Determination of some physical properties of date fruit (cv. Mazafati)

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Most of the date fruit processing is still traditional method. 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. This study was to present basic principals of physical properties of date fruit (cv. Mazafati) in order to facilitate the design of some machines for its processing. Dry-basis moisture content of date fruits found to be 44.41% (47.73% for pitted dates and 18.87% for their pits). Other results showed that linear dimensions varied from 32.10 to 43.50mm in length, 20.50 to 28.20mm in width, and 19.90 to 26.90mm in thickness. Mean mass and fruit volume were measured as 8.39g and 10.31cm^3, respectively. The projected areas along length (P_L), width (P_W), and thickness (P_T) were 462.80, 716.33 and 749.86 mm^2, respectively. The fruit density and pitted fruit density were measured 0.82and 1.25g/cm^3 while bulk density and porosity were 0.44g/cm^3 and 44.90%, respectively. The geometric mean diameter, sphericity and surface area were obtained as 27.87mm, 0.73, and 2446.70mm^2, respectively. The mean coefficients of static friction were measured as 0.38, 0.43 and 0.44 on galvanized iron steel, plywood, and glass surfaces, respectively.

Key words: date fruit, mazafati, jahrom, physical properties, post harvest

Introduction

Botanically the date fruit is a berry consisting of a single seed surrounded by a fibrous, parchment like endocarp, a flashy mesocarp and the fruit skin (pericarp). The fruit is attached to the spikelet by a perianth (calyx or crop). Dates are unique in that they constitute a set of properties and characteristics, which distinguish them from all major fruits. Dates have significance as a stable food as well as a desert fruit, whilst their use in date products and industrial applications has increased. According to variety and growth conditions date fruit (tamr) vary in shape, size and weight. Usually they are

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oblong though certain varieties may reach a near round shape. Agricultural materials and food products have several unique characteristics which set them apart from engineering materials. Design of machines and process to harvest, handle and store agricultural materials and to convert these materials in to food and feed requires an understanding of their physical properties (Stroshine, 1998). Size and shape are often used when describing grains, seeds, fruits and vegetables. Shape and physical dimensions are important in screening solids to separate foreign materials and in sorting and sizing of fruits and vegetables. Size and shape 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 grains and other particulate solids are transported pneumatically or 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. Physical properties can be used when designing and sizing machine components (Stroshine, 1998). Also the information is useful in equipment such as cleaning, sorting, grading and kernel removing. Many researchers have conducted experiments to find the physical properties of various fruits and crops. Paksoy and Aydin (2004) estimated some physical properties of squash seeds at different moisture content (6.4–52.9%). The role of moisture content was also studied. Owolarafe and Shotonde (2004) determined some physical properties for okro fruit at a moisture content of 11.42% (wet basis). Akar and Aydin (2005) evaluated some physical properties of gumbo fruit varieties as functions of moisture content. Karababa (2006) evaluated physical properties of popcorn kernels as a function of kernel moisture content, varying from 8.95% to 17.12% (db). Kashaninejad *et al.* (2006) determined some physical and aerodynamic properties of pistachio nut and its kernel in order to design processing equipment and facilities. Several physical properties of pistachio nut and its kernel were evaluated as a function of moisture content in the range of 4.10–38.10% (w.b.). Topuz *et al.* (2005) determined and compared several properties of four orange varieties. Keramat Jahromi *et al.* (2007) determined dimensions and projected areas of date (Barhi variety) by image processing technique. Also many studies have been reported on the physical properties of agricultural crops.

Objectives of this study were to determine physical properties of date (cv. Mazafati) to develop appropriate technologies for its processing.

Materials and methods

In this study, the date fruit was selected from Mazafati cultivar (Fig.1). The samples of 500 fruits were selected at random from a local market in Jahrom (an important city in date production located in the south of Iran).

The fruits were 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 (SP-1D2 kitte) for 3 days at 105 °C. Weight loss on drying to a final constant weight was recorded as moisture content by AOAC (1984) recommended method and using the following equation (1):

$$MC = \frac{M_0 - M_d}{M_o} \times 100 \qquad (1)$$

where MC is moisture content (w.b.), M_0 is initial mass and M_d is the final mass of date fruit (g).

Mass of individual fruit was determined using an electronic balance with a sensitivity of 0.0l g. 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 densities (g/cm^3) were calculated by using the following equation (2) (Mohsenin, 1986):

$$\rho_f = \frac{M_a}{M_a - M_w} \times \rho_w \qquad (2)$$

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 3) (AOAC, 1984; Owolarafe *et al*., 2007) by filling an empty plastic container of predetermined volume and mass with the fruits were poured from a constant height, and weighed.

$$\rho_b = \frac{M}{V} \qquad (3)$$

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 (2007), Fraser *et al.*, (1978) and Suthar *et al.*, (1996).

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 (Jain and Bal, 1997; Vursavus *et al.*, 2006; Owolarafe et al., 2007):

$$\varepsilon = (\frac{\rho_f - \rho_b}{\rho_f}) \times 100 \qquad (4)$$

Linear dimensions, i.e. length, width and thickness and also projected areas, were determined by image processing method. In order to obtain dimensions and projected areas, WinAreaUt_06 system (Mirasheh, 2006) was used (Fig. 2).

