Physical Properties of Iranian Berhi Date at Different Stages of Maturity

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Abstract

In the present study, some physical properties of the Iranian date (Berhi variety) were determined at three stages of maturity namely Khalal, Rotab and Tamar. Color and textural features of samples were extracted by image processing toolbox of Matlab software. Total soluble solids (TSS), pH and weight of samples were also measured. The relationship between color and TSS, surface area and weight were obtained. The maximum correlation between TSS content and color occurred in blue for Rotab and Tamar but in red for Khalal. In the meantime, color and textural features differences between three stages of maturity were significant. There was a linear relationship between weight and surface area. The weights and areas of Rotab and Tamar were significantly different from those of Khalal.

Keywords: date, Khalal, Rotab, physical properties, Tamar

1. Introduction

Date is one of the non-oil export products of Iran that play very important role in terms of increasing the assets of the country. Date is one of the rare fruits that all of its parts such as flesh, stone, leaf, etc. can benefit food supply chain if processed properly. Nearly 75 percent of the dried material of Date is sugar. Date fruits are known to be a source of iron, potassium, calcium, chlorine, copper and Sulphur. Also it contains A, B1 and B2 vitamins and Tarooneh water is extracted from outer cover of Date bunch that is used as tranquilizer. Ground stone of Date is included in animal diet. It is also worth to mention that leaf and branches of Date palm are used as raw materials in Paper mill and artifact industries. Confectioneries and processing industries are also among those sectors that can benefit from Date processing wastes (Rohani, 1988).

The first step in mechanizion of post-harvest operations related to Date, acquires a sound knowledge concerning its physical properties. Size and shape characteristics are most often used in sorting and sizing of fruits, and determining an appropriate size for packages and plastic bags used in date handling.

Akar and Aydin (2005) evaluated some physical properties of gumbo fruit varieties as a function of moisture content. Kashaninejad et al. (2006) determined some physical and aerodynamic properties of pistachio nut and its kernel as a function of moisture content in order to design processing equipment and facilities. Topuz et al. (2005) determined and compared several properties of four orange varieties. Keramat Jahromi et al. obtained some physical properties of Date (cv. Lasht) in 2007 and Date (cv. Behr and Khasoei) in 2008. Safa and Khazaei (2003) determined and modeled some physical properties of pomegranate fruits related to packaging.

In the present research, some physical properties of the Iranian Date (Berhi variety) were determined at three stages of maturity namely Khalal, Rotab and Tamar. Color and textural features of samples were extracted by image processing. Total soluble solids (TSS), pH and weight of samples were also measured. The relationship between color and TSS, surface area and weight were obtained. Compression tests were also performed to examine its firmness. In the meantime its relaxation behavior under constant displacement was evaluated and surface area of the fruit was determined for the purpose of heat and mass transfer modeling during storage period, cooling and drying operations.

2. Methods and Materials

In this study, the date fruit samples were selected randomly from Berhi cultivar from Date research institute in Ahvaz (located in the south of Iran). The samples were at 3 stages of maturity namely Khalal (under mature), Rotab (semi mature) and Tamar (full mature). The fruits were taken to the Laboratory individually and were weighed one by one by a digital balance with 0.01 gr accuracy. Then images of all samples were captured by an industrial digital camera (Telecam No.Nck 41CV) and a capture card (winfast 2000) and saved in personal computer. Total soluble solid (TSS) in the liquid extract of Date was measured by a refractometer (MASTER-53M) and was stated as Brix%.

To obtain liquid extract of the Date, nearly 30 gr of each sample was crushed uniformly by an electronic mixture. 100 ml distilled water was added into the mixture and stored in 60 ℃ water bath for 20 minutes. Finally, it was filtered. To measure the pH of Date samples, titration method was used. 5 ml of liquid extract of sample was poured into Erlenmeyer flask that contained nearly 50 ml of distilled water. Titration was performed by 2-3 drops of Phenolphthalein along with 0.1 NaOH. Acidity (pH) of the sample was determined from the amount of NaOH used based on Malic acid.

The coefficients of friction between the product and galvanized steel surface were determined by using an inclined plane (Figure 1) as described by Nalbandi et al. (2011). The plane, containing a sample, was kept in its horizontal position in the beginning of test and then its inclination angle was increased gradually. As soon as slippage of the sample was observed, the angle of the plane was recorded. Tangent of the angle was reported as the coefficient of friction:

$$\mu = \tan\varphi$$

Where, μ is the coefficient of friction and φ is the inclination angle of the friction surface.

