

Post Harvest Physical and Nutritional Properties of Two Apple Varieties

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Abstract

In this research, physical and nutritional properties of two Iranian apple varieties (Golab Kohanz, Shafi Abadi) were determined and compared. The physical properties were average fruit length, width and thickness, geometric, arithmetic and equivalent mean diameters, projected area, surface area, sphericity index, aspect ratio, fruit mass, volume, bulk and fruit densities and coefficient of static friction and the nutritional properties were PH, titratable acidity and total soluble solids. Average moisture content of the Golab Kohanz (GK) and Shafi Abadi (SA) varieties were 86% and 84% (w.b.), respectively. Based on statistical analysis, the properties were statistically different at 1% and 5% levels of significance for both varieties. However, the differences between the two studied varieties in the case of the aspect ratio, coefficient of static friction on various surfaces and PH were not significant ($P>0.05$).

Keywords: Physical properties, Nutritional properties, Golab Kohanz, Shafi Abadi

1. Introduction

Fruits are attractive and nutritional foods, because of their colour, shape, unique taste and smell, and rich in minerals, vitamins and other beneficial components (Cassano *et al.*, 2003). Apple is a tree and its pomaceous fruit, of species *Malus domestica* Borkh in the rose family *Rosaceae*, is one of the most widely cultivated tree fruits. There are more than 7500 known cultivars of apples (Dobrzański *et al.*, 2006). Iran, with 190000 ha of cultivation area (2.8% of the world production area) is among the world's top apple producers. In spite of 2.66 million tons of annual Iranian apple production, exportation of that is low (FAO, 2007). One of the most important problems preventing export from increasing is loss of post-harvest operations. Grading and sizing of fruit is a prerequisite to proper packaging, but not much importance has been attached to its study (ICRI, 2005). There does not exist any suitable set of standards for grading and sorting of the fruit in Iran (Sharifi *et al.*, 2007). There only exists a rough grading manual of not much scientific value, as reported through some publications of Iran Standard and Industrial Research Institute, ISIRI (WSFV, 1999 and SWFV, 2002). To design a machine for handling, cleaning, conveying and storage, the physical properties of agricultural products must be known.

Physical characteristics of agricultural products are the most important parameters for determination of proper standards of design of grading, conveying, processing, and packaging systems (Tabatabaeefar and Rajabipour, 2005). Among these physical characteristics, mass, volume, projected area, and centre of gravity are the most important ones in determining sizing systems (Khodabandehloo, 1999; Peleg and Ramraj, 1975). 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 (Beyer *et al.*, 2002; Schmidt *et al.*, 1995). Quality differences in fruits can often be detected by differences in density. When fruits are transported hydraulically, the design fluid velocities are 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. Awareness of fruit surface area would be useful in determination of mass of the cuticular membrane per unit fruit surface area (Peschel *et al.*, 2007). Determining a relationship between mass, dimensions and projected areas is useful and applicable in weight sizing (Wright *et al.*, 1986). Safwat and Moustafa (1971) studied theoretically and predicted the volume, surface area and centre of gravity of different agricultural products. Safa *et al.* (2003) and Al-Maiman *et al.* (2002) studied the physical properties of pomegranate and found models of predicting fruit mass while employing dimensions, volume and surface areas. Topuz *et al.* (2004) studied the physical and nutritional properties of four varieties of orange. They presented their report on dimensions, volume, mean geometrical diameter, surface area, fruit density, pile density, porosity, packaging coefficient, and friction coefficient. Owolarafe *et al.* (2006) investigated the physical properties of two varieties of palm fruit useful in production of palm oil and palm kernel. Several physical and hydrodynamic properties of two apple varieties (Redspar and Delbarstival), newly planted varieties in Iran, were determined and compared by kheiralipour *et al.* (2008). Ozturk *et al.* (2009) studied some chemical and physico-mechanical properties of pear cultivars (Deveci and Santa Maria). Review of the literature showed that physical and nutritional properties of two Iranian apple varieties of Golab Kohanz and Shafi Abadi have not been determined. These properties are necessary for the design of equipments for harvesting, processing, transporting, sorting, separating and packing. Therefore, in this study the physical properties, namely, average fruit length, width and thickness, geometric, arithmetic and equivalent mean diameters, projected area, surface area, sphericity index, aspect ratio, fruit mass, volume, bulk and fruit densities and coefficient of static friction on various surfaces (galvanized steel, plywood and glass) and nutritional properties such as PH, TA and TSS, of the two apple varieties were determined and compared.

