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# Physical properties of apricot to characterize best post harvesting options

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**Abstract**

Some physical properties of three apricot varieties *(Nasiry Rajabali, and Ghavami*) fruits are presented in this study. These properties are necessary for the design of equipment for harvesting, processing, transporting, separating, packing and storage processes. Technological properties such as physical characteristics (linear dimensions, mass, volume, and so on), elasticity modulus, and hydrodynamic characteristics (terminal velocity, drag force, and so on) were determined at 79.61 %( *Nasiry)*, 84.17 %(*Rajabali*) and 79.84 % (*Ghavami*) moisture content. The mean values of length, width, thickness, sphericity, mass, elasticity modulus, terminal velocity and drag force of three different apricot fruits were established between 36.94-48.51 mm, 34.11-43.32 mm, 31.65-40.84mm, 0.84-0.94, 25.56-53.69 g, 0.32-0.53 M Pa, 0.17-0.21 $ms^{-1}$ and 0.01-0.08 N, respectively.

***Keywords:*** Drag force; elasticity modulus; fruit; sphericity; technological properties; terminal velocity; varieties.

**Abbreviations**

$C_d$-drag coefficient; CPA-criteria projected area; $D_g$ -geometric mean diameter; E-elasticity modulus; F-compression force; $F_b$-drag force; $F_d$-bouncy force; g-gravity force; L-length of fruit; M-mass of fruit; $N_R$-Reynolds number; $PA_1$-first projected area; $PA_2$-second projected area; $PA_3$-third projectrd area; R-half of tickness S-surface area; T-thickness of fruit; $T_d$-dropping time; V-volume of fruit; $V_o$-total volume; $V_r$-velocity; $V_t$-terminal velocity; W-width of fruit; ε-porosity; $\rho_b$-bulk density; $\rho_b$ -bulk density; Φ-sphericity; $v$-dynamic viscosity of water; λ-packing coefficient; δ-deformation of one side of fruit.

## Introduction

Apricot (*prunus armeniaca L.*) is classified under the *prunus* species of *prunoidae* 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 domestication (Ōzbek, 1978). Apricot plays an important role in human nutrition, and can be used as a fresh, dried or processed fruit such as frozen apricot, jam, jelly, marmalade, pulp, juice, nectar, extrusion products etc. Moreover, apricot kernels are used in production of oils, cosmetics, active carbon and aroma perfume (Yildiz, 1994). The agriculture of apricot needs extensive labor and energy. Annual labor requirement of the agriculture of apricot is about 700 h $ha^{-1}$

(Gezer et al., 2002). Total energy input, total energy output for a year and output/input ration are $22341\times10^{6}$ J $ha^{-1}$, $75265\times10^{6}$ J $ha^{-1}$ and 3.37, respectively (Gezer et al., 2003). Australia, France, Hungary, Iran, Italy, Morocco, Spain, Tunisia and Turkey are among the most important apricot producer countries. While some of the countries such as Hungary, Morocco, Iran and Tunisia are considered as fresh apricot exporters, the others, such as Australia and Turkey, are major dried apricot producers and exporters. Turkey and Iran (having cultivated area with 20000 hectares and with average annual production of 275580 ton) have been the largest producers of apricot in the world (USDA, 2004). Agricultural crops and food products have several unique characteristics which set them different from engineering materials.

