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Some Physical Properties of Tabarzeh Apricot Kernel

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Abstract: Physical properties of apricot kernel are necessary for the design of equipments for processing, transportation, sorting and separating. In this paper the physical properties of apricot kernel have been evaluated as a function of moisture content varying from 3.19% to 17.46% (w.b.). With increasing in moisture content, kernel length, width, thickness, Geometric mean diameter and surface area increased; the sphericity varying from 59.79 % to 62.21%; mass, thousand grain mass, volume and true density increase from 0.380 to 0.448 (gr), 381.6 to 447.9 (gr), 0.442 to 0.463 (cm^3) and 882.588 to 983.383 (kg/m^3) respectively; The porosity and bulk density decreased from 52.68% to 51.33% and 471.6 to 406.8 (kg/m^3) respectively; the coefficient of static friction on all surfaces increased as the moisture content increased; and the rupture strength in weakest direction (through length) decrease from 23.443 to 16.620 (N).

Key words: Apricot kernel, apricot fruit, seeds, moisture content

Introduction

Apricot (*Prunus armenia L.*) has an important place in human nutrition and apricot fruits can be used as fresh, dried or processed fruit. Stone-fruit crops, including apricot are temperate fruits which are grown in climates with well-differentiated seasons. Mechanisms against the impact of low winter temperatures and frost damage have been developed by species growing under these conditions. Dormancy and freezing tolerance are the main mechanisms developed against these difficulties and, although they could be independent (Irving and Lamphear, 1967), freezing tolerance cannot be developed adequately without growth cessation (Fuchigami *et al.*, 1971), which marks the onset of dormancy. As known, the fruit of apricot is not only consumed fresh but also used to produce dried apricot, frozen apricot, jam, jelly, marmalade, pulp, juice, nectar, extrusion products etc. Moreover, apricot kernels are used in the production of oils, benzaldehyde, cosmetics, active carbon and aroma perfume (Yildiz, 1994). Apricot is rich in minerals such as potassium and vitamins such as β - carotene. β-carotene, which is the pioneer substance of mineral A, is necessary for epithelia tissues covering our bodies and organs, eye-health, bone and teeth development and working of endocrine glades. Moreover, vitamin A plays important role in reproduction and growing functions of our bodies, in increasing body resistance against infections. Iran is the second apricot producer in the world with 275580 ton production and 8.2% share (FAO, 2005). In Iran, the most widely produced types are Tabarzeh, Kardi Damavandi, Nakhjavan and Sonnati. Turkey, Iran, Italy, Pakistan and France are the principal apricot countries. Trees are also grown in Spain, Japan, Syrian Arab Republic and Algeria. Iran has exported more than 680 tones to different countries in 2005 (FAO, 2005). The trees of these types of apricot are high, strong and grow rapidly and have wide and shallow branches. They bear fruits every year in fertile and irrigated soils. The distance between trees is approximately 10 m, average fruit weight ranges between 20 and 60 g, dried substance percentage in fruit is 18-28%, pH value is between 4.0 and 5.0 and their color are yellow. Their harvesting phase is between the last of June and the beginning of July. The first three of these varieties are evaluated as dry products; the other three are evaluated as fresh products. The agriculture of apricot needs extensive labor and energy. In Iran, apricot fruits are harvested at about 77% moisture level (ASB, 2005). Apricot pits are also separated into shells and kernels in the regional conglomerates which have washing, sorting and breaking and separation units. The resulting shells are generally used as fuel. The physical properties of apricot are important for the design of equipments for harvesting and post-harvesting technology transporting, storing, cleaning, separating, sorting, sizing, packaging and processing it into different food. Since currently used systems have been generally designed without taking these criteria into consideration, the resulting designs lead to inadequate applications. These results in a reduction in work efficiency, an increase in product loss. Therefore, determination and consideration of these criteria have an important role in designing of these equipments.

