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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Post Harvest Physical and Mechanical Properties of Apricot Fruits, Pits and Kernels (C.V. Sonnati Salmas) Cultivated in Iran

Hojat Ahmadi, Hamzeh Fathollahzadeh and Hossein Mobli
Department of Agricultural Machinery, Faculty of Biosystems Engineering,
University of Tehran, Karaj, Iran

Abstract: The physical and mechanical characteristics of Sonnati Salmas apricot fruits, pits and kernels were studied in this study. Technological properties such as dimensions, geometric mean diameter, sphericity, surface area, bulk density, true density, porosity, volume, mass, true density, bulk density, porosity, 1000-unit mass, coefficient of static friction on various surface and rupture force in 3 axes, were determined at 82.34, 16.48 and 13.03% moisture contents for apricot fruits, apricot pits and apricot kernels respectively. Bulk densities of fruits, pit and kernels were 443.2, 539.4 and 540.1 kg/m^3, the corresponding true densities were 940.7, 1045.5 and 1023.6 kg/m^3 and the corresponding porosities were 52.87, 48.40 and 47.21%, respectively. The volumes, mass and surface area of fruits were larger than those of pits and kernels. Static coefficient of friction of fruit on all surfaces (wood, glass, galvanize sheet and fiber glass sheet) were measured and static coefficient of friction was less bout for pits and kernels on glass and their value were 0.474 and 0.188, respectively. Rupture force of fruit, pit and kernel were 10.11, 497.79 and 18.92 N through length, 7.98, 322.59 and 41.97N through width and 7.01, 337.21 and 99.58 N through thickness. Results showed that rupture force through length were minimum and this result is very important factor in design post harvest machines, especially about apricot pit crasher machine.

Key words: Apricot, fruit, pit, kernel, physical properties, mechanical properties

Introduction

Apricot (*Prunus armenia* L.) is classified under the prunus species of Prunaidea sub-family of the Rosaceae family of the Rosales group. This type of fruit is a cultivated type of zerdali (wild apricot) which is produced by inoculation (Ozbek, 1978). Apricot 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. Behaviors 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 can not 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 b-carotene, which is the precursor substance of vitamin A, which 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, 2007). In Iran, the most widely produced types are Sonnati salmash, Kardi Damavandi, Nakhjavan and Tabarzeh. 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 >680 tones to different countries in 2007 (FAO, 2007). 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 mass 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 (ABS, 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 chemical and the physical-mechanical properties of fruits, such as Chang (1988) for grain kernels, Oje and Ugbor (1991) for oilbean seed, Carman (1996) for lentil seed, Singh and Goswami (1996) for Cumin seed, Suthar and Das (1996) for karingda, Visvanathan *et al.* (1996) for Neem Nut, Ogut (1998) for white Lupin, Olajide and Igbeka (2003) for Groundnut kernels, Nimkar and Chattopadhyay (2001) for green gram, Aydin (2002) for Hazelnut, Kaleemullah and Gunasekar (2002) for arecanut kernels, Demir *et al.* (2002) for hackberry, Gezer *et al.* (2002) for apricot pit, Konak *et al.* (2002) for Chick pea, Aydin (2003) for Almond nut and kernel, Bart-Plange and Baryeh (2003) for Category B cocoa bean, Olajide and Igbeka (2003) for Groundnut kernels, Calisir and Aydin (2004) for cherry laurel, Altuntas and Yildiz (2007) for faba bean grain, Dursun and Durson (2005) for Caper seed, Kashaninejad *et al.* (2005) for pistachio. As it can be found from literature review, there was no published paper about the physical properties of apricot kernel, except for Gezer *et al.* (2002) research, 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 is very essential and practical for its process. Then some important physical and mechanical properties of apricot fruit, pit and kernel such as axial dimensions, 1000-unit mass, bulk density, coefficient of static friction and rupture force were determined.

Materials and Methods

Apricots of Sonnati Salmas variety which used in this study were produced on 2007 in the west Azarbayjan province of Iran. Shelled of fruit had been broken and then, by use of air pressure cleaned and separated from waste materials. All products were kept in the room temperature for 2 days. All measurements had been done on the apricot fruits, pits and kernels with moisture contents 84.19, 16.48 and 13.03%, respectively, which those moistures are suitable for processing of product. One hundred apricot fruits, pits and kernels randomly was selected and then technological properties such as Length (L), Width (W), Thickness(T), mass (m), Volume (V), True density (Td), Bulk density (Bd), Geometrical mean Diameter (D_g), sphericity (ϕ) factor and Surface area (S), coefficient of static friction (μ) on various surface, rupture force through 3-axis were measured. Geometrical dimensions and mass of apricot fruits, pits and kernels, were measured by coulisse and digital balance with accuracy 0.01 mm and 0.001 g, respectively.

