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FULL LENGTH ARTICLE

Aerodynamic separation and cleaning of pomegranate arils from rind and white segments (locular septa)

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Abstract In the process of pomegranate arils pneumatic separation, the aerodynamic characteristics of pomegranate aril, rind and locular septa are essential. The main aim of this study was to measure and compare the aerodynamic characteristics of these materials to provide the data and to facilitate the design and adjustment of machines that perform separation of pomegranate arils from rind and locular septa based on aerodynamic characteristics (terminal velocity, drag coefficient and Reynolds number). To achieve this objective, Ashraf variety pomegranate fruit during its maturity stages was studied. The obtained results showed that the variation in maturity stage significantly influenced the terminal velocity, drag coefficient and Reynolds number ($P < 0.05$). During the fruit maturity, the terminal velocity of locular septa, rind and pomegranate aril increased from 1.05 to 1.16, 3.16 to 3.73 and 5.89 to 6.70 m s^{-1}, respectively. The corresponding value of drag coefficient of the three studied materials decreased from 0.92 to 0.79, 0.75 to 0.59 and 0.53 to 0.36, respectively with advancing fruit maturity. Also these ranges for Reynolds number were 403.24–617.75, 1213.44–1986.37 and 2261.76–3568.02, respectively. Consequently, aerodynamic separation of pomegranate aril from locular septa and rind is theoretically possible if the air velocity value is adjusted according to the terminal velocity of pomegranate aril. Also the obtained equations can be used for calculating the parameters of pomegranate aril movement in pneumatic tunnels or in the design and development of air conveyor and pneumatic separator of pomegranate aril.

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1. Introduction

Pomegranate aril is an important product because of its high nutritional value, delicious taste, excellent flavor and low calories (Holland et al., 2009). In handling and processing of this product in the food industry, often air is used as a carrier for either transport or separating arils from unwanted materials (namely pomegranate rind and white segments separating the arils, locular septa). So the aerodynamic characteristics of pomegranate arils, rind and locular septa such as terminal velocity, drag coefficient and Reynolds number are needed for air conveying and pneumatic separation of materials (Khodabakhshian et al., 2012). For separation purposes, air velocity greater than terminal velocity lifts the particles to allow falling heavy particles, so the air velocity could be adjusted to a point just below the terminal velocity (Mohsenin, 1986; Khodabakhshian et al., 2009).

An analysis of published papers (Mohsenin, 1986; Tabak and Wolf, 1998; Aydin, 2002; Nimkar et al., 2005; Kashaninejad et al., 2006; Gupta et al., 2007; Matouk et al., 2008; Khodabakhshian et al., 2009, 2012; Shahbazi et al., 2014) specifies that aerodynamic characteristics of agricultural materials are affected by their parameters such as species (variety), maturity, ripeness and moisture content. Also, many researchers have reported a linear increase in terminal velocity with increase in moisture content for various food and agricultural produce such as pigeon pea (Sherpherd and Bhardwaj, 1986); soybean (Deshpande et al., 1993), lentil seed (Carman, 1996), hazel nut (Aydin, 2002), almond nut and kernel (Aydin, 2003), moth gram (Nimkar et al., 2005); rice and corn (Matouk et al., 2008); sunflower seed (Khodabakhshian et al., 2009, 2012) and wheat seeds (Shahbazi et al., 2014).

Matouk et al. (2008) found that increasing the grain moisture content tented to an increase on terminal velocity, drag coefficient and Reynolds number of rice, corn, wheat and barley. They showed that the relationship between terminal velocity and moisture content may be described by an exponential model while drag coefficient and Reynolds number increased linearly as the moisture content increased. Khodabakhshian et al. (2012) conducted an experiment to study terminal velocity, drag coefficient and Reynolds number of three varieties of Iranian sunflower seed and its kernel as a function of size and moisture content at three moisture content levels in the range of 3–14% d.b. They stated that terminal velocity and Reynolds number of sunflower seed and its kernel for each three studied varieties and size categories increased and drag coefficient for both seed and kernel decreased with the increase in moisture content.