Many studies have reported on the physical properties of kernels and seeds such as Dutta *et al.* (1988) for gram, Gupta and Das (1997) for almond nut and kernel, Ogut (1998) for white Lupin, Aydin (2002) for Hazel nuts, Kaleemullah and Gunasekar (2002) for arecanut kernels, Gezer *et al.* (2002) for apricot pit and its kernel, Sahoo and Srivastava (2002) for okra seed, Konak *et al.* (2002) for chickpea seeds, Aydin (2003) for Almond nut

Fig. 1: Tabarzeh apricot kernel.

and kernel, Baryeh and Mangope (2003) for pigeon pea, Kashaninejad *et al*. (2005) for pistachio nuts and kernels, Karababa (2006) for popcorn kernels, Razavi *et al*. (2007) for pistachio nuts and their kernels. As it can be found from literature review, there was no published paper about the physical properties of Iranian apricot kernel, who studied some of their physical properties have been evaluated as a physical of moisture content. As it can be found from literature review, there was no published paper about the physical properties of Iranian apricot kernel, who studied some of their physical properties have been evaluated as a physical of moisture content.

It is clear that investigating on physical and mechanical properties of apricot kernel is very essential and practical for its process. Then for achieving this aims, some important physical properties of apricot such as axial dimensions, thousand grain mass, true and bulk density, porosity, spherisity, coefficient of static friction and rupture strength on 4 level of moisture were determined.

Materials and Methods

Apricot of Tabarzeh variety (Fig.1) used for this study was collected from the orchard located in Salmas village in west Azarbayjan, Iran in August 2007. Broken pits and foreign matters such as dust, dirt, stones and chaff were removed from 7 kg apricot pit then 4 kg apricot kernel was obtained. Apricot kernels were cleaned by exposing them to air screen cleaner for foreign matters. All products were kept in the room temperature for two days. Moisture content was immediately measured on arrival. The kernels were divided into four batches in order to obtain four moisture levels for the experiments. For obtain the desired water contents of apricot kernel, the moisture of kernel samples were measured at six day intervals after apricots harvesting. The first water content of kernel was 17.46%, then after 6 days the water content of apricot kernels had fallen down to 11.69%, 4.49% and 3.19% (w.b.), respectively. Moisture contents of the kernels were determined by using a standard method (USDA, 1970).

One hundred apricots randomly selected and its kernel parameters including length (L) in mm, width (W) in mm, thickness (T) in mm, weight (g) in kg, volume (V) in cm^3, true density (Td) in kg/m^3, geometrical mean diameter (Dg) in mm, sphericity (ϕ) factor and surface area (S) in mm^2 measured. Geometrical dimensions and mass of kernels, measured by micrometer and digital balance with accuracy 0.01mm and 0.001g respectively. By use of three dimensions, geometrical mean diameter, sphericity factor and surface area (S1 and S2) obtained from fallow equations (Mohsenin, 1970; Jain and Bal, 1997).

Fig. 2: The device for determining coefficient of static friction

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

$$\Phi = (Dg/L)*100 \quad (2)$$

$$S1 = \pi\_Dg^2 \quad (3)$$

$$S2 = \frac{\pi BL^2}{2L - B} \quad \text{Where } B = (WT =)^{0.5} \quad (4)$$

In order to determining thousand grain mass (M_{1000}) in g, randomly 100 seed selected and weighted. True density (Td) in kg/m^3 and volume (V) determined by use of displacement in liquid method. We use toluene instead of water as liquid, because it is more advantages. As we know toluenes have less surface tension and degeneration. (Mohsenin, 1970; Ogut, 1998). The bulk density (Bd) is in kg/m^3 the ratio of the mass sample of the kernels to its total volume. It was determined by filling a 1000 ml container with kernels from a height of about 15 cm, striking the top level and then weighing the contents (Desphande *et al.,* 1993). Also porosity (P) calculated by follow equation (Thompson and Isaacs, 1967; Mohsenin, 1970).

$$P = \frac{1-Bd}{Td} \quad (5)$$

Coefficient of static friction (μ) of kernels on four surface including wood, fiberglass, glass and galvanize seet were determined. In order to determining coefficient of static friction, we put products on the surface with