2. Materials and methods

2.1 Material

Two Iranian apple varieties (Golab Kohanz, Shafi Abadi) were prepared in 2009 summer season from an orchard located at the Horticultural Research Center, Agricultural Faculty, University of Tehran, Karaj, Iran. GK and SA are premature and middle maturing varieties, respectively. The experiments were carried out during the period of July–August in 2009. The fruits were harvested carefully by hand at their commercial maturity stage and transferred to the laboratory in plastic bags to reduce water loss during transport. The fruits were cleaned to remove all foreign matters such as dust, dirt and chaff as well as immature and damaged fruits. The analysis was carried out at a room temperature of 23°C. All tests were carried out in the Biophysical and Biological laboratory of the University of Tehran, Karaj, Iran.

2.2 Methods

2.2.1 Chemical analysis

The nutritional composition of the apple fruits juice was studied as explained below:

PH value was measured using a Macroprocessor PH meter (iHANNA pH211, Made in Italy). The total titratable acidity was determined by titration with sodium hydroxide (0.1 N) and expressed as a percent of malic acid (AOAC, 1984). Total soluble solid contents (TSS) were determined by extracting and mixing two drops of juice from the two cut ends of each fruit into a digital refractometer (Neerveld 14-B22550, GETI, Belgium) at 22°C and the result expressed as Brix (Ozturk *et al.*, 2009).

2.2.2 Physical analysis

The physical properties of the two apple varieties were determined by the following methods:

100 apples from each variety were taken as study sample. The initial moisture contents of the fruits were determined using the oven dry method, at 77°C for 10 days (kheiralipour *et al.*, 2008). The initial moisture contents of GK and SA varieties were 86% and 84% (w.b.), respectively.

To determine the average size of the fruits, three linear dimensions, namely length (L); equivalent distance of the

stem (top) to the calyx (bottom), width (W); the longest dimension perpendicular to L, and thickness (T); the longest dimension perpendicular to L and W, (Fig. 1), were measured by using a digital caliper with accuracy of 0.01 mm. The fruit mass was determined with an electronic balance of 0.1 g accuracy. The geometric mean, equivalent and arithmetic diameters were calculated using the following equation (Mohsenin, 1986):

$$D_g = \sqrt[3]{LWT} \quad (2)$$

$$D_p = \left[L \frac{(W+T)^2}{4} \right]^{1/3} \quad (3)$$

$$D_a = \left(\frac{L+W+T}{3} \right) \quad (4)$$

where: D_g is geometric mean diameter, D_p is equivalent diameter, D_a is arithmetic diameter, L, W and T are linear dimensions of fruit (all in mm).

The sphericity, S_p (%), defined as the ratio of surface area of a sphere having the same volume as that of fruit to the surface area of the fruit, was determined using the following formula (Mohsenin, 1986):

$$S_p = \frac{(LWT)^{1/3}}{W} \times 100 \quad (5)$$

The surface area of the fruit was calculated using the following formula (Mohsenin, 1986):

$$S = \pi(D_g)^2 \quad (6)$$

where: S is surface area (mm^2).

The aspect ratio, R_a was calculated as (Omobuwajo *et al.*, 1999):

$$R_a = \frac{L}{W} \quad (7)$$

In order to figure out fruit volume, a container filled with water was placed on the balance and the displaced water caused by the floated fruit was calculated. Toluene (C_7H_8) was used, rather than water, because water is absorbed by the fruits (Mohsenin, 1986; Sitkei, 1986):

$$\text{volume}(\text{cm}^3) = \frac{\text{displaced water}(\text{g})}{\text{water density}(\text{gcm}^{-3})} \quad (8)$$

Fruit density was obtained as:

$$\varphi_f = \frac{M}{V} \quad (9)$$

where: φ_f is fruit density (g cm^{-3}), M is fruit mass (g), V is fruit volume (cm^3) (Mohsenin, 1986).