These properties determine the quality of the fruit and identification of correlation among in these properties makes quality control easier (Jannatizadeh et al., 2008). To design a machine for handling, cleaning, conveying, and storing, the physical, mechanical and hydraulic properties of agricultural products must be known. Physical characteristics of agricultural products are the most important parameters to determine the proper standards of design of grading, conveying, processing, and packaging systems (Tabatabaeefar and Rajabipour, 2005). Among these physical characteristics, mass, volume, projected area are the most important ones in determining sizing systems (Khodabandehloo, 1999). Information regarding dimensional attributes is used in describing fruit shape which is often necessary in horticultural research for a range of differing purposes including cultivar descriptions in applications for plant variety rights or cultivar registers (Schmidt et al., 1995; Beyer et al., 2002) .Quality differences in apricot fruit can often be detected by differences in density. When apricot fruits are transported hydraulically, the design of fluid velocity is related to both density and shape. Volumes and projected area of fruits must be known for accurate modeling of heat and mass transfer during cooling and drying (Peschel et al., 2007). Hydrodynamic properties are very important characters in hydraulic transport and handling as well as hydraulic sorting of agricultural products. To provide basic data essential for development of equipment for sorting and sizing apricots needed to determine several properties of apricot such as: fruit density and terminal velocity of that (Matthews et al.,1965; Dewey et al., 1966).
Many studies have reported on the chemical and physical-mechanical properties of fruits, such as wild plum (Calisir et al., 2005), rose fruit (Demir and Ozcan, 2001), orange (Topuz et al., 2004). But limited study concerning Hydrodynamic and physio-mechanical properties of Iranian apricot have been performed yet. There are two main objectives for this study. The first is to determine the Hydrodynamic and physio-mechanical properties of three apricot cultivars in Iran (*Ghavami, Nasiry* and *Rajabali*).The second is to produce a convenient reference table with Hydro dynamical, physical and mechanical information suitable for fresh apricot mechanization and progressing.

**Materials and methods**

The Iranian apricot cultivars consisted of *Ghavami, Nasiry* and *Rajabali* were obtained from orchard located in shahroud, Iran (170 km far from Semnan Province) in July 2008. The 100 fruits of each variety were tested in the Biophysical laboratory and Biological laboratory of University of Tehran, Karaj, Iran. The samples of the fruits were weighted and dried in an oven at a temperature of 78 ° c for 48 h and then weight loss on drying to final content weight was recorded as moisture content (AOAC, 1984). The remaining material was kept in cold storage at 4 ºC until use. Fruit mass (M) was determined with an electronic balance with 0.1 g sensitivity. To determine the average size of the fruits, three linear dimensions namely as length, width and thickness were measured by using a digital caliber with 0.1 mm sensitivity. Volume (V) and true density ($\rho_t$) were determined by the water displacement method (Mohsenin, 1986). The geometric mean diameter ($Dg$), sphericity ($\Phi$) and surface area (S) were determined by using following formula (Mohsenin, 1986), respectively:

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

$$\Phi = \frac{(LWT)^{\frac{1}{3}}}{L} \quad (2)$$

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

Where: L is length of apricot fruit, W is width of apricot fruit; T is thickness of apricot fruit.

Also, Apricots' picture was taken by Area Measurement System Delta T–England apparatus. Then, projected areas ($PA_1$, $PA_2$ and $PA_3$) in three perpendicular directions of the fruits were calculated by applying the software written in Visual Basic. And criteria projected area (CPA) is defined (Mohsenin, 1986).

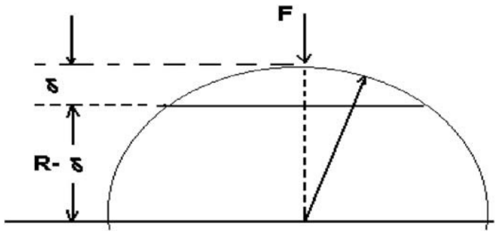


***Fig1.*** Forming deformation in measuring elastic module where δ is deformation of one side of fruit R is half of thickness, and F is compression force

$$CPA = (PA_1+PA_2+PA_3)/3 \quad (4)$$

Where $PA_1$, $PA_2$ and $PA_3$are first, second and third projected area.

The bulk density was determined by using a plastic container with predetermined volume. The fruit were left to fall from a constant height, striking off the top level and weighting. The bulk density is the ratio of fruit mass to container volume, while the porosity was determined by the following equation:

$$\varepsilon= 1- (\rho_b/\rho_t) \quad (5)$$

Where ε is porosity, $\rho_b$ is bulk density and $\rho_t$ is true density.

Packing coefficient was defined by the ratio of the volume of fruit packed to the total volume and was computed as:

$$\lambda= V/V_0 \quad (6)$$

Where λ is packing coefficient, V is volume of apricot fruit and $V_0$ is total volume.

