American-Eurasian J. Agric. & Environ. Sci., 3 (1): 132-136, 2008
ISSN 1818-6769

Changes in Physical Properties of Date Fruit (cv. Shahani) During Three Edible Stages of Ripening

Mahdi Keramat Jahromi, Ali Jafari, Shahin Rafiee, Reza Mirasheh and Seyed Saied Mohtasebi

Department of Agricultural Machinery, Faculty of Biosystems Engineering, University of Tehran, Karaj, Iran

Abstract: Most of the date fruit processing methods employed is still traditional. It becomes imperative to characterize the fruits with a view to understand the properties that may affect the design of machines to handle their processing. In this study, physical properties of date fruit during Khalal, Rotab and over ripened stages of ripening were investigated. Moisture contents were measured as 183.23%, 84.65% and 42.49%d.b. for each of stages, respectively. Results showed that the average dimensions of Khalal, Rotab and over ripened date were 48.49, 48.13 and 46.98mm in length, 21.56, 21.58 and 21.71mm in width, and 20.96, 20.91 and 19.78mm in thickness, respectively. The mean values of 11.55, 11.68 and 8.69g and 10.49, 10.47 and 8.66cm^3 were measured for average mass and volume of Khalal, Rotab and over ripened date, respectively. The average of projected areas decreases during ripening period. The particulate density, pitted density, bulk density and porosity were measured as 1.10, 1.10, 0.57g/cm^3 and 47.44% for Khalal, 1.12, 1.30, 0.60g/cm^3 and 46.33% for Rotab and 1.02, 1.33, 0.51g/cm^3 and 49.02% for over ripened date stages, respectively. The geometric mean diameter, sphericity and surface area were calculated as 27.97mm, 0.58 and 2473.66mm^2 for Khalal, 27.89mm, 0.58 and 2457.04mm^2 for Rotab and 27.21mm, 0.58 and 2332.41mm^2 for over ripened date fruit, respectively. Finally coefficients of static friction of each stage on three different materials were measured and compared.

Key words: Date fruit · Shahani · Jahrom · physical properties · ripening · sorting · postharvest

INTRODUCTION

Date (*Phoenix dactylifera* L.) fruit is an important tropical fruit having heavy demands in world markets. Shahani date fruit is one of the most famous cultivars of dates in Iran. Fruit color is yellow in Khalal stage, bright brown in Rotab and then becomes dark brown in over ripened stage. The best kind of Shahani is produced in Jahrom which is one of the most important centers of horticultural products in south of Iran [1]. The edible stages of ripening of date fruit could be divided into three main phases i.e. Khalal, Rotab and over ripened date. Fruit can be eaten during all these stages; however fruit in Rotab stage is very delicious. Design of machines and process to harvest, handle and store agricultural materials and to convert these materials to food and feed requires an understanding of their physical properties. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin [2]. These dimensions can be used in design of machine components and its parameters. The major axis has been found to be useful for indicating the natural rest position of the fruit.

Size and shape are most often used when describing grains, seeds, fruits and vegetables. Shape and physical dimensions are important in sorting and sizing of fruits and determine how many fruits can be placed in shipping containers or plastic bags of a given size. Quality differences in fruits, vegetables, grain and seeds can often be detected by differences in density. When fruits and vegetables are transported hydraulically, the design fluid velocities are related to both density and shape. Volumes and surface areas of solids must be known for accurate modeling of heat and mass transfer during cooling and drying. The porosity, which is the percentage of airspace in particulate solids, affects the resistance to air flow through bulk solids. Airflow resistance, in turn, affects the performance of systems designed for force convection drying of bulk solids and aeration systems used to control the temperature of stored bulk solids. Knowledge of frictional properties is needed for design of handling equipment [3] and also separation process.

Many researchers have conducted experiments to find the physical properties of various fruits and crops. Owolarafe and Shotonde [4] determined some physical

Corresponding Author: Dr. Ali Jafari, Department of Agricultural Machinery, Faculty of Biosystems Engineering, University of Tehran, Karaj, Iran

properties for okro fruit at a moisture content of 11.42% (wet basis). Akar and Aydin [5] evaluated some physical properties of gumbo fruit varieties as functions of moisture content. Kashaninejad *et al.* [6] 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.* [7] determined and compared several properties of four orange varieties. Also Keramat - Jahromi *et al.* [8] obtained some physical properties of date (cv. Lasht).

In the present research, changing in some important physical and morphological properties of date fruit (cv. Shahani) were investigated during ripening in order to develop appropriate technologies for it's processing. The development of the technologies will require the properties of this fruit.

MATERIALS AND METHODS

In this study, the samples were selected from Shahani variety (Fig. 1) at random from a garden in Jahrom. The fruits were individually transported, individually to the Physical Laboratory of Biosystems Faculty in the University of Tehran. All experiments were carried out at a temperature range of 25-30°C in three days.