Literature review showed that despite an extensive research on some physical properties of pomegranate arils has been reported (Martínez et al., 2012), any published results on the aerodynamic characteristics of pomegranate arils, rind and locular septa are not available. Hence, the objective of this study was to measure and compare the aerodynamic characteristics of these materials to provide the data and to facilitate the design and adjustment of machines that perform separation of pomegranate arils from rind and locular septa based on aerodynamic characteristics (terminal velocity, drag coefficient and Reynolds number). To achieve this objective, a various collection of pomegranate fruit (Ashraf variety) at different maturity stages (four distinct maturity stages between 88 and 143 days after full bloom (DAFB)) was examined. The resulting data can be used to model conveying and pneumatic sorting–cleaning systems used in pomegranate industry.

2. Materials and methods

2.1. Sample collection and preparation

Arils, rind and locular septa samples were selected from an Iranian variety of pomegranate fruit namely Ashraf. The fruits were handpicked randomly from a commercial orchard in Shahidabad Village, Behshahr County, Mazandaran Province, Iran, during 2014 growing season. Sampling started on 31 August 2014, when it was possible to squeeze juice from the arils, and ended in October 2014 at fruits' commercially full ripe stage. The 100 sample pomegranate fruits were divided into four groups of 25 samples, each representing maturity levels of 1–4 corresponding to 88, 109, 124 and 143 days after full bloom (DAFB), respectively (Fig. 1). Then pomegranate arils were extracted and cleaned manually to remove all foreign material and broken arils. Finally, the samples were transferred to the laboratory to measure studied characteristics. The initial moisture content of arils samples (in d.b.%) at each studied stages was 15%, 19.81%, 23.33% and 26.66% respectively, and determined using the standard hot air oven method with a temperature setting of 105 ± 1 °C for 24 h (Mohsenin, 1986) and then sealing in separate polyethylene bags of 90 μm thickness and storing at 5 °C in a refrigerator for 7 days. Before starting the tests, the samples were taken out of the refrigerator and allowed to warm up to room temperature for approximately 2 h (Khodabakhshian et al., 2009, 2012).

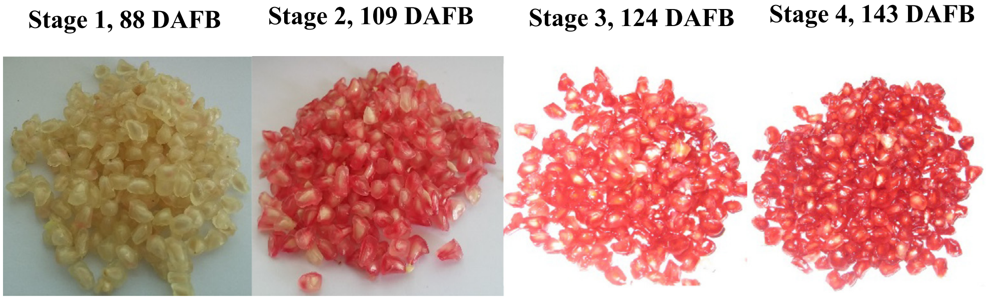

Figure 1 Arils of pomegranate fruit (cv. 'ASHRAF') cultivar at different maturity stages.

2.2. Handling characteristics measurement

- The major dimensions of the pomegranate arils (length, L; width, W and thickness, T) were measured using digital caliper (Mitutoyo, Japan) with an accuracy of ±0.01 mm.
- To study the shape of pomegranate arils, the following indexes were computed.

