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Studying some hydrodynamic properties of Iranian two local apples varieties related to harvest times (Ashegi and Gare Yapraq)

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ABSTRACT

In order to design and manufacturing some postharvest equipment, determination of some hydrodynamic properties of crops are necessary. The quality of products in global and local markets can be increased by applying these properties and receive economical benefits. For these purpose, two local varieties of apples in the East Azerbaijan province, Iran(Asheghi and Gare Yapraq)were selected.Asheghi and Gare Yapraq apples varieties were randomly hand picked in two times (14th and 23th July, 2012) ,and in one time (14th July, 2012) respectively. Then some of their physical and hydrodynamic properties such as mass, density, volume, projected area, terminal velocity, drag, bouncy and gravity forces were studied. The mean values of mass of fruit, density, volume, projected area, terminal velocity, drag, bouncy and gravity forces of Asheghi variety for first harvest time, were 47.57 gr, 773.23 kg m^{-3} , 61.71 cm^3, 32.23 cm^2 ,0.40 m s^{-1}, 0.12 N , 0.61 N, 0.42 N and for second harvest time, 58.82 gr , 765.81 kg m^{-3}, 77.06 cm^3, 25.80 cm^2, 0.43 m s^{-1}, 0.11 N, 0.76 N, 0.52 N respectively. The corresponding value for Gare Yapraq variety were obtained as 66.42 gr, 712.67 kg m^{-3} , 93.43 cm^3, 45.38 cm^2, 0.52 m s^{-1}, 0.29 N, 0.92 N, 0.60 N respectively.

Keyword: Apple, Hydrodynamic properties, Terminal velocity, Drag force, Bouncy force

INTRODUCTION

Apple is a fruit tree that is cultivated in different parts of the world. It has a good flavor, aroma, and one of the most nutritious fruits that contain high amounts of minerals and vitamins that human body needs them. It is consumed in different forms, such as fresh fruit, concentrated juice or thin dried slices. Among all the fruits produced in Iran, apple is the most important economical and industrial fruit (Meisami-asl et al, 2009). Although Iran is ranked 8th (1.66 million ton) among the apple producing countries of the world, but the amount of export is low (Anonymous, 2010). Apples which transported to global market, needs some principles and necessary standards for harvesting, grading, packing and handling. One of the major causes of low export, the high loss in post-harvest operations, differences in shape, size, and lack of appropriate packaging qualities (Gorji Chakespari et al, 2010). To design a machine for handling, separation, and transporting of fruits and vegetables, including potatoes, apples, cherries, tomatoes and citrus fruits by water at the packing stations and processing plants, some of the physical and

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hydrodynamic properties of agricultural products must be known (Edgar and Calycome, 1957; Pflug and levin, 1961; Stout et al, 1966). Physical properties of agricultural products are one of the most important parameters in designing of grading, conveying, processing and packaging systems. Hydrodynamic properties are very important characters in hydraulic transport and handling as well as hydraulic sorting of agricultural products. The fruit sorting is to use the terminal velocity of fruit moving in a fluid that has a density above or below the fruit density. Fruit with different terminal velocities will reach different depths after flowing a fixed distance in a flume and may be separated by suitably placed dividers (Jordan and Clerk, 2004; Matthews et al, 1965; Dewey et al, 1966).
To provide basic essential data which are necessary to developed the equipment for sorting and sizing fruits needed to determine several properties of fruits such as: mass, volume, density, projected area, terminal velocity of that (Matthews et al, 1965; Dewey et al, 1966; Khodabandehloo, 1999). There were several studies conducted on the physical and hydrodynamic properties of different varieties of crops in different parts of Iran and other countries (Khodabandehloo, 1999; Mirzaee et al, 2009;Kheiralipour and Tabatabaeefar,2008; Saracoglu and Ozarslan, 2011;Ozturk et al,2010;Jannatizadeh et al, 2008; Jordan and Clerk, 2004).While a few studies have been done on local products and there is a little information available on their properties. The aim of this study was to determine the hydrodynamic properties such as terminal velocity, drag, bouncy, gravity forces of two apple varieties in East Azerbaijan province, Iran (Asheghi and Gare Yapraq). The results provide useful data to be used by engineers in designing of suitable post-harvest equipment such as transport, handling, sorting and sizing machines.Thus providing aquality product in the global market.