In order to obtain the moisture content, samples were kept in an oven for 3 days at 105°C. Weight loss on drying to a final constant weight was recorded as moisture content by AOAC [9] recommended method.

Mass of individual fruit was determined using an electronic balance with a sensitivity of 0.01g. Fruit volumes were measured by water displacement method. Fruits were weighed in air and allowed to float in water. Fruits were lowered with a needle into a graduated beaker containing water and the mass of water displaced by the individual fruit was recorded. Finally, fruit density (g/cm^3) was calculated by using the following equation [2]:

$$\rho_f = \frac{M_a}{M_a - M_w} \times \rho_w \quad (1)$$

where ρ_f and ρ_w are fruit and water densities (g/m^3); M_a and M_w are mass of date in air and water, respectively. The bulk density was determined using the mass/volume relationship (Equation 2) by filling an empty plastic container of predetermined volume and mass with the fruits were poured from a constant height and weighed [9, 10].

Fig. 1: WinAreaUt_06 system

Fig. 2: Three major dimensions and projected areas of date fruit

$$\rho_b = \frac{M}{V} \quad (2)$$

where ρ_b is the bulk density (g/cm^3), M and V are bulk mass of fruit (g) and the plastic container volume (cm^3), respectively. This method was based on the work of Owolarafe *et al.* [10], Fraser *et al.* [11] and Suthar *et al.* [12].

Porosity (ε) was calculated as the ratio of the differences in the fruit and bulk densities to the fruit density value and expressed in percentage [10, 13, 14]:

$$\varepsilon = \left(\frac{\rho_f - \rho_b}{\rho_f}\right) \times 100 \quad (3)$$

Linear dimensions and also projected areas were determined by image processing method. In order to obtain dimensions and projected areas, WinArea_Ut_06 system [15] was used (Fig. 2). WinArea_Ut_06 system comprises of following components:

1. Sony photograph camera Model CCD-TRV225E
2. Device for preparing media to taking a picture
3. Card capture named Winfast model DV2000
4. Computer software programmed with visual basic 6.0

Captured images from the camera are transmitted to the computer card which works as an analog to digital converter. Digital images are then processed in the software and the outputs are determined. Total error

for those objects was less than 2%. This method has been used and reported by several researchers [8, 16, 17]. From Fig. 3, L, W and T are perpendicular dimensions of date fruit namely length, width and thickness and P_L, P_W and P_T are the projected areas taken along these three mutual perpendicular axes. The average projected areas (known as criteria projected areas) were calculated as suggested by Mohsenin [2]:

$$\text{Criteria areas (CPA)} = \frac{(PA_1+PA_2+PA_3)}{3} \quad (4)$$

Geometric mean diameter (D_g), sphericity (Φ) and surface areas (S) were calculated by using the following equations:

$$D_g = (LWT)^{1/3} \quad (5)$$

$$F = D_g/L \quad (6)$$

$$S=p.D_g^2 \quad (7)$$

These equations were reported by Mohsenin [2] and Kabas *et al.* [18].

The coefficients of static friction were obtained with respect to three different surfaces namely galvanized steel, plywood and glass surfaces by using an inclined plane apparatus as described by Dutta *et al.* [19]. The inclined plane was gently raised and the angle of inclination at which the sample started sliding was read off the protractor with sensitivity of one degree. The tangent of the angle was reported as the coefficient of friction [9].

RESULTS AND DISCUSSION

Moisture contents were measured as 183.23, 84.65 and 42.49% d.b., for Khalal, Rotab and over ripened date, respectively. Moisture contents of fruit, pitted fruit and its pit are given in Table 1. Result showed that the moisture content decreases during ripening. Average dimensions obtained as 48.49 mm in length, 21.56 mm in width and 20.96 mm in thickness for Khalal, 48.13 mm in length, 21.58 mm in width and 20.91 mm in thickness for Rotab stage and 46.98 mm in length, 21.71 mm in width and 19.78 mm in thickness for over ripened date stage. Date dimensions decreases during ripening, too. Mean mass and volume of Khalal, Rotab and over ripened fruit were 11.55, 11.68 and 8.69 g and mean volume of Khalal, Rotab

Table 1: Moisture content of date fruit (cv. Shahani) during ripening

Stage of ripening	Pitted fruit	Moisture (d.b.) kernel	Fruit with its kernel
Khalal	208.83	54.44	183.23
Rotab	91.55	30.88	84.65
Over ripened date	44.93	21.79	42.49

Table 2: Summary of some physical properties of date fruit (cv. Shahani) during ripening with standard deviation