Geometric mean diameter, D_g (mm); sphericity, ϕ; surface area, S (mm^2) and volume, V (cm^3) of arils were computed using the following formulas, respectively (Mohsenin, 1986):

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

$$\phi = D_g / L \tag{2}$$

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

$$V = \frac{4}{3}\pi ab \tag{4}$$

- Rind thickness (t), expressed in mm.
- Aril mass, m, expressed in g, was measured by counting and weighting 100 arils by a precision weighting device (PX-200, Phantom Scales LLC), with an accuracy of 0.0001 g and then divided by 100 to give the unit mass of aril.
- Bulk density of aril, ρ_b, expressed in g/cm^3. This parameter was determined by filling a cylindrical container of 500 ml volume with arils to a height of 15 cm at a constant rate and then weighting the contents.
- True density of arils, ρ_t, expressed in g/cm^3, was calculated by dividing the unit of mass of aril to its volume.

2.3. Aerodynamic characteristics measurement

The aerodynamic characteristics of pomegranate arils, rind and locular septa were measured in terms of terminal velocity, drag coefficient and Reynolds number as following.

2.3.1. Terminal velocity

The terminal velocity (V_t) of a seed is defined as the air velocity at which a particle is suspended in a vertical column (Mohsenin, 1986). The terminal velocity of aril samples (totally 25 arils were randomly selected, after extracting from 25 fruits by hand), rind and locular septa samples (some rind and locular septa samples were randomly selected after extracting from 25 fruits by hand) was measured using an air column (Fig. 2). It consists of a vertical transport column made of Plexiglas so that the suspended arils could be seen from the outside, the inverter, AC electric motor, fan and diffuser. The latest part, diffuser, provides equal distribution of air inside column. For each test, a sample was dropped into the air stream from the top of the air column, up which air was blown to suspend the sample. The air velocity inside column that is called terminal velocity was measured by a hot-wire anemometer (Anemo-thermometer, Friendswood, TX, USA) with the accuracy of ±0.1 m s^{-1} (Khodabakhshian et al., 2009, 2012). Ten replicate measurements were taken for each sample and the average terminal velocity for each sample was determined. This methodology was used by Matouk et al. (2008), Khodabakhshian et al. (2009, 2012), and Shahbazi et al. (2014).

2.3.2. Drag coefficient

The bed thickness of the seed, shape, surface roughness, and its orientation influence the drag coefficient of a seed and its resistance to airflow (Gupta et al., 2007). Gorial and O'Callaghan (1990) measured terminal velocities and established the drag coefficients of a wide range of grain straws. They proposed volume shape factors for non-spherical particles and drag coefficients were determined for different seeds and straws as a function of Reynolds number. Becker (1959) proposed a formula for drag coefficient, C_d, which is dependent on shape, orientation and Reynolds number. So, in mathematical terms drag coefficient could be expressed as

$$C_d = f(\text{shape, surface roughness, orientation and Reynolds number}) \tag{5}$$

Many researchers have shown that with knowing V_t, the drag coefficient was calculated using the following formula (Mohsenin, 1986; Matouk et al., 2008; Khodabakhshian et al., 2009, 2012; Shahbazi et al., 2014):

$$C_d = \frac{2mg}{V_t^2 A \rho_a} \tag{6}$$

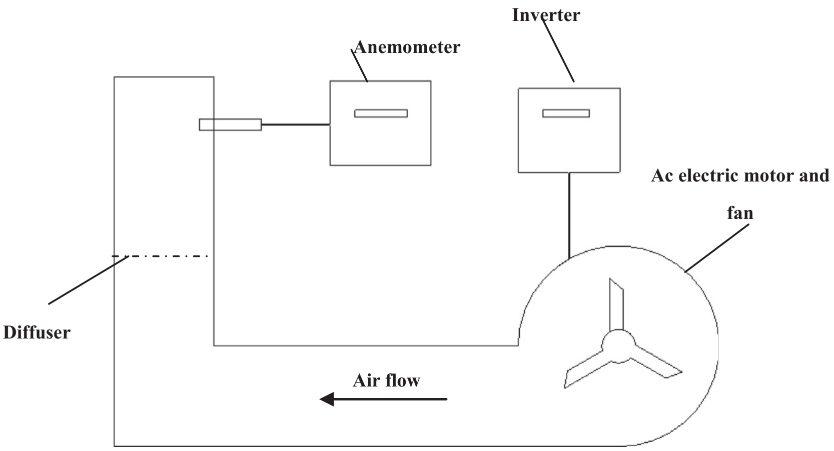

Figure 2 Schematic diagram representing experimental apparatus used to determine terminal velocity.

