major and famous dried apricot producers and exporter countries (Togrul, 2003). Apricot has an important place in human nutrition and apricot fruits can be used as fresh, dried or processed fruits. Apricot is rich in minerals such as potassium and precursors such as β -carotene, which is the precursor substance of vitamin A. Apricot kernels are used in production of oils, benzaldehyde, cosmetics, active carbon, and perfume aroma (Yildiz, 1994). Apricot farming needs extensive labor and energy. In Iran, apricot fruits are harvested at about 77 % moisture content (ASB, 2008). Apricot pits are also separated into shells and kernels in the regional conglomerates which have washing, sorting, breaking and separating units. The shells are generally used as fuel. Physical properties of apricot are important for designing of equipments for harvesting and post-harvest technology: transporting, storing, cleaning, separating, sorting, sizing, packaging and processing it into different foods. Since currently used systems have been generally designed without taking these criteria into consideration, the resulting designs led to inadequate applications. These results cause a reduction in work efficiency and an increase in product loss. Therefore, determination and consideration of these criteria plays important role in the design of these equipments.

Many studies have reported about the physical and mechanical properties of kernels, seeds and fruits such as Gezer *et al.* (2002) and Fathollahzadeh *et al.* (2008) for apricot pit and apricot kernel respectively, Puchalski *et al.* (2003) for apple, Aydin (2003) for almond nut and kernel, Khazaei and Mann (2004) for sea buckthorn berries, Mamman *et al.* (2005) for desert date nuts, Kashaninejad *et al.* (2006) and Razavi *et al.* (2007) for pistachio nuts and kernels, ElMasry *et al.* (2006) for potato, Keramat Jahromi *et al.* (2007) for date fruit cv. 'Lasht', Keramat Jahromi *et al.* (2007) for bergamot fruit, Sessiz *et al.* (2007) for caper fruit and Ghadge *et al.* (2008) for chick pea split.

As it can be found from literature review, there is no published paper about the physical properties of apricot pit, except one work (Gezer *et al.*, 2002), who studied some physical properties as function of moisture content.

Also in spite of the fact that Iran is the second apricot producer in the world, exportation of this product and its process is so low. It is clear that studying the physical and mechanical properties of apricot is essential and practical for its process. In order to achieve this objective, some important physical properties of apricot pit such as axial dimensions, 1000 grain mass, bulk density and coefficient of static friction in three moisture content levels were determined.

2. MATERIALS AND METHODS

Apricot pit of cultivar ‘Sonnati Salmas’ (fig. 1) used in this study was produced in the West Azarbayjan province of Iran. Pits were cleaned to remove all foreign matter. Finally 20 kg net pit was obtained. All products were kept in room temperature for two days. All experiments were done on apricot pit with moisture contents of 5.11, 11.23 and 16.48 % which are suitable for processing. One hundred apricots were randomly selected and their pit parameters including length (L) in mm, width (W) in mm, thickness (T) in mm, weight (m) in g, volume (V) in cm³, true density (Td) in kg/m³, geometrical mean diameter (D_g) in mm, sphericity factor (Φ) and surface area (S) in mm² were measured. Geometrical dimensions and weight of pits were determined using a micrometer caliper and a digital balance having accuracy of 0.01 mm and 0.0001 g, respectively.



Figure 1. Apricot pit of cv. ‘Sonnati Salmas’

Geometrical mean diameter (D_g), sphericity factor (Φ) and surface area (S) were obtained from the following equations (Mohsenin, 1970; Fathollahzadeh *et al.*, 2008):

$$D_g = (LWT)^{0.333} \quad (1)$$

$$\phi = (D_g / L) \times 100 \quad (2)$$

$$S = \pi D_g^2 \quad (3)$$

In order to determine thousand grain mass (M₁₀₀₀), 100 pits were randomly selected and weighed. True density (Td) and volume (V) were determined using liquid displacement method. Toluene was used instead of water as liquid, because it has more advantages. As it is known, toluene has less surface tension and degeneration (Mohsenin, 1970). The bulk density (Bd) is the ratio of the mass of sample pits to the total volume. It was determined by filling a 1000 ml container with pits from a height of about 15 cm, striking the top level and then weighing the contents (Deshpande *et al.*, 1993). Also porosity (P) was calculated by the following equation (Mohsenin, 1970; Fathollahzadeh *et al.*, 2008):

$$P = 1 - \frac{Bd}{Td} \quad (4)$$

Coefficient of static friction (μ) of apricot pits on four surfaces including wood, glass, galvanized steel and fiberglass were determined. In order to determine coefficient of friction, products were put on the surface with adjustable slope. When pit started to move, the tangent of the slope angle showed the coefficient of friction (Fathollahzadeh *et al.*, 2008).