The calculation of elasticity modulus is based on the following assumption and using Universal Testing Machine (Santam, SMT-5) (This machine has three main components, which are a stable forced and moving platform, a driving unit (AC electric motor and reduction unit) and a data acquisition (load cell, PC card and software) system. The machine was equipped with a load cell of 500 N at a compressive rate of 30 mm $min^{-1}$. Failure force and deformations of samples are expressed in terms of the peak of force-deformation curve):

(a) The apricots are long elliptic in shape,
(b) Very small expansion in the longitudinal plane occurred with compression in vertical plane,
(c) Each side of the apricot in contact with the flat plates has an equal defection (O.Brien et al., 1965)

According to following expression, the modulus of elasticity was calculated by the following equation:

$$E=F/\pi\delta^2 \quad (7)$$

Where E is elasticity modulus of fruits, δ is deformation of one side of fruit and F is compression force (Fig1).

To determine some hydrodynamic properties of apricots, a glued Plexiglas column was used with a height of 1200 mm and a cross-section of 400 × 400 mm. The column was constructed with a diameter five times more that that of the fruit (Vanoni, 1975). The column was filled with tap water to a height of about 1100 mm (Kheiralipour, 2008).

Each fruit was placed on the top of the column with hand and then released, and if any bubble appeared on them, it was removed by rubbing the fruit. Fruit was then positioned flat (i.e., with their largest two dimensions oriented horizontally) on the top of column. In order to determine the terminal velocity of the fruit, a digital camera, JVC (770) with 25 fps, recorded the moving of fruits from releasing point to the bottom of water column, simultaneously. Video to frame software were used to change video film to pictures and subsequently to calculate dropping times ($T_d$) and terminal velocities ($V_t$)of fruits by knowing the fact that each picture takes 0.04 s. Drag ($F_d$) and Bouncy ($F_b$) are forces for and against moving of fruits in water defined by following formula, respectively:

$$F_d = C_d A_p \frac{\rho_t V_r^2}{2} \quad (8)$$

$$F_b = \rho_t V g \quad (9)$$

Where $C_d$ , drag coefficient, is a function of fruit velocity and can be modeled well at low velocity using Stokes' law (Crowe et al., 2001). Thus:

$$C_d = \frac{24}{N_R} \quad \text{For} \quad N_R < 1 \quad (10)$$

$$N_R = \frac{Vd}{\nu} \quad (11)$$

Where $N_R$ is Reynolds number, $\nu$ is the dynamic viscosity of water, g is gravity force, $v_r$ is the velocity, d is the diameter, $\rho_t$ is the true density and $V$ is the fruit volume and $A_p$is projected area.

**Results and Discussion**

A summary of the physical, mechanical and hydrodynamic properties of *Ghavami, Nasiry* and