where m is the mass of the sample in kg, ρ_a is the air density in kg m^{-3}, g is acceleration of gravity in m s^{-2} and A is the projected area of the sample normal to the direction of motion in m^2. The value of the air density was assumed as 1.2 kg m^{-3} at temperature of 25 °C (Gupta et al., 2007). The projected area (A) of the samples was determined by image processing method using an imaging system developed by authors.

2.3.3. Reynolds number

Reynolds number is defined as the ratio of the fluid's inertial forces to its drag forces. This parameter is a critical issue in the matter of convention of agricultural produce (Matouk et al., 2008). In this study, Reynolds number (Re) was calculated using the terminal velocity and drag coefficient of each sample by following expression (Matouk et al., 2008):

$$Re = \frac{\rho_a D_g V_t}{\mu} \tag{7}$$

where μ is the air viscosity at room temperature (1.85×10^{-5} N s m^{-2}) and D_g is the geometric mean diameter of samples. Geometric mean diameter of rind and locular septa samples also was calculated by Eq. (1).

2.4. Statistical analysis

The experiments were done at least in ten replications for each stage of maturity, and then the mean (±S.E.) values reported. Statistical analysis was applying the analysis of variance (ANOVA) using SPSS 16.0 software package for windows. The Duncan's multiple ranges test was used to separate means at a 5% level of significance. The terminal velocity, drag coefficient, Reynolds number and the maturity stage data of pomegranate arils, rind and locular septa were fitted to linear, logarithmic, exponential and polynomial models. The models were evaluated according to the statistical criterion R^2 and SEE (Standard Error of Estimate) for verifying the adequacy of fit. The best model with the highest R^2 and lowest SEE was selected to predict the terminal velocity drag coefficient, Reynolds number of samples as a function of maturity stage.

3. Results and discussion

3.1. Handling characteristics

From a marketing viewpoint, some handling characteristics of agricultural materials such as size and shape are one of the important attributes that influence consumer preference (Opara, 2000; Maguire et al., 2001; Holland et al., 2009). The average values and standard deviations of rind thickness and some handling characteristics of pomegranate arils at four studied maturity stages are presented in Table 1. Analysis of data shows significant differences ($P < 0.05$) were observed among studied handling characteristics of pomegranate arils with advancing fruit maturity. However Salah and Dilshad (2002) found that physical properties of pomegranate fruit (Taifi variety) during pomegranate fruit maturation showed no statistical differences ($P < 0.05$) in length, diameter or volume. As it can be seen from Table 1, the pomegranate arils will show increase in main dimensions (length, width, thickness), surface area, volume and geometric mean diameter while it will decrease in sphericity (shape index) with advancing fruit maturity. As described before, sphericity value of agricultural produce shows its shape relative to the shape of a sphere of the same volume. So, the decreasing of sphericity with progress of fruit maturity means those pomegranate arils at immature stage had spheroidal shape. The obtained results are supported by Fawole and Opara (2013). They reported that spherical shape fruits lose their sphericity while they are growing because of faster growth in fruit diameter than in length. Aril mass increased from 0.184 g at stage 1 to 0.407 g at stage 4. Similarly, there was a significant increase on bulk density of aril (0.696–0.865 g/cm^3), throughout the developmental stages investigated (Table 2). However, in this maturity stages the true density of arils (1.196–1.04 g/cm^3) decreased. The same result also was reported by Mirdehghan and Rahemi (2007) for pomegranate 'Malas Yazdi' cultivar grown in Iran. Also, the similar trend was found during maturity of pomegranate fruit (Taifi variety) by Salah and Dilshad (2002). Many researchers have reported similar results for handling characteristics of other bulk materials such as agricultural seeds

Table 1 Influence of maturity stages on handling characteristics of 'Ashraf' pomegranate arils during 2014 growing season.