Bulk density was obtained as:

$$\varphi_b = \frac{M_f}{V_c} \quad (10)$$

where: φ_b is apparent density (g cm^{-3}), M_f is fruits mass (g), V_c is fruits carton volume (cm^3) (Mohsenin, 1986).

Porosity was obtained as:

$$P = \frac{V_c - V_o}{V_c} \times 100 \quad (11)$$

where: P is porosity and V_o is true volume of apples present in the carton.

Coefficient of packaging was obtained as (Topuz *et al.*, 2005):

$$\lambda = \frac{V_o}{V_c} \quad (12)$$

where: V_o is volume of fruit present in the carton (cm^3) and V_c is volume of the carton (cm^3).

The coefficients of static friction on three different frictional surfaces, namely steel, plywood, and glass were measured for apple fruits using the inclined plate method (Al-Maiman and Ahmad, 2002). The friction tests were replicated three times for each surface. The coefficient of static friction was calculated from the following equation:

$$\mu_s = \tan \theta \quad (13)$$

Where: μ_s is the coefficient of friction and θ is the tilt angle of the friction device.

Projected area P_L (area perpendicular to diameter L), P_W (area perpendicular to diameter W) and P_T (area perpendicular to diameter T) of each apple were recorded with an accuracy of 0.05 mm using a device with Win Area-UT-06 soft ware (Mirasheh, 2006). The device (Fig. 2) is composed of the following:

1. Sony camera, model CCD-TRV225E.
2. Light chamber, an assembly constructed to provide an environment for taking photos of the desired quality.
3. Capture card Win Fast, model DV 2000.
4. Software, written in Visual Basic 6.0.

The basic operating principle of this equipment set is using 'image processing'. Light emitting chamber is so designed as to emit light from behind the fruit. The equipment set is, as a whole, composed of the three different basic sections of light source, diffuser, and camera holding stand. The function of the light source (4, 20W lamps) is to emit light to the bottom section of the diffuser. The diffuser task is to diffuse light at its Owen level. The overall operation of the equipment set is as follows:

The image coming from the camera is transferred to the capture card.

The function of the card is to change the analogue image into a digital one.

The digitized image is transmitted to the image processing window by computer software.

The equipment set, through the processing of 3 orthogonal images of the fruit, determines the large, medium, and small diameters together with the areas along these diameters. The outcome is presented in the display window. The equipment error for objects that occupy at least 5% of the viewing scope of the camera is below 2%.

All data were subjected to statistical analysis using the analysis of variance (ANOVA) test, and means were compared using Duncan's multiple range tests at 5% level of significance.

3. Result and discussion

A summary of the physical and nutritional properties of Golab Kohanz and Shafi Abadi cultivars is shown in table 1. As seen in Table 1, many physical properties of the apple varieties were found to be statistically significant at different probability levels (5% and 1%), with the exception that the aspect ratio, PH and coefficient of static friction on the all surfaces were found to be insignificance. These significant and insignificance findings could be the result of the individual properties of apple varieties, and environmental and cultivation conditions. The moisture contents were 86% and 84% (w.b.), for GK and SA varieties, respectively.

According to the results, for GK variety the mean fruit length, width, and thickness were respectively 51.56, 54.86 and 53.03 mm, whereas the corresponding values for the SA variety were 53.09, 59.37 and 57.02 mm. Based on the results of Duncan's multiple range tests, the dimensions of the two apple varieties were significantly different ($p < 0.01$). The SA variety is bigger than GK variety in the all dimensions, therefore, is better using plates with bigger hole size in grading machine of SA variety. Kheiralipour *et al.*, (2008), studied two different common commercial export varieties of Iranian apples (Redspar and Delbarstival). They obtained 74.78, 83.8, and 80.37 mm as the mean fruit length, width and thickness for Redspar and 58.31, 67 and 65.04 mm for Delbarstival, respectively. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin (1986). The geometric, equivalent and arithmetic mean diameter of GK and SA apples were 53.11, 53.12, 53.15 mm for GK and 56.41, 56.42, 56.49 mm for SA variety, respectively (significant difference, $p < 0.01$). These results confirm SA variety is bigger than GK variety.