By use of those three dimensions, geometrical mean diameter, sphericity factor and Surface area (S) were obtained from fallow equations (Jain and Bal, 1997; Mohsenin, 1970).

$$D_g = (LWT)^{(\frac{1}{3})} \tag{1}$$

$$\varphi = (D_g / L) \times 100 \tag{2}$$

$$S = \pi D_g^{\,2} \tag{3}$$

In order to determining 1000-unit mass (m_{1000}), randomly 100 seed were selected and weighted. True density (Td) and Volume (V) were determined by use of displacement in liquid method. We had been used toluene instead of water as liquid, because it was more advantages. As we know toluenes have less surface tension and degeneration (Mohsenin, 1970; Ogut, 1998; Sitkei, 1976; Singh and Goswami, 1996). The Bulk density (Bd) is 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 was weighed the contents (Desphande *et al.*, 1993). Also, Porosity (P) was calculated by follow equation (Mohsenin, 1970; Thompson and Isaacs, 1967).

$$P = 1 - \frac{Bd}{Td} \tag{4}$$

Coefficient of static friction μ of apricot fruits, pits and kernels on four surface including woods, glass, galvanizes steel and fiberglass was determined. In order to determining coefficient of friction, we had been put products on the surface with changeable slip. When product was started to motion, tangent of slip angle was showed the coefficient of friction Baryeh (2001), Dutta *et al.* (1988) and Suthar and Das (1996) had used similar methods.

Rapture strength for apricot kernel determined from forces acting on the three dimensions length, width and thickness with speed of load 50 mm/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.

Quasi-static compression tests were performed with an Instron Universal Testing Machine (Model Santam SMT-5) equipped with a 25-kg compression load cell

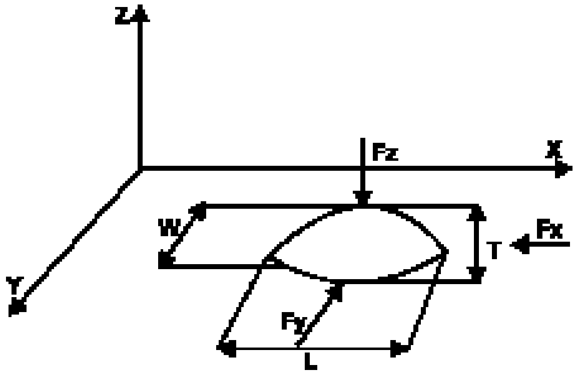

Fig. 1: Representation of the 3 axes and three perpendicular dimensions of apricot, pit and kernel

Fig. 2: Universal testing machine (Model Santam SMT-5)

and integrator (Khazaei, 2002). The measurement accuracy was 0.001N in force and 0.001 mm in deformation. For each treatment 10 apricot were randomly selected and the average values of all the 10 tests were reported.

The individual pit was loaded between 2 parallel plates of the machine (Fig. 2) and compressed at the preset condition until rupture occurred as is denoted by a bio-yield point in the force-deformation curve. The bio-yield point was detected by a break in the force deformation curve. Once the bio-yield was detected, the loading was stopped. The mechanical properties of apricot fruit, pit and kernel were expressed in terms of rupture required for initial rupture.

Results and Discussion

Moisture content: Average of dry base moisture content of 10 Sonnati Salmas apricot fruits and their pits and kernels was shown in Table 1. Results showed that the moisture content of pit and kernel were near together. Each value is average of 10 measurements.

Table 1: Average of dry base moisture content of Sonnati salmas apricot fruits and their pits and kernels

Part of fruit	N	Average of moisture content (d.b%)	Standard deviation
Fruit	10	82.34	3.634
Pit	10	16.48	1.421
Kernel	10	13.03	1.396

Geometrical properties: Table 2 shows the geometrical properties such as length, width, thickness, geometrical mean diameter, spherically and surface area of 100 Sonnati salmas apricot fruits and their pits and kernels. Results showed that the fruits had spherically shape.

Post harvest gravimetrical properties of Sonnati salmas apricot fruit such as length, width, thickness, geometrical mean diameter, sphericity and surface area was lower than Kabaasi variety of apricot cultivated in turkey (Haciseferogullari *et al*., 2007).

Gravimetrical properties: Gravimetrical properties such as volume, mass, true density and bulk density of Sonnati Salmas apricot fruits and their pits and kernels were showed in Table 3. Results showed that true density of kernel was more than pit but its opposite about bulk density of pit. The porosity of kernel was more than pit and it is related to it's spherically.

True density, bulk density and porosity of Sonnati Salmas apricot fruit were lower than Kabaasi variety of apricot (Haciseferogullari *et al*., 2007).

Frictional properties: Coefficient of static friction of fruits, pits and kernels on various surface were showed in Table 4. Results showed that static friction coefficient of fruit was more than its pit and kernel on different surface but only the static friction coefficient of pit was more than its kernel on entire materials. Each value is average of 3 measurements.

Sonnati Salmas apricot coefficient of static friction on wood and galvanize sheet iron surfaces were lower than Kabaasi variety of apricot (Haciseferogullari *et al*., 2007).