Geometrical attributes	Fruit maturity stages			
	S_1	S_2	S_3	S_4
L (mm)	8.74^{a} (0.81)	10.71^{b} (0.29)	11.15^{bc} (0.34)	12.01^{c} (0.41)
W (mm)	5.82^{a} (0.97)	6.47^{ab} (0.35)	7.14^{bc} (0.28)	7.71^{c} (0.36)
T (mm)	4.09^{a} (0.56)	5.72^{b} (0.06)	5.25^{c} (0.41)	6.14^{c} (0.28)
D_g (mm)	5.92^{a} (0.71)	7.34^{b} (0.21)	7.39^{b} (0.35)	8.21^{c} (0.45)
ϕ	0.69^{a} (0.01)	0.68^{a} (0.05)	0.67^{a} (0.02)	0.67^{a} (0.01)
S (mm^2)	111.26^{a} (27.43)	169.58^{b} (9.54)	171.57^{b} (15.23)	211.75^{c} (10.92)
V (cm^3)	0.213^{a} (0.21)	0.291^{b} (0.18)	0.33^{c} (0.22)	0.39^{d} (0.12)
Arils mass (g)	0.184^{a} (0.02)	0.324^{b} (0.01)	0.351^{c} (0.02)	0.407^{d} (0.02)
True density (g/cm^3)	1.196^{a} (0.01)	1.17^{a} (0.04)	1.09^{b} (0.03)	1.04^{c} (0.02)
Bulk density (g/cm^3)	0.696^{a} (0.04)	0.81^{b} (0.01)	0.835^{bc} (0.02)	0.865^{c} (0.01)
t (mm)	2.19^{a} (0.55)	2.80^{b} (0.29)	3.25^{bc} (0.48)	3.76^{c} (0.12)
Moisture content of arils (d.b.%)	15.00	19.84	23.33	26.66

Different letter(s) on column indicate statistical significant differences ($p < 0.05$) according to Duncan's multiple range test. n.s. = non-significant.

Table 2 Mean comparison of terminal velocity (m s^{-1}), drag coefficient and Reynolds number of pomegranate arils, rind and locular septa considering effect of maturity stage.

Aerodynamic characteristics	Material	Fruit maturity stages			
		S_1	S_2	S_3	S_4
Terminal velocity	Locular septa	1.05^a	1.09^a	1.13^b	1.16^b
	Rind	3.16^a	3.34^b	3.5^b	3.73^c
	Aril	5.89^a	6.14^b	6.41^c	6.7^d
Drag coefficient	Locular septa	0.92^a	0.88^a	0.84^b	0.79^b
	Rind	0.75^a	0.69^b	0.66^b	0.59^c
	Aril	0.53^a	0.47^b	0.41^b	0.36^c
Reynolds number	Locular septa	403.24^a	518.96^b	541.67^c	617.75^d
	Rind	1213.44^a	1590.21^b	1677.73^c	1986.37^d
	Aril	2261.76^a	2923.31^b	3072.64^c	3568.02^d

Different letter(s) on column indicate statistical significant differences ($p < 0.05$) according to Duncan's multiple range test. n.s. = non-significant.

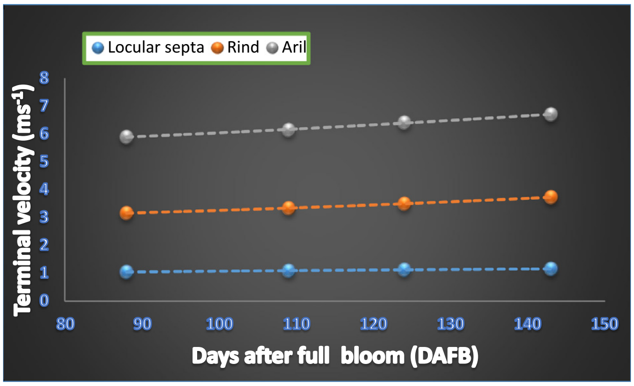

Figure 3 Variation in terminal velocity of pomegranate arils, rind and locular septa with maturity stage.