There was significant difference in 1% statistically level between GK and SA varieties for projected areas and surface area. The mean projected areas perpendicular to length, width, and thickness were obtained as 2305.87, 2232.77 and 2300.17 mm² for GK variety and 2912, 2798.74, 2862.88 mm² for SA variety, respectively. It was found the projected area, perpendicular to length, has higher values than of other projected areas in each two varieties also were obtained that mean projected areas perpendicular to each three orientation for SA is greater than GK variety. The mean surface area resulted 8902.1, 10041.8 mm² for GK and SA varieties, respectively. These results in comparison with studies of Tabatabaefar and Rajabipour, (2005) showed that a mixed of varieties of Red Delicious and Golden Delicious is greater than GK and SA varieties in projected and surface areas. Fruits mass were obtained 64.22 and 75.67 g for GK and SA varieties, respectively (significant difference, P<0.01). The average fruit mass of the SA variety is higher than the GK variety. The volume and fruit density and bulk density were obtained 82.8 cm³, 0.77 and 0.46 g cm⁻³ for GK variety, respectively. The corresponding values for SA variety were 99.94 cm³, 0.75 and 0.52 g cm⁻³, respectively. There were significant differences for volume, fruit density (P<0.01) and bulk density (P<0.05). The volume and density of SA variety is more than the GK variety. In comparison with results of Kheiralipour *et al.* (2008) on Redspar and Delbarstival varieties, mass, volume and density of GK and SA varieties are lower than those values. Quality of food materials can be assessed by measuring their densities. Density data of foods are required in separation processes, such as centrifugation and sedimentation and in pneumatic and hydraulic transport of powders and particulates (Sahin and Gülüm Sumnu, 2006). The packaging coefficient was 0.6 and 0.68 for GK and SA varieties, respectively (significant difference, P<0.05). Against of Topuz *et al.* (2004) results, in this study the packing coefficient increased with increased fruit volume. This result is due to shape and size of fruits or large volume range for SA variety (57.14-165.33 cm³) than GK variety (58.93-128.34 cm³), on the other hand the small fruits filled the vacancy among big fruits. Sphericity and aspect ratio of apple cultivars were 0.96% and 0.96 for GK variety and 0.95% and 0.96 for SA variety, respectively. Based on table 1 there was significant difference for sphericity (p<0.05) whereas there was insignificance difference in aspect ratio between GK and SA varieties. Sphericity is an expression of a shape of a solid relative to that of a sphere of the same volume while the aspect ratio relates the width to the length of the fruit which is an indicative of its tendency toward being oblong in shape (Omobuwajo *et al.*, 2000). This result indicates that GK variety has a higher tendency to have its shape towards a sphere than the SA variety. The high sphericity of the apple fruit is indicative of the tendency of the shape towards a sphere. Taken along with the high aspect ratio of 0.96, it may be indicated that the apple fruit will rather roll than slide on a flat surface. However, the aspect ratio value is being close to the sphericity values may also mean the apple fruit will undergo a combination of rolling and sliding action on a flat surface. Porosity of GK and SA was 39.95% and 31.82%, respectively. The lower porosity or percentage volume of voids in the SA and GK varieties may be due to the higher sphericity and aspect ratio. The coefficient of static friction of the GK variety was 0.55 on plywood, 0.52 on galvanized steel and 0.48 on a glass surface. The coefficient of static function of the SA variety was 0.5 on plywood, 0.48 on galvanized steel and 0.46 on glass surface, respectively. There was no significant difference in the coefficient of friction on all surfaces. The highest coefficient of static friction was obtained on plywood and the lowest of that was found over glass surface for the two varieties. This is due to the frictional properties between the fruits and surface materials. In comparison with the other fruit specie, the static friction of apple was higher than those orange (Sharifi *et al.*, 2007) and date fruits (Keramat Jahromi *et al.*, 2006). Total soluble solids, pH and titratable acidity of two apple varieties are shown in Table 1. There was significant difference between apple varieties in TSS and TA (p<0.01). In the case of the PH, as shown in table 1, there were no significant differences between the studied varieties. For the GK variety, the average values of the TSS, TA and PH were 8.75%, 0.013 and 3.9 and the corresponding values for the SA variety were 11.1%, 0.026 and 3.65, respectively. The variation of TSS, TA and pH in apple fruits could be result of varieties and the effect of different environmental conditions where the varieties grown. These physical and nutritional results should be considered in the harvesting, handling and processing of apple.