*Table1.*Some engineering properties of three Iranian apricot fruits

| Properties | Varieties | | | Significant level |
|---|---|---|---|---|
| | *Nasiry* | *Ghavami* | *Rajabali* | |
| L(mm) | 36.94 $\pm$ 2.16 | 41.21 $\pm$ 1.87 | 48.51 $\pm$ 3.72 | ** |
| W(mm) | 35.45 $\pm$ 2.05 | 34.11 $\pm$ 1.99 | 43.32 $\pm$ 3.12 | ** |
| T(mm) | 34.16 $\pm$ 1.94 | 31.65 $\pm$ 1.63 | 40.84 $\pm$ 2.72 | ** |
| M(g) | 25.56 $\pm$ 3.91 | 27.71 $\pm$ 3.19 | 53.69 $\pm$ 8.96 | ** |
| V($cm^3$) | 23.30 $\pm$ 3.92 | 26.20 $\pm$ 3.24 | 45.60 $\pm$ 9.49 | ** |
| Dg(mm) | 34.89 $\pm$ 1.91 | 35.42 $\pm$ 1.52 | 44.09 $\pm$ 2.82 | ** |
| Φ(-) | 0.94 $\pm$ 0.01 | 0.84 $\pm$ 0.02 | 0.91 $\pm$ 0.03 | ** |
| S($mm^2$) | 3900.10 $\pm$ 428.79 | 3884.62 $\pm$ 338.70 | 6109.42 $\pm$ 774.57 | ** |
| $PA_1$ ($mm^2$) | 1022.59 $\pm$ 77.72 | 1206.77 $\pm$ 83.04 | 1868.23 $\pm$ 193.69 | ** |
| $PA_2$ ($mm^2$) | 984.19 $\pm$ 100.41 | 1144.70 $\pm$ 84.43 | 1797.11 $\pm$ 181.10 | ** |
| $PA_3$ ($mm^2$) | 899.05 $\pm$ 83.27 | 915.13 $\pm$ 82.49 | 1555.69 $\pm$ 159.20 | ** |
| CPA($mm^2$) | 912.26 $\pm$ 84.11 | 1088.86 $\pm$ 79.97 | 1740.34 $\pm$ 174.24 | ** |
| $\rho_b$ ($kg\ m^{-3}$) | 590.15 $\pm$ 31.19 | 677.78 $\pm$ 9.22 | 716.47 $\pm$ 3.25 | ** |
| $\rho_t$ ($kg\ m^{-3}$) | 1085.56 $\pm$ 70.76 | 1045.07 $\pm$ 65.91 | 1191.11 $\pm$ 92.89 | ** |
| ε (%) | 45.46 $\pm$ 2.70 | 36.07 $\pm$ 0.95 | 37.41 $\pm$ 0.61 | ** |
| λ(-) | 0.65 $\pm$ 0.005 | 0.74 $\pm$ 0.01 | 0.72 $\pm$ 0.01 | ** |
| E (MPa) | 0.32 $\pm$ 0.06 | 0.51 $\pm$ 0.11 | 0.53 $\pm$ 0.11 | ** |
| $V_t$ ($ms^{-1}$) | 0.17 $\pm$ 0.01 | 0.17 $\pm$ 0.01 | 0.21 $\pm$ 0.01 | ** |
| $T_d$ (s) | 6.07 $\pm$ 0.89 | 6.07 $\pm$ 0.61 | 5.22 $\pm$ 0.34 | ** |
| $F_b$ (N) | 0.21 $\pm$ 0.02 | 0.26 $\pm$ 0.02 | 0.49 $\pm$ 0.08 | ** |
| $F_d$ (N) | 0.01 $\pm$ 0.003 | 0.02 $\pm$ 0.01 | 0.08 $\pm$ 0.03 | ** |

*Rajabali* cultivars is shown in Table1. These properties were found at specific fruit moisture contents of cultivars (*Ghavami, Nasiry* and *Rajabali*) at 79.84, 79.61 and 84.17%wd, respectively. Knowing these moisture content values is helpful in analyzing the convective dehydration of apricot as suggested by Ochao et al., (2007);who reported that during convective dehydration of whole apricots, both volume and surface area changes are independent of operating conditions in the tested range, and are related only to the moisture content of the partially dehydrated fruit. As seen in Table 1, all properties which were considered in the current study were found to be statistically significant at 1% probability level. According to these results the greatest dimensional characteristics were found for *Rajabali* cultivar with means of 48.51, 43.32 and 40,84 mm length, width and thickness, respectively, whereas these values were 41.21, 34.11, 31.65 mm and 36.94, 35.45 and 34.16 mm for *Ghavami* and *Nasiry* varieties, respectively. To design a mechanism for mechanical harvesting of apricot *(Hacthaliloglu L.)*, Erodgan et al., (2003); reported length, width and thickness of the fruit as 40.92, 38.94 and 35.21 mm, respectively. The axial dimensions are important indetermining aperture size of machines, particularly in separation of materials and these dimensions may be useful in estimating the size of machine components. The major axis has been found to be useful by indicating the natural rest position of the material and hence in the application of compressive force to induce mechanical rupture.

The highest geometric mean diameter value was found for *Rajabali* variety with means of 44.09 mm, whereas this value was 35.42 and 34.89 mm for *Ghavami* and *Nasiry* varieties, respectively. The knowledge related to geometric mean diameter would be valuable in designing the grading process. In a study conducted by Jannatizadeh et al., (2008); the highest geometric mean diameter for apricot was obtained as 45.27 mm. The volume of the *Rajabali* cultivar (45.60 $cm^3$) was significantly greater than that of the other ones. The volume values of the *Ghavami* and *Nasiry* were 26.20 and 23.30 $cm^3$ , respectively. Considering the latter result, it is clear that a large number of *Nasiry* fruits could be packed in the predetermined volume compared with the other cultivars. Sphericity values differed significantly among the tested cultivars. The latter property values were 0.91, 0.84 and 0.94 for *Rajabali*, *Ghavami* and *Nasiry,* respectively. The mass of the *Rajabali* cultivar (53.69 g) was significantly greater than that of the other ones. The mass values of the *Ghavami* and *Nasiry* were 27.71 and 25.56 g, respectively. When the fruit mass in this study was compared with previous studies, the mean mass of the *Rajabali* (53.69 g) cultivar was greater than that of the mixed varieties of *Zerdali, Cataloglu, Hacithaliloglu, Hasanbey, Soganci* and *Kabaasi*, 41.48 g (Haciseferogullari et al., 2006). This property may be useful in the separation and transportation of the fruit by hydrodynamic method. The surface area of the *Rajabali* cultivar (6109.42 $mm^2$) was significantly grater than those of the other studied cultivars. The surface area of the *Ghavami* and *Nasiry* cultivars were 3884.62 and 3900.10 $mm^2$, respectively. These properties could be beneficial in proper prediction drying rates and hence drying time in the dryer.