	Mean (±Standard deviation)		
Physical properties	Khalal	Rotab	Over ripened date
Mass (g)	11.5517±3.11	11.68±2.45	8.69±1.21
Volume (cm^3)	10.49±2.87	10.47±2.26	8.67±1.55
Length (L) (mm)	48.49±3.94	48.13±3.98	46.98±3.04
Width (W) (mm)	21.56±1.77	21.58±1.52	21.71±1.36
Thickness (T) (mm)	20.96±1.77	20.90±1.57	19.78±1.37
Projected area perpendicular to L (mm^2)	391.34±73.26	392.28±65.03	378.94±42.11
Projected area perpendicular to W (mm^2)	823.34±137.56	805.54±125.19	749.41±92.50
Projected area perpendicular to T (mm^2)	831.51±141.33	819.38±122.05	813.13±90.69
Fruit density (g cm^{-3})	1.19±.05	1.31±.05	1.02±0.11
Pitted density (g cm^{-3})	1.19±0.11	1.31±.03	1.33±.08
Bulk density (g cm^{-3})	0.57±0.06	0.60±.03	0.51±0.03
Porosity (%)	47.63±0.48	46.33±2.82	49.02±3.15
Geometric mean diameter (mm)	27.97±2.22	27.89±2.03	27.21±1.52
Sphericity	0.57±2.00	0.58±2.00	0.58±2.00
Surface area (mm^2)	2780.91±400.30	2764.14±356.10	2332.41±259.01

Table 3: Coefficient of static friction with three different materials during ripening

	Static coefficient of friction for		
Stages of ripening	Plywood	Glass	Galvanized iron steel
Khalal	0.33	0.36	0.38
Rotab	0.55	0.52	0.42
Over ripened date	0.44	0.42	0.41

and over ripened fruit were measured as 10.49, 10.47 and 8.66cm^3, respectively. The projected areas along L, W and T were obtained as 391.34, 823.34 and 831.51mm^2 for Khalal, 392.28, 805.54 and 819.38 mm^2 for Rotab and 378.94, 749.41 and 813.13 mm^2 for over ripened fruit and their averages were obtained as 682.07 mm^2 for Khalal, 672.40 mm^2 for Rotab and 647.16 mm^2 for over ripened fruit, respectively. The average projected area decreases during ripening period. The fruit density, fruit pitted density, bulk density and porosity were measured as 1.10, 1.10, 0.57 g/cm^3 and 47.44% for Khalal, 1.12, 1.30, 0.60 g/cm^3 and 46.33% for Rotab and 1.02, 1.33, 0.51 g/cm^3 and 49.02% for over ripened fruit, respectively. The particulate density and pitted density decrease during ripening while bulk density and porosity increase at the first, and then started to decrease. The geometric mean diameter, sphericity and surface area were 27.97 mm, 0.58 and 2473.66mm^2 for Khalal, 27.89mm, 0.58 and 2457.04 mm^2 for Rotab and 27.21 mm, 0.58 and 2332.41 mm^2 for over ripened fruit, respectively. The geometric mean diameter and surface area decrease during ripening while sphericity increases at the first then started to decrease. A summary of results of the determined physical parameters are shown in Table 2. The mean coefficients of static friction for galvanized iron steel, plywood and glass surfaces, obtained as 0.38, 0.33 and 0.36 for Khalal, 0.42, 0.55 and 0.52 for Rotab and 0.41, 0.44 and 0.42 for over ripened date, respectively. The result of friction test is shown in Table 3. Comparing coefficients of static friction by Duncan's multiple test showed that there is a significant difference among stages of ripening. This is due to existence of the frictional properties between the fruits and surface materials. In addition to stage of ripening, the surface material affects the static coefficient too. Comparing coefficient of static friction (by Duncan's multiple tests) showed that the coefficient of static friction on glass surface has significant difference with plywood and galvanized iron steel. The Physical properties of date fruit were presented in Table 2 in order to design of a specific machine properly for post-harvesting operations.

CONCLUSIONS

1. Moisture content was measured as 183.23%, 84.65% and 42.49% d.b., for Khalal, Rotab and over ripened date stages, respectively.
2. The average dimensions of Khalal, Rotab and over ripened date were 48.49, 48.13 and 46.98mm in length, 21.56, 21.58 and 21.71mm in width, and 20.96, 20.91 and 19.78mm in thickness, respectively.
3. The mean values of 11.55, 11.68 and 8.69g in mass and 10.49, 10.47 and 8.66cm^3 in volume were measured for Khalal, Rotab and over ripened date, respectively.
4. The average projected areas decreases during ripening period.
5. The particulate density and pitted density decrease during ripening while bulk density and porosity increase at the first, and then started to decrease.
6. The geometric mean diameter, sphericity and surface area were calculated as 27.97 mm, 0.58 and 2473.66 mm^2 for Khalal, 27.89 mm, 0.58 and 2457.04 mm^2 for Rotab and 27.21 mm, 0.58 and 2332.41 mm^2 for over ripened date fruit, respectively.
7. The mean coefficients of static friction for galvanized iron steel, plywood and glass surfaces, obtained as 0.38, 0.33 and 0.36 for Khalal, 0.42, 0.55 and 0.52 for Rotab and 0.41, 0.44 and 0.42 for over ripened date, respectively.