4. Conclusions

Some physical properties of Golab Kohanz and Shafi Abadi apple varieties are presented in this study. From this study it can be concluded that:

1. The values of all the nutritional properties of apple juices, except pH, were statistically different with respect to the varieties and TSS and TA for Shafi Abadi variety were more than Golab kohanz variety as a result Shafi Abadi Variety is tarter than Golab Kohanz variety.
2. For Shafi Abadi variety, length, width and thickness values were larger than those of Golab Kohanz variety, by 3%, 8%, and 7%, respectively. These results indicated that Shafi Abadi variety has generally bigger size than Golab Kohanz variety, also width value (W) is biggest diameter in all varieties.

3. It was observed that surface area and projected area values of Shafī Abadi variety are greater than those values of Golab Kohanz variety. The sphericity and aspect ratio values for the Golab Kohanz variety are lower than those values for Shafī Abadi variety, by 3% and 5.7%, respectively.
4. These data are valuable for packing task of apples. The mass values of both varieties had a 15% difference. There were significant differences between the fruit density and bulk density of the cultivars studied.

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Table 1. Several physical and nutritional properties of the two apple varieties (Golab Kohanz, Shafi Abadi)

Properties	No. observations	Shafi Abadi			Golab Kohanz			Significant level
		Max	Min	Mean±SD	Max	Min	Mean±SD	
Moisture, %w.b	3	84.7	83.5	83.9±0.7 ^b	86	84.94	85.61±0.58 ^a	*
Fruit mass, (g)	100	123.1	44.11	75.67±14.42 ^a	97.33	46.61	64.22±13.2 ^b	*
Fruit length, (mm)	100	62.77	43.05	53.09±3.86 ^a	60.32	44.41	51.56±3.82 ^b	*
Fruit width, (mm)	100	71.6	51.8	59.37±3.83 ^a	64.28	48.85	54.86±3.83 ^b	*
Fruit thickness, (mm)	100	67.6	46.36	57.02±3.97 ^a	63.76	40.41	53.03±3.98 ^b	*
Projected area, (mm²)								
P _L	100	4191	1969	2912±421.88 ^a	3196	1509	2305.87±327.75 ^b	*
P _W	100	3975	1832	2798.74±425.17 ^a	3035	1428	2232.77±297.55 ^b	*
P _T	100	4037	1982	2862.9±404.6 ^a	3002	1648	2300.17±310.02 ^b	*
Surface area (mm ²)	100	14197	6920.1	10041.8±1321.2 ^a	12121	7055.6	8902.1±1214.5 ^b	*
Geometric mean diameter, (mm)	100	67.22	46.93	56.41±3.67 ^a	62.11	47.4	53.11±3.58 ^b	*
Equivalent diameter (mm)	100	67.24	46.98	56.43±3.67 ^a	62.11	47.4	53.12±3.58 ^b	*
Arithmetic diameter (mm)	100	67.32	47.07	56.5±3.67 ^a	62.17	47.4	53.15±3.58 ^b	*
Aspect ratio	100	0.99	0.87	0.96±0.02 ^a	0.99	0.71	0.96±0.02 ^a	ns
Fruit volume, cm ³	100	165.33	57.14	99.94±20.03 ^a	128.34	58.93	82.8±17.62 ^b	*
Fruit density (g cm ⁻³)	100	0.87	0.64	0.75±0.02 ^b	0.91	0.71	0.77±0.02 ^a	*
Bulk density (g cm ⁻³)	3	0.54	0.5	0.52±0.01 ^a	0.5	0.44	0.46±0.02 ^b	**
Sphericity (%)	100	0.99	0.88	0.95±0.02 ^b	0.99	0.93	0.96±0.01 ^a	*
Packaging coefficient	3	0.7	0.66	0.68±0.01 ^a	0.63	0.56	0.6±0.03 ^b	**
Porosity (%)	3	33.24	30.47	31.82±1.38 ^b	43.36	36.57	39.95±3.4 ^a	**
Coefficient of static friction								
Galvanized steel	3	0.5	0.46	0.48±0.02 ^a	0.57	0.5	0.52±0.04 ^a	ns
Plywood	3	0.55	0.46	0.5±0.04 ^a	0.6	0.46	0.55±0.07 ^a	ns
Glass	3	0.48	0.42	0.46±0.03 ^a	0.5	0.44	0.48±0.03 ^a	ns
TSS (%)	3	11.3	10.9	11.1±0.2 ^a	9	8.5	8.75±0.25 ^b	*
PH	3	3.85	3.45	3.65±0.2 ^a	4.2	3.6	3.9±0.3 ^a	ns
TA (%)	3	0.027	0.024	0.026±0.001 ^a	0.014	0.012	0.013±0.001 ^b	*