3. RESULTS AND DISCUSSION

Mean values of apricot pit physical properties measured at different moisture contents were compared by Duncan's multiple rang test. Comparison of average data ($p < 0.05$) by Duncan's method related to dimension, mass, volume, density and coefficient of static friction on four surfaces are shown in table 1.

Table 1. Physical properties compared by Duncan's multiple range test ($p < 0.05$)

Moisture content*	5.11 %	11.23 %	16.48 %	
Length, mm	20.73 ^b ± 1.250	20.89 ^{ab} ± 1.248	21.18 ^a ± 1.256	
Width, mm	16.07 ^b ± 0.880	16.22 ^{ab} ± 0.886	16.41 ^a ± 0.886	
Thickness, mm	10.11 ^a ± 1.018	10.20 ^a ± 1.017	10.33 ^a ± 1.019	
Geometric mean diameter, mm	14.93 ^b ± 0.740	15.06 ^{ab} ± 0.737	15.25 ^a ± 0.738	
Spherically, %	72.16 ^a ± 3.42	72.14 ^a ± 3.39	72.10 ^a ± 3.36	
Surface area, mm ²	702.00 ^b ± 69.72	714.01 ^{ab} ± 70.15	732.28 ^a ± 71.58	
Volume, cm ³	1.49 ^a ± 0.21	1.50 ^a ± 0.21	1.51 ^a ± 0.22	
Mass, g	1.55 ^a ± 0.221	1.56 ^a ± 0.222	1.58 ^a ± 0.222	
True density, kg/m ³	1043.97 ^a ± 44.50	1040.02 ^a ± 43.26	1045.51 ^a ± 43.18	
Bulk density, kg/m ³	527.65 ^a ± 2.85	532.42 ^a ± 2.99	539.44 ^a ± 9.83	
Coefficient of static friction on	wood	0.53 ^a ± (0.102)	0.57 ^a ± (0.023)	0.62 ^a ± (0.098)
	glass	0.337 ^b ± (0.021)	0.360 ^{ab} ± (0.036)	0.360 ^a ± (0.031)
	galvanize sheet	0.357 ^b ± (0.032)	0.430 ^{ab} ± (0.042)	0.490 ^a ± (0.064)
	fiberglass sheet	0.38 ^a ± (0.108)	0.42 ^a ± (0.039)	0.44 ^a ± (0.025)

*Presented results are average values for 100 apricot pits.

Same superscript letters in a row indicate that difference was not significant at $p < 0.05$ level.

3.1 Axial Dimensions and Geometrical Mean Diameter

The axial dimensions, including length, width, and thickness of apricot pits measured at 5.11, 11.23 and 16.48 % wet base moisture contents are shown in figure 2.

The relationships between length, width and thickness were given by the following equation:

$$L = 1.29 W = 2.04 T \quad (5)$$

Axial dimensions were increased with increasing moisture content. The reason for this increase was probably the presence of some tiny voids on the pits. Similar findings were reported for other grains (Aydin, 2003; Kashaninejad *et al.*, 2006; Al-Mahasneh and Rababah, 2007; Gezer *et al.*, 2002). Axial dimensions are important to determine aperture size for designing of pit handling machinery. Geometrical mean diameter was also increased with increasing moisture

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content (table 1). Gezer *et al.* (2002), Baryeh (2001) and Fathollahzadeh *et al.* (2008) have reported similar trends.