ACKNOWLEDGEMENTS

This Research was financed by Faculty of Biosystems Engineering, University of Tehran. It is necessary to thank Ali Mirshekari, Gholamhasan Eskandari and Alireza Baghban for help and support.

REFERENCES

1. Roohani, I., 1988. Date Fruit. University publication center, Iran (in Farsi).
2. Mohsenin, N.N., 1986. Physical properties of Plant and Animal Materials. 2nd Edn. Gordon and Breach Science Publishers, New York.
3. Stroshine, R., 1998. Physical Properties of Agricultural Materials and Food Products. Course manual. Purdue Univ., USA.
4. Owolarafe, O.K. and H.O. Shotonde, 2004. Some physical properties of fresh okro fruit. J. Food Eng., 63: 299-302.
5. Akar, R. and C. Aydin, 2005. Some physical

properties of gumbo fruit varieties. J. Food Eng., 66: 387-393.
6. Kashaninejad, M., A. Mortazavi,, A. Safekordi and L.G. Tabil, 2006. Some physical properties of Pistachio (*Pistacia vera* L.) nut and its kernel. J. Food Eng., 72: 30-38.
7. Topuz, A., M. Topakci, M. Canakci, I. Akinci and F. Ozdemir, 2005. Physical and nutritional properties of four orange varieties. J. Food Eng., 66: 519-523.
8. Keramat Jahromi, M., A. Jafari, S. Rafiee, A.R. Keyhani, R. Mirasheh and S.S. Mohtasebi, 2007. Some physical properties of date fruit (cv. Lasht). Agric. Eng. Intl. The CIGRE J. Manuscript FP 07 019, Vol: 9.
9. Keramat Jahromi, M., A. Jafari, S. Rafiee, A.R. Keyhani, R. Mirasheh and S.S. Mohtasebi, 2007. Some physical properties of date fruit (cv. Lasht). Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 07 019, Vol. IX.
10. Keramat Jahromi, M., S. Rafiee, R. Mirasheh, A. Jafari, S.S. Mohtasebi, and M. Ghasemi Varnamkhasti, 2007. Mass and surface area modeling of bergamot *(Citrus medica)* fruit with some physical attributes. Agricultural Engineering International: the CIGR Ejournal. Manuscript FP 07 029. Vol. IX. October, 2007.
11. Khoshnam, F., A. Tabatabaeefar, M. Ghasemi Varnamkhasti and A. Borghei, 2007. Mass modeling of pomegranate (*Punica granatum* L.) fruit with some physical characteristics. Scientia Horticualturae, 114(1): 21-26.
12. Mirasheh, R., 2006. Designing and making procedure for a machine determining olive image dimensions. Master of Science Thesis, Faculty of Biosystems Engineering, University of Tehran.
13. Jain, R.K. and S. Bal, 1997. Properties of pearl millet. J. Agric. Eng. Res., 66: 85-91.
14. Vursavus, K., H. Kelebek and S. Selli, 2006. A study on some chemical and physico-mechanic properties of three sweet cherry varieties (*Prunus avium* L.) in Turkey. J. Food Eng., 74: 568-575.
15. Mirasheh, R., 2006. Designing and making procedure for a machine determining olive image dimensions. Master of Science Thesis, Tehran University.
16. Keramat Jahromi, M., S. Rafiee, R. Mirasheh, A. Jafari, S.S. Mohtasebi and M. Ghasemi Varnamkhasti, 2007. Mass and surface area modeling of bergamot *(Citrus medica)* fruit with some physical attributes. Agric. Eng. Intl.: The CIGRE J. Manuscript FP 07 029, October, 2007, Vol: 9.
17. Khoshnam, F., A. Tabatabaeefar, M. Ghasemi Varnamkhasti and A. Borghei, 2007. Mass modeling of pomegranate (*Punica granatum* L.) fruit with some physical characteristics. Scientia Hortic., 114 (1): 21-26.
18. Kabas, O., A. Ozmerzi and I. Akinci, 2006. Physical properties of cactus pear (*Opuntia ficus* India L.) grown wild in Turkey. J. Food Eng., 73: 198-202.
19. Dutta, S.K., V.K. Nema and R.K. Bhardwaj, 1988. Physical properties of grain. J. Agric. Eng. Res., 39: 259-268.