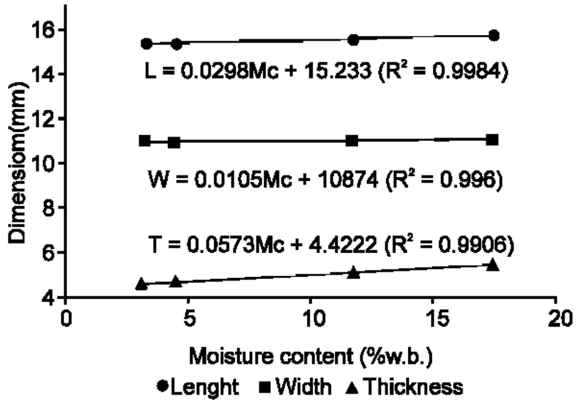

Fig. 3: Effect of moisture content on symmetrical dimensions

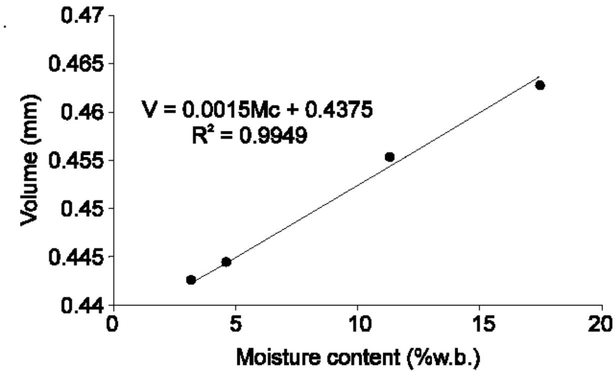

Fig. 4: Effect of moisture content on grain volume of apricot kernel

changeable slip (Fig.2). When product started to motion, tangent of slip angle show the coefficient of friction (Baryeh, 2001).
Rapture strength for apricot kernel determined from forces acting on the three dimensions length, width and thickness with speed of load 50mm/min (Gezer *et al.*, 2002). Method of test was putting shelled apricot on desired dimension and selecting speed of loading and after that applying force till product fractured. On the monitor of device shows graph of force- displacement.

Results and Discussion

Physical properties mean comparison by Duncan's multiple range tests: Average physical properties of apricot kernel in different moisture content was compared by Duncan's multiple rang test. Comparing average data by Duncan method related to dimension, mass, volume and density are shown in Table 1. Results show that with increasing moisture content of apricot kernels, its physical properties including geometrical dimensions, spherically, surface area, volume, mass, true density and coefficient of static friction on varying surfaces such as wood, glass, galvanized sheet and fiberglass sheet will be increase and bulk density were decrease.

Investigating effect of moisture content on physical properties of apricot

Dimensions and Geometrical mean diameter: Effect of moisture content on geometry dimension, such as length, width and thickness of apricot kernels, was shown on Fig. 3. It is clear that there is much correlation between them. Reason for these phenomena is cellules inflation and penetration water in the porous area. Also by increasing humidity content, Geometrical mean diameter was increased. The positive linear relationship of dimension and geometric mean diameter with moisture content were also observed by other research workers such as Gezer *et al.* (2002) and Kashaninejad *et al.* (2005) for apricot kernel and pistachio nut, respectively.

Sphericity: Spherically is a measure to determining shape of seed which can describe Figure of it. In the present study, change in spherically percentage with multi moisture content, were measured. Results show that spherically at 3.19%, 4.49%, 11.68%, 17.64% moisture content were 59.79 %, 59.74%, 61.04% and 62.21% respectively. As it is clear, spherically increase with increasing in moisture content, but moisture between 3.19% till 4.49% were exception. Maybe their reasons were related to proportion change in width and thickness to change in length. Gezer *et al.* (2002) and Desphande *et al.* (1993) have found an increasing relationship between sphericity and moisture content in their experiments with apricot kernel and soyabean, respectively.