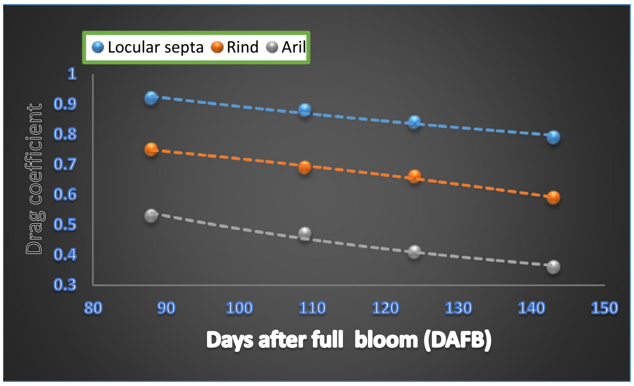

Figure 4 Variation in drag coefficient of pomegranate arils, rind and locular septa with maturity stage.

and grains (Mohsenin, 1986; Ozarslan, 2002; Kashaninejad et al., 2008; Khodabakhshian et al., 2010a,b; Kalkan and Kara, 2011).

3.2. Aerodynamic characteristics

The aerodynamic characteristics of pomegranate arils, rind and locular septa of studied variety against four maturity stages are presented in Figs. 3–5, respectively.

3.2.1. Terminal velocity

The variation of terminal velocity of the pomegranate arils, rind and locular septa at four studied maturity stages is shown in Fig. 3. The results of the Duncan multiple range tests for comparing the means of the terminal velocity of pomegranate arils, rind and locular septa are presented in Table 2. As it can be seen from these results, the terminal velocity for each three studied materials increased from 1.05 to 1.16, 3.16 to 3.73 and 5.89 to 6.70 m s^{-1} respectively when maturity increased from about 88 to 143 days after full bloom (DAFB). The reason can be attributed to the increase in mass per unit volume. The other reason is probably that the drag force can be affected by the moisture content of sample. A similar increasing trend of terminal velocity with moisture content has been reported by other researcher for pumpkin seeds, lentil seeds, cotton seeds, pistachio nut and kernel, sunflower seed, canola seeds, soybean, sunflower seed and kernel, wheat (Joshi et al., 1993; Carman, 1996; Tabak and Wolf, 1998;

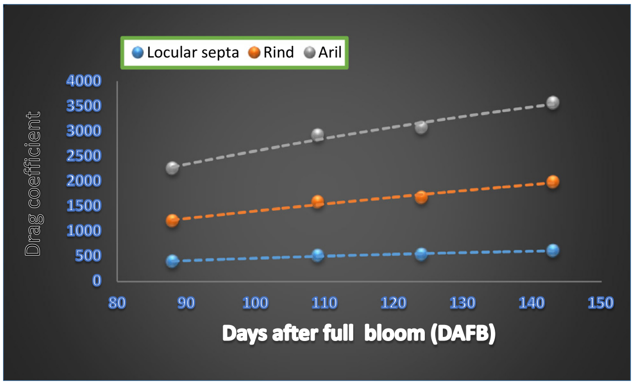

Figure 5 Variation in Reynolds number of pomegranate arils, rind and locular septa with maturity stage.

Kashaninejad et al., 2006, 2008; Gupta et al., 2007; Matouk et al., 2008; Khodabakhshian et al., 2012; Shahbazi et al., 2014).