The highest $PA_1$, $PA_2$and $PA_3$values were for *Rajabali* cultivar, with mean of 1868.23, 1797.11 and 1555.69 $mm^2$, respectively, whereas these values were 1206.77, 1144.70, 915.13 $mm^2$ and 1022.59, 984.19 and 899.05 $mm^2$ for *Ghavami* and *Nasiry* varieties, respectively. The results for the projected area are due to the differences in value of dimensional characteristic. The criteria projected area of *Rajabali* cultivar was significantly greater than that of the other ones. According to the results, the mean true density values for *Rajabali*, *Ghavami* and *Nasiry* were 1191.11, 1045.07 and 1085.56 kg $m^{-3}$ , respectively. Also, the mean bulk density values for *Rajabali*, *Ghavami* and *Nasiry* were 716.47, 677.78 and 590.15 kg $m^{-3}$ , respectively. Hence the mean values porosity values for *Rajabali*, *Ghavami* and *Nasiry* were 37.41, 36.07 and 45.46 %, respectively. The Packing coefficient of the apricot fruits resulted in different means, varying from 0.65 (*Nasiry*) to 0.72 (*Rajabali*). Having any information about Packing coefficient of apricot could result in efficient control of fruit quality during storage .According to the results, the highest modulus of elasticity value was found for *Rajabali* variety with means of 0.53MPa, whereas this value was 0.51 and 0.32MPa for *Ghavami* and *Nasiry* varieties, respectively. The knowledge related to this property would be valuable in transportation for decreasing the damage and post harvest process.

Terminal velocity of *Rajabali*, *Ghavami* and *Nasiry* cultivars was found to be 0.21, 0.17 and 0.17 $ms^{-1}$ , respectively. The similar research was conducted by Kheiralipour (2008); he concluded 0.42 $ms^{-1}$ as coming up terminal velocity for apple (Var. *Delbarstival*). As seen *Rajabali*, *Ghavami* and *Nasiry* cultivars have 5.22, 6.07 and 6.07 s as dropping time. Logically, would be concluded that with decreasing terminal velocity, the dropping time of apricots increased. Finally, the bouncy and drag force were 0.49 and 0.08 N for *Rajabali* variety, 0.26 and 0.02 N for *Ghavami* variety and 0.21 and 0.01 N for *Nasiry* variety, respectively. These data can be used to modeling terminal velocity and dropping time of apricots, because to reach the terminal velocity, two drag and bouncy forces must be in balance with weight of apricots. Having any information about latter properties is important in hydro sorting mechanisms.

## Conclusions

Some physical properties of *Ghavami, Nasiry* and *Rajabali* apricot varieties are presented in this study. From this study it can be concluded that:

The highest and the lowest of length, geometric mean diameter, volume and mass were obtained for *Rajabali* and *Nasiry* cultivars, respectively.

The highest and the lowest of width, thickness and surface area obtained for *Rajabali* and *Ghavami* cultivars, respectively. The criteria projected area of each apricot cultivar resulted in difference means, varying from 912.26 to 1740.34 $mm^2$. The highest and the lowest of modulus of elasticity were found for *Rajabali* and *Nasiry* cultivars, with means of 0.32 and 0.53 MPa, respectively. The highest and the lowest values for the terminal velocity and dropping time were found for *Rajabali* cultivar, with means of 0.21 $ms^{-1}$ and 5.22s, respectively. The greatest values for the bouncy and drag forces were found for *Rajabali* cultivar.