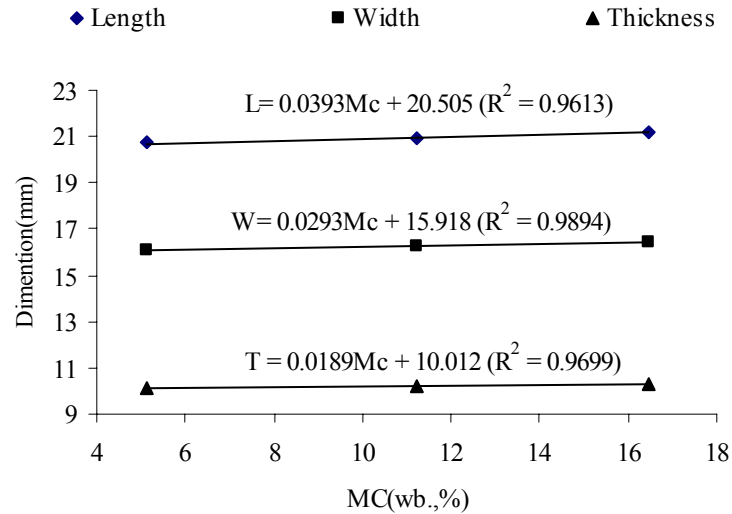


Figure 2. Effect of moisture content on symmetrical dimensions of apricot pit

3.2 Sphericity

The sphericity of apricot pit decreased from 72.167 to 72.100 % as the moisture content increased (table 1). The relationship between sphericity and moisture content can be represented by the following equation ($R^2=0.9461$):

$$\Phi = 72.27 - 0.0104 MC \quad (6)$$

ÇalŞir *et al.* (2005) and Gezer *et al.* (2002) have reported similar trends.

3.3 Volume

The grain volume of apricot pit varied between 1.49 and 1.51 cm³ (fig 3). The relationship between grain volumes and the moisture content was found as represented by equation 7 ($R^2=0.9917$):

$$V = 0.0021MC + 1.4788 \quad (7)$$

Volume of apricot pits increased with moisture content. Deshpande *et al.* (1993), Gezer *et al.* (2002), Razavi *et al.* (2007) and Fathollahzadeh *et al.* (2008) have reported similar results.

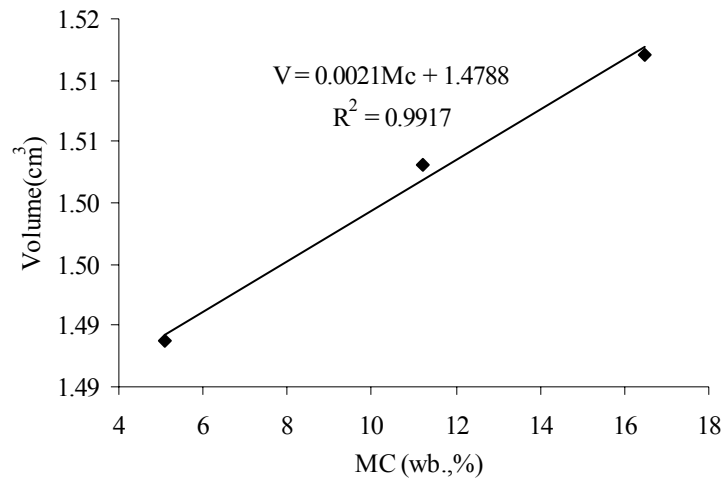


Figure 3. Effect of moisture content on grain volume of apricot pit

3.4 True Density

As it is shown in figure 4, true density of apricot pits increased from 1043.97 and 1045.51 kg/m³. The relationship between true density and the moisture content was expressed by the following equation ($R^2=0.889$):