Also from data in Fig. 3 it can be seen that the ranges of terminal velocity for pomegranate arils, rind and locular septa do not overlap in all four different studied maturity stages. The difference in terminal velocity between these materials could be the result of their various mass. Consequently, aerodynamic separation of pomegranate arils from rind and locular septa is theoretically possible. The terminal velocity data for pomegranate arils, rind and locular septa in Fig. 3 were fitted as a function of maturity stage to four mathematical models (linear, logarithmic, exponential and polynomial models). These models were evaluated for verifying the adequacy of fit using the R^2 and SEE value. The best model with the highest R^2 and lowest SEE was selected. By comparing these values of each model with each other, it is indicated that the polynomial model for pomegranate arils and the logarithmic model for locular septa had the highest R^2 and lowest SEE values. Accordingly, the polynomial model was selected as a suitable model to predict the terminal velocity of rind as a function of maturity stage. These relationships are shown in Table 3. Razavi et al. (2007) reported that the terminal velocity of pistachio nut and kernel was linearly related to moisture content. Khodabakhshian et al. (2009) developed a linear equation between the terminal velocity of sunflower seed and kernel as a function of moisture content. However, Nalbandi et al. (2010) reported a polynomial relationship for the terminal velocity of wheat kernels as a function of moisture content. Khodabakhshian et al. (2012) found a nonlinear equation for the terminal velocity sunflower seed and kernel as a function of the combination of variety, moisture content and seed size. Also Shahbazi et al. (2014) reported a polynomial equation for the terminal velocity of Makhobeli seeds as a function of moisture content

3.2.2. Drag coefficient

Fig. 4 shows the variation of the drag coefficient with maturity stage for three studied materials. The results showed that pomegranate arils, rind and locular septa decreased from 0.53 to 0.36, 0.75 to 0.59 and 0.92 to 0.79, respectively with advancing fruit maturity. This may attributed to increasing terminal velocity with maturity stage and moisture content because of a substantial decrease in drag coefficient (Eq. (1)). In agreement with these results Gupta et al. (2007), Matouk et al. (2008), Khodabakhshian et al. (2012) and Shahbazi et al. (2014) reported similar results for African yam bean, sunflower seed, coffee cherries, canola seeds, sunflower seed and kernel, wheat seeds respectively. The results of the Duncan multiple range tests for comparing the means of the calculated drag coefficients of pomegranate arils, rind and locular septa are presented in Table 2. As it can be found from this table, the drag coefficient of locular septa was about 1.28-fold of that ones for rind averagely. In the same way, the average drag coefficient of rind was about 1.53-fold of that of pomegranate arils.

The models fitted to the drag coefficient variation vs. maturity stage data in Fig. 3, using the regression technique, showed that the drag coefficient decreased nonlinearly with advancing fruit maturity for three studied materials. By comparing values of each four studied model with each other, it was obvious that the polynomial model for all three studied materials had the highest R^2 and lowest SEE values. These relationships are shown in Table 3. Similar results were also reported by Khodabakhshian et al. (2012) for three varieties of sunflower seed and kernel. They found a nonlinear relationship for the drag coefficient sunflower seed and kernel as a function of the combination of variety, moisture content and seed size. However, many researchers have reported that the relationship between drag coefficient and moisture content may be described by a linear model (Matouk et al., 2005, 2008; Gupta et al., 2007; Shahbazi et al., 2014).

3.2.3. Reynolds number

The mean values of Reynolds number of pomegranate arils, rind and locular septa at four different studied maturity stages are plotted in Fig. 5. It is seen from this figure that the Reynolds number of each three studied materials increased during fruit growth. This may be due to increasing terminal velocity and geometric mean diameter with advancing fruit maturity or moisture content (Eq. (3)). In agreement with these results Matouk et al. (2008) found that increasing the grain moisture content tented to increase of rice, corn, wheat and barley. Also Khodabakhshian et al. (2012) reported similar trends for Reynolds number of sunflower seed and kernel with increasing of moisture content. The results of the Duncan multiple range tests for comparing the means of the calculated Reynolds number of pomegranate arils, rind and locular septa are revealed in Table 2. The regression relationships between Reynolds number and fruit maturity for three studied materials are

Table 3 Terminal velocity (V_t), drag coefficient (C_d) and Reynolds number (Re) of pomegranate arils, rind and locular septa as a function of maturity stage (S).