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**References**

AOAC (1984) Official Methods of Analysis. Association of Official Analytical Chemists Press, Washington, DC

Beyer M, Hahn R, Peschel S, Harz M, Knoche A (2002) Analyzing fruit shape in sweet cherry (Prunus avium L.). Sci Horticulture J 96:139-150

Calisir S, Haciseferogullari H, Ozcan M, Arsalan D (2005) some nutritional and technological properties of wild plum (prunus spp) fruit in turkey. J Food Eng 66:223-237

Crowe CT, Elger DF, Roberson JA (2001) Engineering Fluid Dynamics. 7rd edn. Wiley, New York

Demir F, Ozcan M (2001) Chemical and technological properties of rose (Rosa canina L) fruits grown wild in turkey. J Food Eng 47:333-523

Dewey DH, Stout BA, Matthews RW, Bekker-Arkema FW (1966) Developing of hydro-handling system for sorting and sizing apples for storage in pallet boxes. USDA, Marketing Research Report No: 743 SDT, UDFS

Erodogon D, Guner M, Dursun E, Gezer I (2003) Mechanical harvesting apricots. Biosystem Eng J 85(1):19-28

Gezer I, Acaroglu M, Haciseferogullari H (2003) Use of energy and labor in apricot agriculture in turkey. Biomass and Bio energy J 24:215-219

Gezer I, Atay S, Aydemir E (2002) Structural Situation and Mechanization Properties Apricot Farms in Malatya Region. Paper presented VIIIth International congress on Mechanization and Energy in Agriculture, Kusadasi, Turkey

Haciseferogullari H, Gezer I, Ozcan M, Murutasma B (2007) Post harvest chemical and physical-mechanical properties of some apricot varieties cultivated in Turkey. J Food Eng 79:364-373

Janatizadeh A, Naderi Boldaji M , Fatahi R, Ghasemi Varnamkhasti M, Tbatabaeefar A (2008) Some Post harvest Physical Properties of Iranian apricot fruit. Int. agrophysics 22:356-363

Kheiralipour K (2008) Determination of terminal velocities of two apple varieties (cv; Redspar and Delbarstival) using water column. M.Sc Thesis, University of Tehran, Iran

Khodabandehloo H (1999) Physical properties of Iranian export apples. M.Sc Thesis, University of Tehran, Iran

Matthews RW, Stout BA, Dewey DD, Bekker-Arkema FW (1965) Hydro handling of apple fruits. Trans ASAE 28(3):65-130

Mohsenin NN (1986) Physical properties of Plant and Animal Materials. Gordon and Breach , New York

O˙Brien N, Gentry J, Gibson R (1965) Vibration Characteristics of fruit as related toyn-transitynijury. Trans ASAE 32(7):241-243

Ochao MR, Kesseler AG, Pirone BN, Marqez CA, De Michelis A (2007) Analysis of shrinkage phenomenon of whole sweet cherry fruits (prunus cerasus) during convective dehydration with very simple model .J Food Eng 79:657-661

Ōzbek S (1978) Special Horticulture .C.U.Faculty of Agriculture no.128, Adana, Turkey

Peleg K, Ramraz Y (1975) Optimal sizing of citrus fruit. Trans ASAE 18 (6):1035–1039

Peschel S,Franke R,Schreiber L, Knoche M (2007) Composition of cuticle of developing cherry fruit. Phytochemistry J 68:1017-1025

Schmidt H, Vittrup Christensen J,Watkins R, Smith RA (1995) Cherry descriptors. ECSC, EEC, EAEC, Brussels, Lux and Int Board. Plant Gen Res, Rome, Italy p:23

Tabatabaeefar A, Rajabipour A (2005) Modeling the mass of apples by geometrical attributes. Sci Horticulturae J 105:373–382

Topuz A, Topakci M, Canakci M, Akinci I, Ozdemir F (2004) Physical and nutritional properties of for orange varieties. J Food Eng 66:519-336

USDA (2004) Economic Research Service (ERS). Food Consumption (per capita) Data System.Available at:spx

Vanoni VA (1975) Sedimentation Engineering. ASCE, Manual 54, NY, ASCE, New York

Yildiz F (1994) new technologies in apricot processing. J standard, Apricot Special Issue, Ankara pp8: 67-69