Volume: Trend of change in volume of seed with multi moisture content, were shown on below (Fig. 4). As it is obvious, volume increase with increasing moisture content and its relation is as below:

$$V = 0.0015Mc + 0.4375 \ (R^2 = 0.9949) \quad (6)$$

Similar results have been reported by Desphande *et al.* (1993) for soybean, Ogut (1998) for white lupin, Gezer *et al.* (2002) for apricot kernel and Karababa (2006) for popcorn kernels.

True density: As shown on the Figure 5, true density of apricot kernels at multi moisture content was between 882.59 till 983.38 kg/m^3. Following equation can be used to for determining relation between density and moisture content. Desphande *et al.* (1993) also observed the linear increase in kernel density with increase in grain moisture in the range 8.7-25% db for JS-7244 soybean. Aydin (2003) reported effect of moisture content on true density of almond nut and kernel showed an increase

Table 1: Physical properties mean comparison in different moisture content by Duncan's multiple range

Moisture content*	3.19%	4.49%	11.69%	17.46%
Length (mm)	15.33^{a}(1.247)	15.37^{a}(1.242)	15.57^{a}(1.211)	15.76^{a}(1.194)**
Width (mm)	10.91^{a}(0.916)	10.92^{a}(0.918)	10.99^{a}(0.885)	11.06^{a}(0.877)
Thickness (mm)	4.64^{c}(0.809)	4.66^{c}(0.810)	5.05^{b}(0.718)	5.45^{a}(0.712)
Geometrical mean diameter (mm)	9.138^{c}(0.738)	9.155^{c}(0.740)	9.479^{b}(0.685)	9.785^{a}(0.686)
Spherically (%)	59.791^{b}(4.513)	59.74^{b}(4.479)	61.04^{ab}(3.729)	62.21^{a}(3.385)
Surface area 1 (mm2)	264.93^{a}(42.451)	283.62^{a}(40.743)	297.59^{a}(55.747)	302.17^{a}(60.211)
Surface area 2 (mm2)	199.98^{b}(34.326)	224.29^{ab}(35.516)	239.79^{a}(34.235)	255.33^{a}(35.285)
Volume (cm3)	0.442^{a}(0.108)	0.444^{a}(0.109)	0.456^{a}(0.108)	0.463^{a}(0.109)
Mass (gr)	0.380^{b}(0.103)	0.383^{b}(0.105)	0.417^{ab}(0.101)	0.448^{a}(0.103)
True density (kg/m3)	882.588^{b}(174.68)	885.570^{b}(178.03)	934.054^{ab}(167.20)	983.383^{a}(165.58)
Bulk density (kg/m3)	471.6^{c}(8.303)	440.8^{b}(8.478)	412.2^{a}(8.285)	406.8^{a}(0.011)
Coefficient of static friction on:				
wood	0.3679^{a}(0.121)	0.3685^{a}(0.093)	0.3772^{a}(0.015)	0.3838^{a}(0.051)
glass	0.1768^{c}(0.011)	0.1781^{a}(0.028)	0.1793^{bc}(0.101)	0.2065^{ab}(0.039)
galvanize sheet	0.2141^{a}(0.061)	0.2145^{a}(0.034)	0.2150^{a}(0.015)	0.2216^{a}(0.074)
fiberglass sheet	0.2356^{a}(0.119)	0.2363^{a}(0.093)	0.2369^{a}(0.034)	0.2400^{a}(0.016)

tests (at 5% level). *Above result was for average 100 apricot kernels. **Superscript letters indicate that means with the same letters designation in a column are not significantly different at P = 0.05.

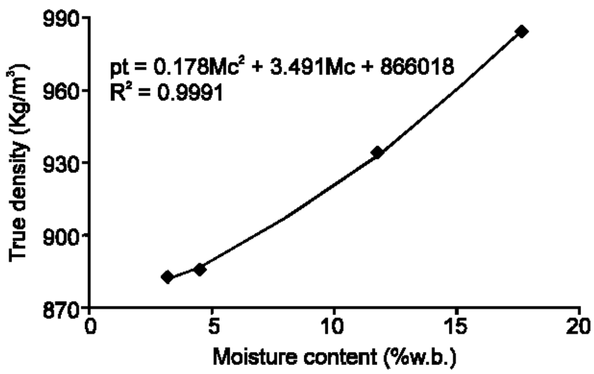

Fig. 5: Effect of moisture content on actual density of apricot kernel.