Material and Methods

Sample Preparation

Two Apple varietiesnamely, Asheghi and Gare Yapraq, planted in the East Azerbaijan province, Iran, were chosen to studysome of their physical and hydrodynamic properties such as mass,density, volume, projected area, terminal velocity, drag, bouncy and gravity forces. Gare Yapraq is a yellow color variety with medium size, while Asheghi is a red and green variety with small size. These apples have good taste and are known in Tabriz city, Iran. Asheghi apples were randomly hand-picked in two harvest times (14th and 23th July, 2012) from 3 trees in an orchard in Marand located in the East Azerbaijan province, Iran (38° 25.192' N, 45° 49.213' E). Also Gare Yapraq apples were harvested in 14th July, 2012from an orchard in Marand (38° 24.605' N, 45° 50.633' E).
Samples of 30-35 fruits of each harvested variety and each tree were transferred to the laboratory in nylon bags. All of the fruits were placed in refrigerator at 4°C until to be used. About 18% of the samples were selected, to study some hydrodynamic and physical properties; all of the tests were carried out at 25°C in the Biophysical Laboratory of University of Tabriz, Iran.

Physical Characteristics

In order to obtain required parameters for determining hydrodynamic properties, some physical properties such as mass, density, volume and projected area ofapples was needed.
The mass of each apple was measured with an electronic balance (MitutoyoAE310F00775) of ± 0.01 gr accuracy.

Apple volume was determined by the plat form scale method and the true density of the fruit was obtained by the ratio of weight to volume (Mohsenin, 1986).

Also, apples picture was taken by digital CCD camera (Proline Uk, model PR-565,Resolution 480TVL). 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 MATLAB and criteria projected area (CPA) is defined (Mohsenin, 1986).

$$CPA = (PA_1+PA_2+PA_3)/3$$

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

Hydrodynamic Characteristics

To determine some hydrodynamic properties of apples, a 1000 × 500 × 500 mm^3 glued glass column was constructed (Figure1). The column was filled with tap water to a height of about 90cm. Each fruit was placed on the bottom of the column and then released. A digital camera, Canon with 50 frames per second, recorded the movement of fruits from releasing point to the top of the water column, simultaneously video to frame software was used to convert the video film to individual images and subsequently, to calculate coming up times and terminal velocities of fruits by knowing the fact that each picture takes 0.02 s.
Considering apples in water, the forces acting on the sample will be the gravity force (F_g) acting downward, bouncy force (F_b) acting upward, and drag force (F_d) acting opposite to the direction of motion. These forces were calculated using the following equations (Mohsenin, 1986;Stroshine, 1998):

$$F_g = \rho_p . \frac{g\pi d^3}{6} \quad (1)$$

$$F_D = C_D . A_p . \frac{\rho_f . {v_t}^2}{2} \quad (2)$$

$$F_b = \rho_f . \frac{g\pi d^3}{6} \quad (3)$$

Where,$\rho_p$is density of fruit in $kg\ m^{-3}$, g is gravitational acceleration in $m\ s^{-2}$, $\rho_f$is fluid density in $kg\ m^{-3}$, $d$is fruit geometric diameter in m^3, $C_D$is the dimensionless drag coefficient, $A_p$is projected area of the fruit, which is perpendicular to the direction of motion in m^2 and $v_t$is terminal velocity in ms^{-1}. Drag coefficient, depends on fruit velocity, the type of flow and Reynolds number value, and were calculated from the following relationships (Mohsenin, 1986; Stroshine, 1998):

$$N_R = \frac{v. d}{\nu} \quad (4)$$

$$C_D = \frac{24}{N_R} \text{laminar flow} (N_R < 1) \qquad (5)$$

$$C_D = 0.44 \quad \text{turbulent flow}(N_R > 10^5) \qquad (6)$$

Where N_R Reynolds number, v Kinematics viscosity of water in $m^2\,s^{-1}$ and velocity of the fluid.

All of data were entered in the Microsoft Office Excel and maximum, minimum, mean and standard deviation were reported.

RESULTS AND DISCUSSIONS

Summary of hydrodynamic properties of Asheghi variety, for two harvest times are shown in Tables1 and2, respectively. Similarly, the same parameters for Gare Yapraq variety are shown in Table 3.

The mean values of fruit mass (47.57& 58.82 gr) of the Asheghi variety for first and second harvest time respectively were recorded in this experiment, whereas this value for Gare Yapraq variety was 66.42 gr.According to these results the projected area of A sheghi variety for first harvest time was found with mean 32.23 cm^2, whereas this value for second harvest time of Asheghi variety was 25.80 cm^2.Also the mean projected area of Gare Yapraq 45.38cm^2 obtained. It can be said that Gare Yapraq variety has big size and A sheghi has small size. Kheiralipour et al, (2008) reported the projected area values of Redspar and Delbarstival varietiesas 59.73and 38.95 cm^2, respectively. On the other hand Ozturk et al,(2010)were obtained the mean values of projected area40.65, 45.85 and 49.60 cm^2 for Golden Delicious, Starking Delicious and Granny Smith varieties, respectively.