Figure1. Inclined plane for measuring the coefficient of friction

Figure 2. Instron model 1140 used in compression test

Figure 3. Pendulum ball for impact test

Compression test was performed by Instron, Model 1140 (Figure 2). All the samples were destoned and placed on flat base plate. 4.8 cm diameter moving plate was used in compression test. The crosshead speed of Instron was 200mm.min^{-1} as described by Myhara et al. (2000). A 50 N capacity load-cell was used during the tests.

Impact test was performed by impact pendulum (Figure 3). A pendulum was used to apply predetermined impact energies to Date fruit. The samples were impacted by a steel ball (32 gr). A single Date was suspended in a cheesecloth pouch in a contact with a solid backstop. The pendulum was released as deflected 30°, 45°, 60° and 90° from its normal position, corresponding to impact energies of 0.00145, 0.00317, 0.0054 and 0.0108J respectively. The impact energy was calculated as follows:

$$E = mgr(1-\cos\varnothing)$$

where

m=mass,

g=acceleration due to gravity,

r=length of pendulum, and

$\varnothing$= angle of release.

Eight fruits per treatment and maturity stage were used.

Drop tests from three heights namely 30, 40 and 50 cm were performed on a solid steel metal. The selected samples of each stage of maturity had nearly uniform size and weight. Assuming an average weight, the equivalent impact energy levels were 0.0445, 0.0415 and 0.03J for Khalal, Rotab and Tamar stages respectively. The drop energy was calculated as follows:

E=mgh

where

m=weight,

g=acceleration due to gravity, and

h=height.

Some other features of Date were extracted by image processing toolbox of Matlab software as shown in Table 1.

Table1. Some features extracted by image processing toolbox of Matlab

Property	Description	Formula
Contrast	Returns a measure of the intensity contrast between a pixel and its neighbor over the whole image.	$\sum_{i,j} \lvert i-j \rvert^2 p(i,j)$
Correlation	Returns a measure of how correlated a pixel is to its neighbor over the whole image.	$\sum_{i,j} \frac{(i-\mu i)(j-\mu j)p(i,j)}{\sigma_i \sigma_j}$
Energy	Returns the sum of squared elements in the gray-level co-occurence matrix(GLCM)	$\sum_{i,j} p(i,j)^2$
Homogeneity	Returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal.	$\sum_{i,j} \frac{p(i,j)}{1+\lvert i-j \rvert}$
Entropy	Returns a measure of entropy of grayscale image	$-\sum_i \sum_j p(i,j)Log_2 p(i,j)$
nth moment		$\mu_n(r) = \sum_{i=0}^{L-1} (r_i - m)^n p(r_i)$
average gray level		$m = \sum_{i=0}^{L-1} r_i p(r_i).$

3. Results and Discussions

For each test, adequate samples were selected. In order to extract the textural and apparent features, 50 samples from each stage of maturity were selected. The images of all samples were captured and analyzed using image processing of Matlab software. As indicated in Tables 2, 3 and 4, there were significant differences between Khalal, Rotab and Tamar in terms of Red and Green component intensities. But there were not significant differences between Rotab and Tamar in terms of Blue intensities. To use a new color space conversion and color distribution analysis techniques for date maturity evaluation, introduced by Lee et al. (2008), concentration should be made on Red and Green component intensities as the present findings suggest.

Table 2. Result of Duncan test for red component

Treatment	N	Subset for alpha = 0.05		
		1	2	3
Tamar	50	136.8507		
Rotab	50		150.0335	
Khalal	50			204.6601
Sig.		1.000	1.000	1.000

Table 3. Result of Duncan test for green component

Treatmen	N	Subset for alpha = 0.05		
		1	2	3
Tamar	50	106.4310		
Rotab	50		116.4903	
Blue	50			179.9518
Sig.		1.000	1.000	1.000

Table 4. Result of Duncan test for blue component

treatment	N	Subset for alpha = 0.05	
		1	2
3	50	85.4513	
2	50	86.3799	
1	50		92.9505
Sig.		.239	1.000

To determine pH, total soluble solids (TSS) and Brix, 5 random samples were selected out of each 50 samples per stage. Table 2 shows that Rotab and Tamar are not significantly different in Brix%, but pH varies significantly with the stage of maturiry (Table 5 and Table 6). Taste of the fruits is determined by the ratio of sugar level to pH level. The best time for harvesting the fruits is when the ratio of Brix to pH is fixed. Christensen et al. (2012) studied the effects of harvest date on Thompson seedless grapes and raisins.