$$Td = 0.1329MC + 1043.2 \quad (8)$$

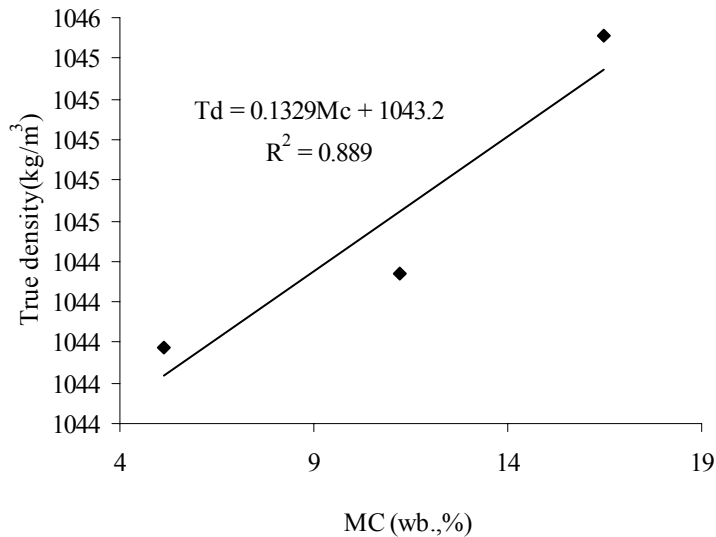


Figure 4. Effect of moisture content on true density of apricot pit

Deshpande *et al.* (1993), Gezer *et al.* (2002) and Kashaninejad *et al.* (2006) have reported similar trends.

3.5 Bulk Density

As it is presented on figure 5, the bulk density of apricot pit varied between 527.65 and 539.44 kg/m³. The relationship between bulk density and moisture content was linear and can be expressed by the following equation ($R^2=0.9764$):

$$Bd = 1.0298MC + 521.91 \quad (9)$$

The present result is similar to the recent works done by Kashaninejad *et al.* (2006) and Gezer *et al.* (2002).

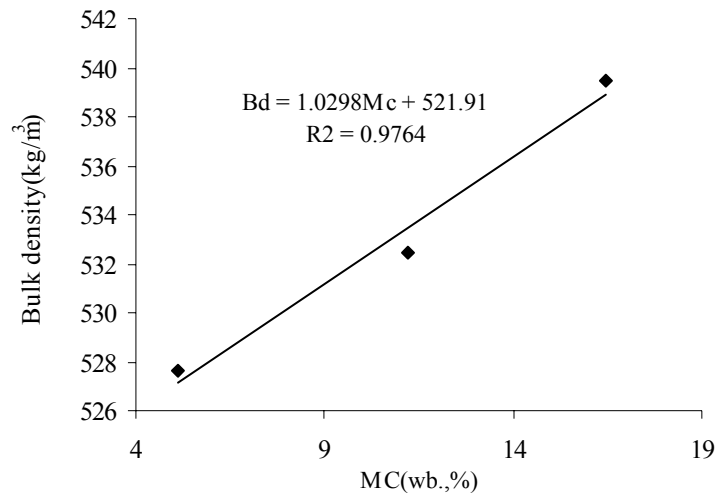


Figure 5. Effect of moisture content on bulk density of apricot pit

3.6 Surface Area

The variation of the surface area with the grain moisture content is shown in figure 6. This figure indicates that the surface area increased linearly with moisture content of pits. The relationship between surface area and moisture content of apricot pit was found to be as follows ($R^2=0.9737$):

$$S = 2.6445 Mc + 687.17 \quad (10)$$

Aydin (2003), Deshpande *et al.* (1993), Gezer *et al.* (2002) and Fathollahzadeh *et al.* (2008) have reported similar trends.

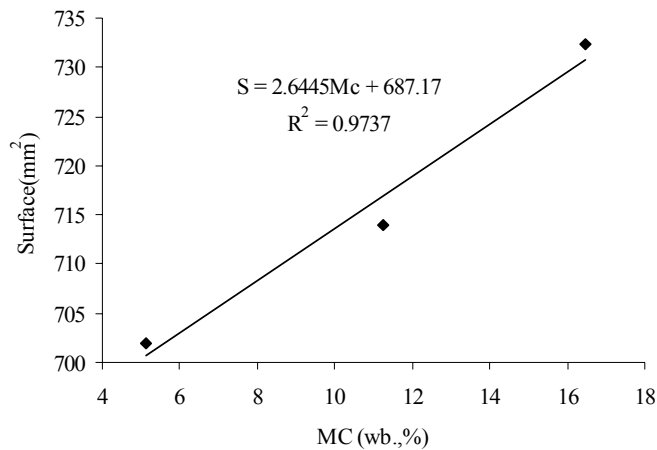


Figure 6. Effect of moisture content on surface area of apricot pit

3.7 Thousand Grain Mass

The variation of the 1000 grain mass with the grain moisture content is shown in figure 7. Results showed that 1000 grain mass at 5.11, 11.23 and 16.48 % moisture contents was 1402.43, 1411.72 and 1437.32 g, respectively. The relationship between 1000 grain mass and moisture content of apricot pit was as follows ($R^2=0.9082$):

$$M_{1000} = 3.0261MC + 1384.1 \quad (11)$$

Mohsenin (1970), Sessiz *et al.* (2007) and Fathollahzadeh *et al.* (2008) have reported similar trends.