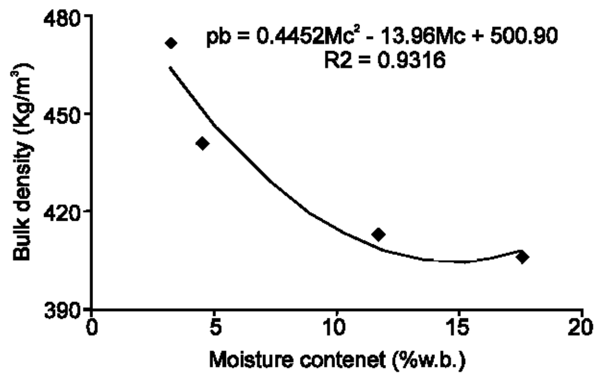

Fig. 6: Effect of moisture content on bulk density.

with moisture content. The negative linear relationship was also observed by Desphande *et al.* (1993) for soy bean, Sahoo and Srivastava (2002) for okra seed, Konak *et al.* (2002) for chickpea seeds and Kaleemullah and Gunasekar (2002) for arecanut kernels, Karababa (2006) for popcorn kernels and Razavi *et al.* (2007) for pistachio nuts and their kernels.

$\rho t = 0.1787Mc^2 + 3.4911M + 868.18$ (R^2 = 09991) (7)

Bulk density: According to Fig. 6, bulk density of apricot kernels at multi moisture content were 407 to 472 Kg/m^3 which its relation was as below:

$\rho b = 0.4452Mc^2 - 13.096Mc + 500.92$ (R^2 = 0.9316) (8)

The negative relationship of bulk density with moisture content was also observed by Aydin (2003) and Gupta and Das (1997) for almond nut and kernel and sunflower seeds, respectively. The relationship between bulk density and moisture content was statistically significant (p < 0:05). In contrast, the negative linear relationship of bulk density with moisture content was observed by various research workers (Konak *et al.*, 2002; Nimkar and Chattopadhyay, 2001). Razavi *et al.* (2007) reported that there is a linear increase in bulk density of pistachio nut and its kernel with an increase in moisture content.

Surface area: In this study, effect of moisture content on surface area of apricot kernels investigated. According to Fig. 7, results show that equation S1 with moisture content 3.19%, 4.49% , 11.69% and 17.64% surface area were 264.93, 283.62, 297.59 and 302.17 mm^2 and with equation S2 it was 199.98, 224.29, 239.79 and 255.33 mm2 respectively.

$S1 = 2.2619Mc + 266.25$ (R^2 = 0.8077) (9)

$S2 = 3.3219Mc + 199.26$ (R^2 = 0.8765) (10)

As it is clear equation S1 show more surface area than equation S2 which this difference related to change in

Table 2: Duncan comparing of mean rupture strength data of apricot kernels in multi moisture content

Moisture content	17.46%	11.69%	4.49%	3.19%
Through length	16.620^{a}(2.089)	18.331^{a}(1.814)	22.588^{a}(9.014)	23.443^{a}(5.937)
Through width	32.25^{a}(1.331)	35.923^{ab}(3.257)	38.870^{ab}(15.734)	46.420^{b}(11.124)
Through thickness	91.221^{a}(13.509)	115.64^{ab}(16.245)	130.550^{b}(27.761)	135.292^{b}(21.307)

Above result was for average 30 apricot kernels.