*Corresponding to 1% significance level.

**Corresponding to 5% significance level.

ns: Corresponding to no significant difference.

a and b: means followed by different letters are significantly different from others (P<0.05).

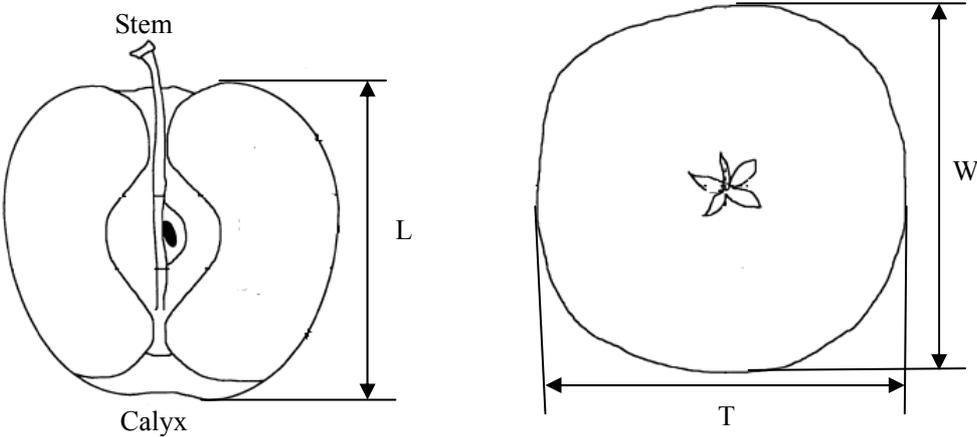


Figure 1. Three major dimensions of apple

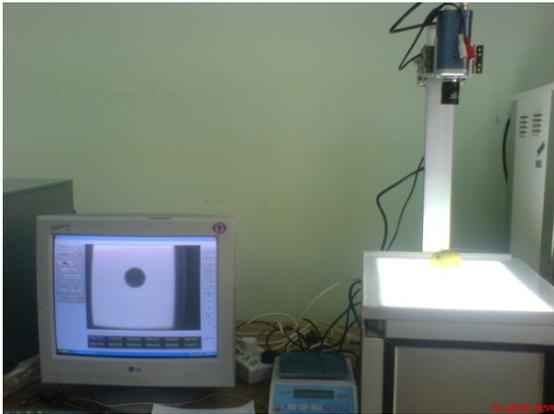


Figure 2. Apparatus used for determining projected areas (Mirasheh, 2006)