Table 5. Result of Duncan test for brix%

Treatment	N	Subset for alpha = 0.05	
		1	2
Kalal	5	3.1400	
Rotab	5		7.3200
Tamar	5		7.3400
Sig.		1.000	.973

Table 6. Result of Duncan test for PH

Treatment	N	Subset for alpha = 0.05	
		1	2
Khalal	5	.6400	
Tamar	4	1.0125	1.0125
Rotab	5		1.4500
Sig.		.278	.207

Brix% plotted versus RGB using Excel and the relation between RGB and %Brix was obtained. In Rotab and Tamar, the maximum correlation occurred in Blue. But in Khalal, the maximum correlation occurred in Red (Figures 4, 5 and 6). Date sugar content is considered as a fruit commercial characteristic where it is important for both fresh consumption and fruit processing. Fadel et al. (2001) and Fadel et al. (2006) studied color properties of date fruits and introduced a computer-based method for date sugar content estimation. This method depends on calculating the intensities of the red, green, and blue components of fruit color via image processing algorithm. Color ingredients intensity was correlated to glucose, fructose and sucrose levels.
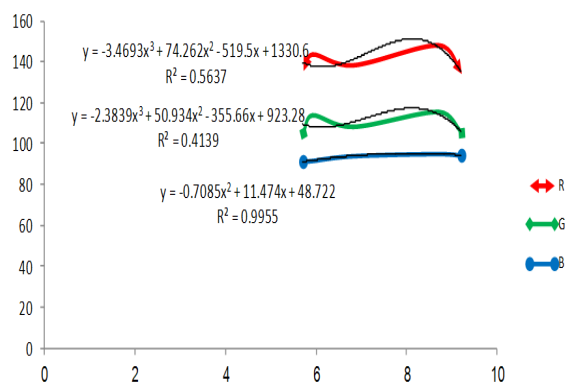

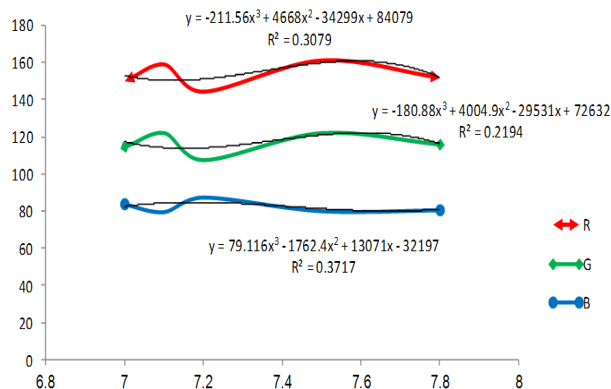Figure 4. Diagram of relationships between Brix and RGB at Tamar stage

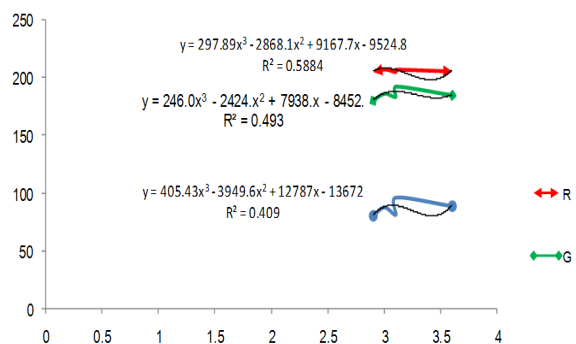Figure 5. Diagram of relationships between Brix and RGB at Rotab stage

Figure 6. Diagram of relationships between Brix and RGB at Khalal stage
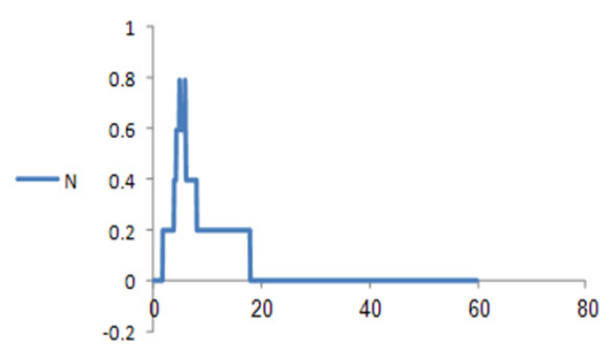

Figure 7. Relaxation curve of Khalal

In another comparison, 10 samples were selected for each stage of maturity and weighed by a digital balance with 0.01 gr accuracy. The surface areas of samples were measured by image processing. According to table 7 and 8, it is obvious that the results from digital balance and those of obtained from software are the same. From the view point of weight and surface area, there were not significant differences between Khala and Rotab but

Tamar was significantly different from Rotab and Khalal. According to the same results, it can be concluded that projected area of fruit in the image can be used instead of weight factor.