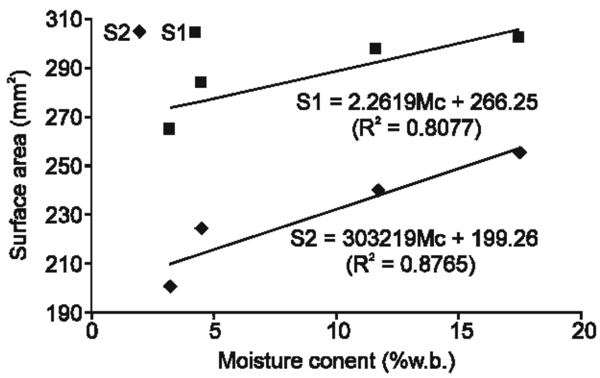

Fig. 7: Effect of moisture content on surface area.

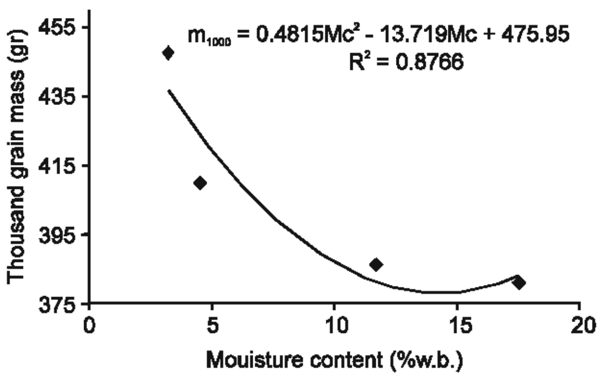

Fig. 8: Effect of moisture content on 1000 grain mass.

data apparatus act on the equations. Similar trends were reported for many other seeds (Mohsenin, 1970). Desphande *et al.* (1993) found that the surface area of soybean grain increased from 0.813 to 0.952 cm^2, when the moisture content was increased from 8.7% to 25% db.

Thousand grain mass: Effect of moisture content from 3.19% to 17.46% on weight of 1000 seed of apricot kernels, were shown on the Fig. 8. Thousand grain mass at this range of moisture content was between 381.6 to 447.9 g. Its equation was:

$$m_{1000}=0.4815Mc^2-13.719Mc+475.95 \ (R^2= 0.9458) \quad (11)$$

Similar results have been reported by Desphande *et al.* (1993); Ogut (1998); Baryeh (2002); Baryeh and Mangope (2003) and Karababa (2006) for soybean, white lupin, millet, pigeon pea and popcorn kernels, respectively.

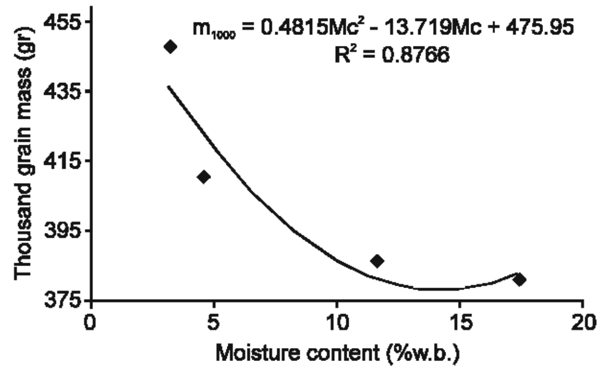

Fig. 9: Effect of moisture content on porosity of apricot kernel.

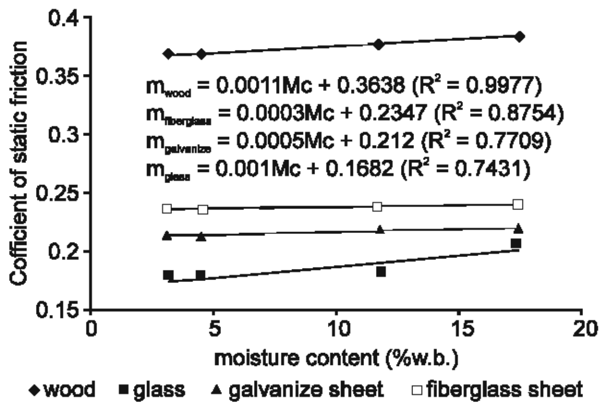

Fig. 10: Effect of moisture content on coefficient of static friction of apricot kernel.

of apricot kernel (with value 51.33% to 52.68%) given in the below equation. Following Fig. 9 shows trend of this variation.