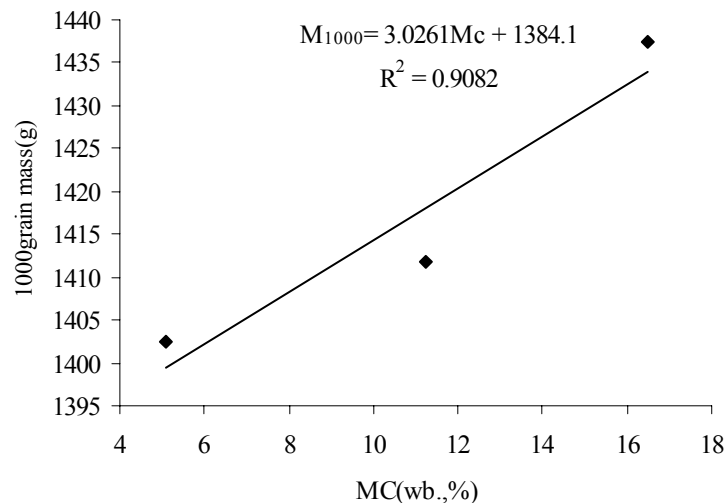


Figure 7. Effect of moisture content on 1000 grain mass of apricot pit

3.8 Porosity

The porosity calculated from experimental data on particle density and bulk density for each pit decreased as the moisture content increased (fig. 8). Results showed that porosity at 5.11, 11.23 and 16.48 % moisture contents was 49.457, 48.807 and 48.404 %, respectively. The following relationship was found between pit porosity and moisture content ($R^2=0.9805$):

$$P = -9.2071MC + 49.967 \quad (12)$$

Deshpand *et al.* (1993) and Sessiz *et al.* (2007) reported similar results.

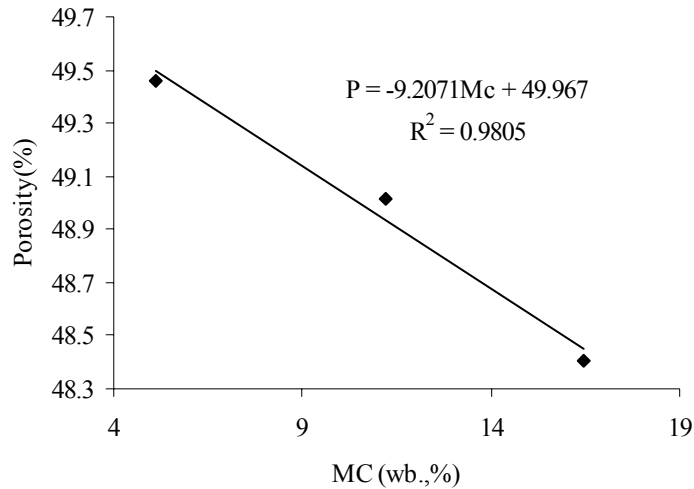


Figure 8. Effect of moisture content on porosity of apricot pit

3.9 Coefficient of Static Friction of Pits on Different Surfaces

Figure 9 shows relationship between coefficient of static friction measured on four surfaces (wood, glass, galvanized steel and fiberglass) and moisture content. With increasing moisture content, coefficient increased for all surfaces but with different levels. The highest values of coefficient of static friction of pits were obtained on wood. At all moisture contents, the least static coefficient of friction was found on glass. Relationship between moisture content and coefficient of static friction of apricot pits on different surfaces was given as bellow:

$$\mu_{wood} = 0.0079MC + 0.4872 \quad (R^2=0.9883) \quad (13)$$

$$\mu_{fiberglass} = 0.005MC + 0.3592 \quad (R^2=0.9841) \quad (14)$$

$$\mu_{galvanize} = 0.0117MC + 0.2976 \quad (R^2=0.9999) \quad (15)$$

$$\mu_{glass} = 0.0021MC + 0.3297 \quad (R^2=0.7872) \quad (16)$$

The reason for increasing friction coefficient at higher moisture content may be the extant water in pit offering a cohesive force on the surface of contact. Water tends to adhere to surface and the water on the moist pit surface would be absorbed to the across surface on which the sample is being moved. Aydin (2003) reported that, at all investigated moisture contents, both static and