Table7. Result of Duncan test for weight

Treatment	N	Subset for alpha = 0.05	
		1	2
Tamar	10	6.0050	
Rotab	10		8.8800
Khalal	10		8.9670
Sig.		1.000	.803

Table 8. Result of Duncan test for surface area

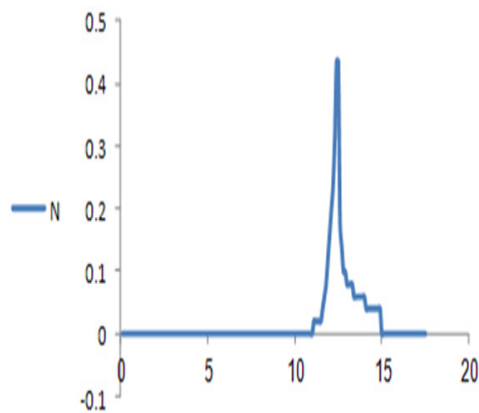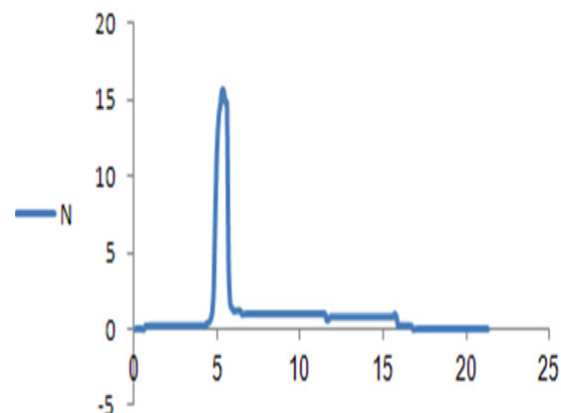| Treatment	N	Subset for alpha = 0.05	
		1	2
Rotab	10	83258.1000	
Khalal	10	83354.4000	
Tamar	10		84023.0000
Sig.		.673	1.000

Figure 8. Relaxation curve of Rotab

Figure 9. Relaxation curve of Tamar

Impact tests were performed on 8 samples. Equivalent energies for impact force at the angles of 30°, 45°, 60° and 90° were 0.00145, 0.00317, 0.0054 and 0.0108 J respectively. In Khalal, skin and flesh of fruit remained intact in all treatments (pendulum release angles). In Rotab however, at the pendulum release angles of 45° and 60°, two samples were damaged insignificantly and at the pendulum release angles of 90°, five samples were damaged slightly. In Tamar, the skin was puffed; and after the pendulum impact, the puffed area was flattened and then its original shape was restored. There were not any damaged samples at pendulum release angles of 30°, 45° and 60°. But the puffed skin of two samples were cut insignificantly at pendulum release angle of 90°.

In Drop test, Equivalent energies for Khalal, Rotab and Tamar at the height of 50 cm were 0.0445, 0.0415 and 0.03J respectively. All samples remained intact. Fruits subjected to impact were damaged more than those fruits that were subjected to drop. This indicates that in designing the end effectors for sorting lines, special consideration should be made in determining the force ranges, so that the damages due to impact to be minimal. Ferreira et al. (2008) used drop test and impact test to consider the strawberry fruit resistance to simulated handling.

In compression test (crosshead speed of 200mm.min^{-1}), force was plotted versus time and only the peak force at 75% compression from original height of the sample was determined. While relaxation characteristics is possible to obtain from aforementioned test, but the sampling speed of the software incorporated into Instron was inadequate, so that the stepwise curve was produced and this prevented the researcher from calculating relaxation time etc. as mentioned by Mohsenin (1970). However, fast relaxation time as observed in Figures 7, 8 and 9, indicate that Date undergo somehow rapid visco-plastic flow under constant displacement; the characteristic that is undesirable from fresh product consumers' point of view and should be considered in designing packing facilities.

The textural features listed in Table 1 were analyzed. With respect to every feature, the differences between Tamar, Rotab and Khalal were significant.

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