Porosity: Reverse relation between porosity and moisture content

$$P = -0.0853Mc + 52.789 \ (R^2 = 0.9463) \quad (12)$$

Other researchers were reported for gram (Dutta *et al.*, 1988), sunflower seeds (Gupta and Das, 1997), white lupin (Ogut, 1998) hazel nuts (Aydin, 2002) chickpea seeds (Konak *et al.*, 2002), arecanut kernels (Kaleemullah and Gunasekar, 2002), okra seeds (Sahoo and Srivastava, 2002) and pigeon pea (Baryeh and Mangope, 2003).

Coefficient of static friction of kernels on 4 surfaces (wood, glass, galvanized sheet and fiberglass sheet).

Fig. 10 shows relations between coefficient of static friction on 4 surfaces (wood, glass, galvanized steel and fiberglass). As it is clear, with increasing moisture content, this coefficient increased for all surfaces but with different levels. Relation between moisture content and coefficient of static friction of apricot kernels on different surface given as bellow:

$$\mu_{galvanize} = 0.0005Mc + 0.212\ (R^2 = 0.771) \quad (13)$$

$$\mu_{wood} = 0.0011Mc + 0.3638\ (R^2 = 0.997) \quad (14)$$

$$\mu_{glass} = 0.0018Mc + 0.1682\ (R^2 = 0.744) \quad (15)$$

$$\mu_{fiberglass} = 0.0003Mc + 0.2347\ (R^2 = 0.875) \quad (16)$$

Gezer *et al*. (2002) stated that as the moisture content increased so the coefficient of static friction increased.

Comparing mechanical properties of apricot kernels by Duncan methods: Comparing average data of rupture strength at three dimension i.e. length, width and thickness by Duncan method given on the Table 2. Results showed that by increasing moisture content of apricot kernels, fracture forces decreases in all three dimensions.

Rapture strength: Following Table 2 shown variations between fracture forces and moisture content for apricot kernels. As it is clear, maximum force was for fracturing shelling apricot at thickness direction. Relation between fracture forces and moisture content presented bellow.

$$F_L = 0.0234Mc^2 - 0.9Mc + 25.32\ (R^2 = 0.9371) \quad (17)$$

$$F_W = 0.046Mc^2 - 1.8196Mc + 50.22\ (R^2 = 0.9397) \quad (18)$$

$$F_T = -0.1261Mc^2 - 0.2289Mc + 134.14 (R^2=0.9733) \quad (19)$$

The study of Gezer *et al*. (2002) supported this result.

Conclusion:

1. The symmetrical dimensions and weight of apricot kernel increased depending on moisture content. This situation stems from water absorption of kernel.
2. measured sphericity from equation 6 and 7 and Geometrical mean diameter value of apricot kernel increased with increasing moisture content.
3. In apricot kernels, 1000 grain weight, grain volume, grain density, and surface area increased with moisture content.
4. The bulk density value decreased with moisture content in apricot kernels. There was a negative relationship between them.
5. Porosity value decreased with increase moisture content. It was maybe due to decreasing sphericity in lesser moistures content.
6. In apricot kernel, the angle of static friction was found to be higher on a wood than on a fiberglass sheet, galvanize sheet and glass, respectively. The value of angle of static friction on all surfaces increased with increase moisture content.
7. Rupture strength decrease when the moisture content increased. That is a negative relationship between them. The force applied through length was found to be lesser and through thickness was found to be highest in apricot kernel.

Nomenclature

L	Length	V	Volume
W	Width	Td	True density
T	Thickness	Bd	Bulk density
Dg	Geometrical mean diameter	M1000	Thousand grain mass
ϕ	Sphericity	p	Porosity
S	Surface area	μ	coefficient of static friction
M	Mass	F	Rapture strength
Mc	Moisture content		

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