dynamic coefficients of friction were the greatest for almond nut and kernel against plywood and least for galvanized sheet metal with rubber in between. As the moisture content of the nut increased, the static and dynamic coefficients increased significantly. Kashaninejad *et al.* (2006) reported that, the static coefficient of friction was the highest for pistachio nut and kernel on rough concrete and the least for galvanized iron. As the moisture content of pistachio nut and kernel increased, the static coefficient of friction increased linearly.

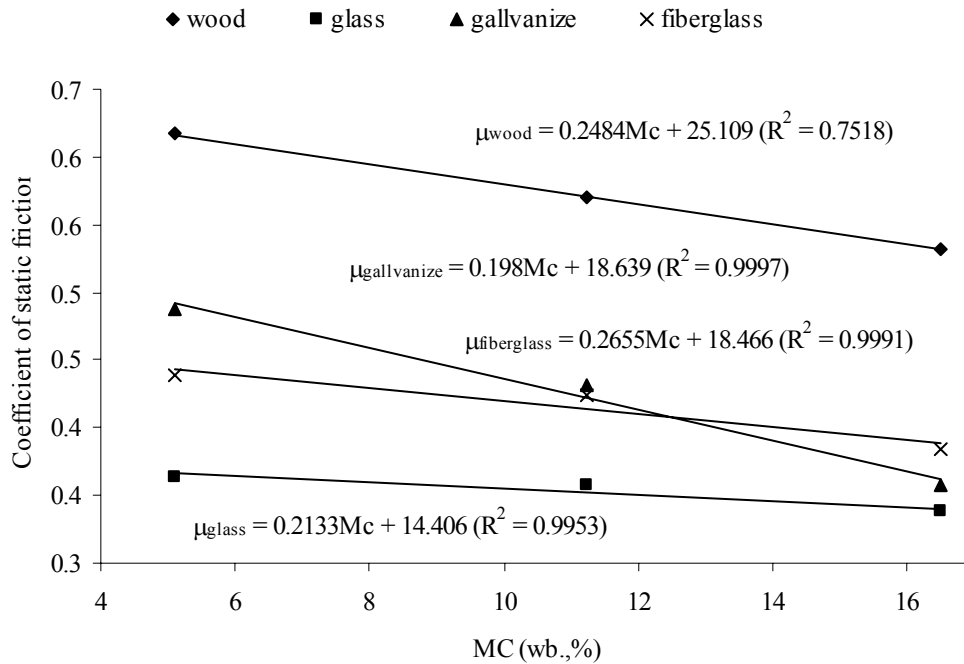


Figure 9. Effect of moisture content on coefficient of static friction of apricot pit

4. CONCLUSIONS

1. Physical properties of apricot pit depend on its moisture content.
2. The symmetrical dimensions and weight of apricot pit increased with moisture content. This situation is due to water absorption by pits.
3. Geometric mean diameter of apricot pit also increased with increasing moisture content.
4. In apricot pits, 1000 grain weight, grain volume, and surface area of apricot pit increased with increase in moisture content.
5. As the moisture content increased from 5.11 to 16.48 % (w.b.) bulk density and true density of apricot pit increased.
6. Sphericity and porosity of apricot pit decreased with increase in moisture content.
7. The static coefficient of friction of apricot pit on four surfaces (wood, glass, galvanized steel and fiberglass) increased linearly with increase in moisture content. The static coefficient of friction for apricot pit was greatest on wood, followed by fiberglass, galvanize sheet and glass.

This report provides information on physical properties and morphological data of apricot pits cv. 'Sonnati Salmas' for expanding the knowledge about this specie and providing useful data for its industrial processing.