Mechanical properties: Rupture force of fruits, pits and kernels through length, width and thickness showed in Table 5. Each value is average of 20 measurements. Results showed that rupture force through thickness for fruit was less than other direction and this mechanical property for pit was less through width and for kernel minimum rupture force was through the length direction. This mechanical parameter and the direction of minimum rupture is very important parameter to design post harvest machinery.

Haciseferogullari *et al*. (2007) have used similar trend for determined fruit hardness.

Conclusion: To design and fabricate the equipment related to the post harvest processing, the physical and mechanical properties of the fruits, nuts and kernels are

Table 2: Geometrical properties of 100 Sonnati salmas apricot fruits and their pits and kernels

Geometrical properties	N	Fruit	Standard deviation	Pit	Standard deviation	Kernel	Standard deviation
Length (mm)	100	31.19	1.102	21.18	2.014	15.43	1.957
Width (mm)	100	29.14	0.981	16.41	0.396	10.49	1.639
Thickness (mm)	100	27.11	0.692	10.33	0.326	5.75	0.088
Geometrical mean diameter (mm)	100	29.01	2.111	15.25	1.918	9.71	0.947
Sphericity (%)	100	92.98	9.308	72.13	12.121	62.90	5.352
Surface area (mm^2)	100	2640.93	144.371	732.28	65.744	297.25	21.755

Table 3: Gravimetrical properties of Sonnati salmas apricot fruits and their pits and kernels

gravimetrical properties	N	Fruit	Standard deviation	Pit	Standard deviation	Kernel	Standard deviation
Volume (cm^3)	100	16.19	1.032	1.512	0.022	0.473	0.064
Mass (g)	100	15.231	1.789	1.580	0.009	0.484	0.236
True density (Kg/m^3)	100	940.700	21.378	1045.500	98.461	1023.600	56.137
Bulk density (Kg/m^3)	3	443.20	36.325	539.400	34.486	540.100	42.007
Porosity (%)	0	52.87	-	48.400	-	47.210	-
1000-unit mass (Kg)	100	19.68	3.749	1.440	0.008	0.484	0.034

Table 4: Coefficient of static friction of fruits, pits and kernels on various surfaces

Coefficient of static friction on various surface	N	Fruit	Standard deviation	Pit	Standard deviation	Kernel	Standard deviation
Wood	3	0.520	0.196	0.532	0.156	0.411	0.211
Glass	3	0.474	0.204	0.338	0.176	0.188	0.156
Galvanize sheet	3	0.584	0.178	0.357	0.155	0.231	0.081
Fiberglass sheet	3	0.548	0.201	0.384	0.199	0.262	0.022

Table 5: Rupture force of fruits, pits and kernels through length, width and thickness

Rupture force through 3-axis(N)	N	Fruit	Standard deviation	Pit	Standard deviation	Kernel	Standard deviation
Length	20	10.11	0.234	497.79	32.123	18.92	0.065
Width	20	7.98	0.194	322.59	40.001	41.97	0.627
Thickness	20	7.01	0.199	337.21	29.816	99.58	2.007

important design parameters. The post-harvest physical and mechanical properties of Sonnati Salmas apricot fruits, pits and kernels, including dimensions, geometric mean diameter, sphericity, surface area, bulk density, solid density, porosity, specific surface area, volume, mass, true density, bulk density, porosity, 1000-unit mass, coefficient of static friction on various surface and rupture force in 3 axes, were determined at 84.19, 16.48 and 13.03% moisture contents for apricot fruits, apricot pits and apricot kernels respectively. Bulk densities of fruits, pit and kernels were 443.2, 539.4 and 540.1 kg/m^3, the corresponding true densities were 940.7, 1045.5 and 1023.6 kg/m^3 and the corresponding porosities were 52.87, 48.40 and 47.21%, respectively. The volumes, mass and surface area of fruits were larger than those of nuts and kernels. Results showed that the fruits had spherically shape and true density of kernel was more than pit but it was opposite about bulk density of pit. The porosity of kernel was more than pit and it is related to it's spherically. The static coefficient of friction of fruit on all surfaces studied (wood, glass, galvanize sheet and fiber glass sheet) were the highest as the surface is viscous and hardness is less. Results showed that static friction coefficient of fruit more than its pit and kernel on different surface but only the static friction coefficient of pit more than its kernel on entire materials. Rupture force of fruit, pit and kernel were 10.11, 497.79 and 18.92 N through length, 7.98, 322.59 and 41.97N through width and 7.01, 337.21 and 99.58N through thickness. Results showed that rupture force through thickness for fruit was less than other direction and this mechanical property for pit was less through width and for kernel minimum rupture force was through the length direction. This mechanical parameter and the direction of minimum rupture is very important parameter to design post harvest machinery.

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Nomenclature: L = Length, V = Volume, W = Width, Td = True density, T = Thickness,Bd = Bulk density, Dg = Geometrical mean diameter, m_{1000} = 1000-unit mass, ϕ = Sphericity, ϵ = Porosity, S = Surface area, μ = coefficient of static friction, m = Mass, Rs = Rapture force, Mc = Moisture content