Aerodynamic characteristics	Material	Relationship	R^2	SEE
Terminal velocity	Locular septa	$V_t = 0.2312\ln(S) + 0.0123$	0.99	0.11
	Rind	$V_t = 0.00005S^2 + 0.0013S + 2.88$	1	0.09
	Aril	$V_t = 0.00005S^2 + 0.0031S + 5.21$	0.99	0.12
Drag coefficient	Locular septa	$C_d = -0.00001S^2 + 0.00008S + 0.99$	0.99	0.08
	Rind	$C_d = -0.00001S^2 - 0.0003S + 0.86$	0.99	0.1
	Aril	$C_d = -0.000002S^2 - 0.00037S + 0.83$	0.99	0.12
Reynolds number	Locular septa	$Re = -0.0921S^2 + 44.073S - 879.77$	0.98	0.09
	Rind	$Re = -0.0329S^2 + 21.095S - 373.53$	0.98	0.12
	Aril	$Re = -0.024S^2 + 9.284S - 223.71$	0.98	0.11

represented in Table 3. As it can be seen from this table, it was clear that the polynomial model for all three studied materials had the highest R^2 and lowest SEE values. The positive nonlinear relationship of Reynolds number as a function of the combination of variety, moisture content and seed size for three varieties of sunflower seed and kernel was found by Khodabakhshian et al. (2012).

3.3. Application of results

An application of obtained results of this study is in handling and processing of pomegranate arils to predict the range of proper air velocity. Characteristically, in the advance of design requirement for either an air conveyor, cleaning or the separation equipment in pomegranate industry. Maximum terminal velocity of pomegranate aril, rind and locular septa to control the proper air speed for conveying was 6.7, 1.16 and 3.73 m s^{-1} respectively. Consequently, aerodynamic separation of pomegranate aril from locular septa and rind is theoretically possible if the air velocity value is adjusted according to the terminal velocity of pomegranate aril. Maximum drag coefficient of pomegranate aril resist to the air flow can be considered about 0.53. Also, the maximum drag coefficient of rind and locular septa for this application was 0.75 and 0.92 m s^{-1} respectively. The higher obtained maximum values of Reynolds number showed the existence of strong inertial forces compared with their viscous forces. Also, the obtained relationships had a high coefficient of determination and low SEE values that they can be beneficial in estimating terminal velocity, drag coefficient and Reynolds number for goals such as air conveyor and pneumatic separator of pomegranate aril.

4. Conclusion

In this paper, aerodynamic characteristics of pomegranate arils, rind and locular septa were investigated as a function of maturity. These characteristics are necessary in order to the designing of equipment for air conveying, cleaning and pneumatic separation in pomegranate industry. The following are concluded from this investigation:

1. Statistically, variation in maturity stage significantly influenced the terminal velocity, drag coefficient and Reynolds number ($P < 0.05$).
2. During fruit maturity, the terminal velocity of locular septa, rind and pomegranate aril increased from 1.05 to 1.16, 3.16 to 3.73 and 5.89 to 6.70 m s^{-1}, respectively. The corresponding value of drag coefficient of three materials decreased from 0.92 to 0.79, 0.75 to 0.59 and 0.53 to 0.36, respectively with advancing fruit maturity. Also these ranges for Reynolds number were 403.24–617.75, 1213.44–1986.37 and 2261.76–3568.02, respectively.
3. Consequently, aerodynamic separation of pomegranate aril from locular septa and rind is theoretically possible if the air velocity value is adjusted according to the terminal velocity of pomegranate aril.
4. Over the same range maturity stage range, all three studied aerodynamic characteristics of pomegranate arils, rind and locular septa were varied following a polynomial relationship (except terminal velocity of locular septa). This relationship can be beneficial in estimating terminal velocity, drag coefficient and Reynolds number for goals such as air conveyor and pneumatic separator of pomegranate aril. This information can be used in the design and development of air conveyor and pneumatic separator of pomegranate aril or other postharvest pomegranate aril processing machines that used air as a carrier for transport or for separating arils from unwanted materials.

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