5. REFERENCES

- Agricultural Statistical Bulletin (ASB). 2008. Crop year 2005-2006. Ministry of Jihad-e-Agriculture of Iran.
- Aydin, C. 2003. Physical properties of almond nut and kernel. *Journal of Food Engineering*, 60, 315-320
- Baryeh, E.A. 2001. Physical properties of bambara groundnuts. *Journal of Food Engineering*, 47, 321-326
- Burgos, L., T. Berenguer and J. Egea. 1993. Self- and cross-compatibility among apricot cultivars. *HortScience*, 28, 148-150
- Çalişir, S., T. Marakoğlu, H. Öğüt and O. Öztürk. 2005. Physical properties of rapeseed (*Brassica napus oleifera* L.). *Journal of Food Engineering*, 69(1), 61-66
- Deshpande, S.D., S. Bal and T.P. Ojha. 1993. Physical properties of soybean. *Journal of Agricultural Engineering Research*, 56, 89-98
- ElMasry, G., E. Moltó, J. Blasco and A. ElSayed. 2006. Influence of hot water treatment on some chemical and mechanical properties of potato. *Agricultural Engineering International: the CIGR EJournal*, 8, 05-013
- 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. Sonnati Salmas). *Agricultural Engineering International: the CIGR EJournal*, 10, 08-008
- Food and Agriculture Organization (FAO). 2008. Statistics, FAOstat.
- Gezer, I., H. Haciseferogullari and F. Demir. 2002. Some physical properties of Hacıhaliloğlu apricot pit and its kernel. *Journal of Food Engineering*, 56, 49-57
- Ghadge, P.N., P.R. Vairagar and K. Prasad. 2008. Physical properties of chick pea split (*Cicer arietinum* L.). *Agricultural Engineering International: the CIGR EJournal*, 9, 07-039
- Kashaninejad, M., A. Mortazavi, A. Safekordi and L.G. Tabil. 2006. Some physical properties of Pistachio (*Pistacia vera* L.) nuts and its kernel. *Journal of Food Engineering*, 72, 30-38
- Keramat Jahromi, M., A. Jafari, S. Rafiee, A.R. Keyhani, R. Mirasheh and S.S. Mohtasebi. 2007. Some physical properties of date fruit (cv. Lasht). *Agricultural Engineering International: the CIGR EJournal*, 8, 07-019
- Keramat Jahromi, M., S. Rafiee, R. Mirasheh, A. Jafari, S.S. Mohtasebi and M. Ghasemi Varnamkhasti. 2007. Mass and surface area modeling of bergamot (*Citrus medica*) fruit with some physical attributes. *Agricultural Engineering International: the CIGR EJournal*, 8, 07-029
- Khazaei, J. and D. Mann. 2004. Effects of temperature and loading characteristics on mechanical and stress-relaxation properties of sea buckthorn berries. Part 1. Compression tests. *Agricultural Engineering International: the CIGR EJournal*, 6, 03-011
- Mamman, E., B. Umar and N. Aviara. 2005. Effect of moisture content and loading orientation on the mechanical properties of *Balanites Aegyptiaca* nuts. *Agricultural Engineering International: the CIGR EJournal*, 7, 04-015
- Mohsenin, N.N. 1970. Physical properties of plant and animal materials. Gordon Breach Science Publishers, New York.

Fathollahzadeh H., Mobli H., Tavakkoli M., Ebrahimzadeh M.R., Tabatabaie S.M.H. "Some Physical Properties of 'Sonnati Salmas' Apricot Pit". *Agricultural Engineering International: the CIGR EJournal*. Manuscript 1157. Vol. XI. May, 2009.

- Puchalski, C., G. Brusewitz and Z. Slipek. 2003. Coefficients of friction for apple on various surfaces as affected by velocity. *Agricultural Engineering International: the CIGR EJournal*, 5, 03-002
- Razavi, S.M.A., A. Rafe, M.T. Mohammadi and A.M. Amini. 2007. Physical properties of pistachio nut and its kernel as a function of moisture content and variety. Part II. Gravimetical properties. *Journal of Food Engineering*, 81, 218-225
- Sessiz, A., R. Esgici and S. Kizil. 2007. Moisture-dependent physical properties of caper (*Capparis ssp.*) fruit. *Journal of Food Engineering*, 79, 1426-1431
- Togrul, I. and D. Pehlivan. 2003. Modelling of drying kinetics of single apricot. *Journal of Food Engineering*, 58, 23-32
- Yildiz, F. 1994. New technologies in apricot processing. *Journal of Standard*, Apricot Special Issue, Ankara, Turkey, 67-69