The true densities of apples were in the ranges of 744.18-794.22kgm^{-3}(Asheghi, at first harvest time), 738.90-787.26kg m^{-3} (Asheghi, at second harvest time)and 694.55-736.23kg m^{-3}(Gare Yapraq).Kheiralipour et al, (2008)reported for Redspar and Delbarstival varieties, mean values837 and 827.91 Kg m^{-3},respectively.

Terminal velocity of Asheghi variety was found to be 0.40 and 0.43 m/s, for first and second harvest time, respectively. Also for Gare Yapraq, terminal velocity was0.52 m/s. The similar researches were conducted by Deweyet al, (1966); Kheiralipour et al, (2008). They concluded 0.53, 0.47 and 0.42 m/s as terminal velocity, for Grani Smith, Redspar and Delbarstival apple varieties.

As seen in tables, the true density of Gare Yapraq variety was less than true density of Asheghivariety. On the other hand, terminal velocity of Gare Yapraq was higher than terminal velocity of Asheghi variety. This variation in terminal velocity, seems be due to differences in projected area and density of the two varieties.So that, the terminal velocity, by decreasing density and increasing projected areawere increased, which were similar to the results obtained by Kheiralipour et al,(2008).They also concluded thatterminal velocity increasedby decreasing true density and increasing geometric mean diameter.

Finally, the mean of drag, bouncy and gravity forces, for the first and second harvest of Asheghi were obtained as 0.12,0.61,0.42 N and 0.11, 0.76, 0.52 N, respectively. Also for Gare Yapraq varietythe mean of drag,bouncy and gravity forces were recorded as 0.29 and 0.92, 0.60 N, respectively. These data can be used in modeling of terminal velocity and coming up time of apples, because to reach the terminal velocity the drag and bouncy forces must be in balance with the weight of apples.

CONCLUSIONS

In this study, some hydrodynamic properties of two apple cultivars were presented. These data may be useful in designing of a specific machine for post-harvest operations.It is recommended that other engineering properties should be measured or calculated to prepare comprehensive information fairly in design parameters. It is suggested for other local varieties such properties to be measured.

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Table 1. Several physical and hydrodynamic properties of Ashghi apple cultivar for first harvest time (14th July, 2012).

Parameters	Max.	Min.	Mean± std.Deviation
Mass of fruit (gr)	66.16	33.5	47.57 ± 11.06
Projected area (cm^2)	43.21	25.27	32.23± 6.16
Volume of fruit (cm^3)	87.55	42.18	61.71 ± 15.15
True density ($kg\ m^{-3}$)	794.22	744.18	773.23 ± 14.96
Terminal velocity ($m\ s^{-1}$)	0.44	0.35	0.40 ± 0.04
Drag force (N)	0.18	0.07	0.12 ± 0.04
Bouncy force (N)	0.86	0.41	0.61 ± 0.15
Gravity force(N)	0.59	0.30	0.42 ± 0.09

Table 2. Several physical and hydrodynamic properties of Ashghi apple cultivar for second harvest time (23th July, 2012).

Parameters	Max.	Min.	Mean±std.Deviation
Mass of fruit (gr)	81.44	31.21	58.82 ± 13.26
Projected area (cm^2)	32.96	16.51	25.80± 4.43
Volume of fruit (cm^3)	107.99	40.10	77.06 ± 18.49
True density (kg m^{-3})	787.26	738.90	765.81 ± 15.41
Terminal velocity (m s^{-1})	0.50	0.38	0.43 ± 0.05
Drag force (N)	0.18	0.05	0.11 ± 0.04
Bouncy force (N)	1.06	0.39	0.76 ± 0.18
Gravity force(N)	0.73	0.28	0.52 ± 0.12

Table 3. Several physical and hydrodynamic properties of Gara Yapraq apple cultivar (14th July, 2012).

Parameters	Max.	Min.	Mean± std.Deviation
Mass of fruit (gr)	81.3	44.91	66.42 ± 14.74
Projected area (cm^2)	53.64	33.61	45.38± 7.90
Volume of fruit (cm^3)	115.53	61.00	93.43 ± 21.53
True density (kg m^{-3})	736.23	694.55	712.67 ± 15.76
Terminal velocity (m s^{-1})	0.58	0.44	0.52 ± 0.08
Drag force (N)	0.40	0.14	0.29 ± 0.12
Bouncy force (N)	1.13	0.60	0.92 ± 0.21
Gravity force(N)	0.75	0.40	0.60 ± 0.14

Figure 1. Water column for determination of hydrodynamic properties. An apple on the bottom of the water column, prepared to be released.