WinArea-Ut-06 system comprises 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

Fig. 1. Date samples (cv. Mazafati)

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 desired user needs are determined. Total error for those objects was less than 2%. This method have been used and reported by several researchers (Keramat Jahromi *et al.*, 2007; Khoshnam *et al.*, 2007). 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. Geometric mean diameter

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

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

$$\Phi = D_g / L \qquad (6)$$

$$S = \pi . D_g^{\ 2} \qquad (7)$$

As reported by Mohsenin (1986) and Kabas *et al.* (2006). 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.* (1988). 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 (Dutta *et al.*, 1988):

$$\mu = \tan \phi \qquad (8)$$

where, μ is the coefficient of friction and ϕ is the tilt angle of the friction device. All the friction experiments were conducted in three replications for each surface.

Also An attempt was made to model date mass based on single or multiple variable regressions of dimensions characteristic, projected areas and single variable regression of volume.

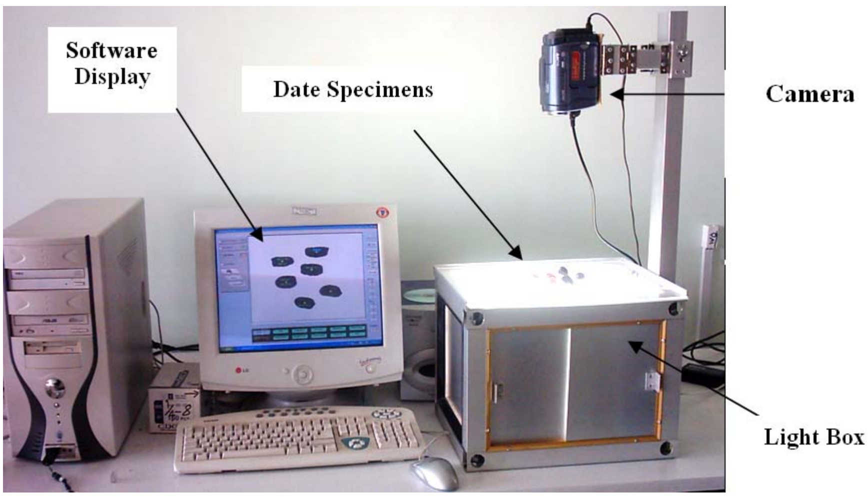

Fig.2. WinAreaUt_06 system

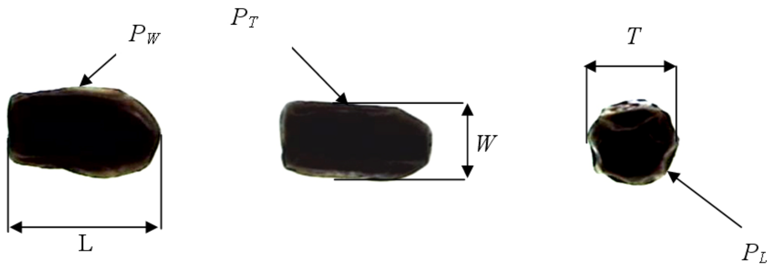

Fig 3. Three major dimensions and projected areas of date fruit

Results

The average dry-basis moisture content of date fruit samples was found to be 44.41% which 47.73% for pitted dates and 18.87% for their pits. Results showed that mass and volume varied from 5.86 to 11.26 g and from 6.74 to 14.21 cm^3 with mean values of 8.39g and 10.31cm^3, respectively. Dimensions varied from 32.10 to 43.50 mm in length, 20.50 to 28.20 mm in width, and 19.90 to 26.90 mm in thickness, with average values of 38.47, 24.37, and 23.13 mm, respectively. The mean projected areas along length, width, and thickness were obtained as 462.80, 716.33 and 749.86 mm^2, with variation of 337.00 to 537.00, 541.00 to 852.00 and 537.00 to 917.00 mm^2, respectively. The whole fruit density and pitted fruit density were measured and found to be between 0.67 to 0.95 and 1.18 to 1.32 g/cm^3 and with average values of 0.82 and 1.25 g/cm^3, respectively. Bulk density and porosity obtained were found to be 0.44 g/cm^3 and 44.90%, respectively. The geometric mean diameter, sphericity and surface area varied from 23.57 to 31.45 mm, 0.66 to 0.77, and 1745.39 to 3107.00 mm^2 while mean values were 27.87 mm, 0.73, and 2446.70 mm^2 , respectively. Also mean coefficient of static friction on galvanized iron steel, plywood and glass surfaces, were obtained as 0.38, 0.43 and 0.44, respectively. It sound that the static coefficient of friction on glass was higher than that of plywood and lower than that of galvanized iron steel surface. This is due to the frictional properties between the fruits and surface materials. These properties may be useful in the separation process and the transportation of the fruits. A summary of results of the determined physical parameters is shown in Table 1.

The physical properties of date fruit were described in order to optimizing and better design of tools, equipment, machines and systems for their processing.

Table1. Physical properties of date (Khashkhashi cultivar)

Properties of date		Number of observations	Minimum value	Maximum value	Mean value	Standard deviation
Mass, g		100	5.86	11.26	8.39	1.22
Volume, mm^3		100	6.74	14.21	10.31	1.64
Length (L), mm		100	32.10	43.50	38.47	2.31
Width (W), mm		100	20.50	28.20	24.37	1.34
Thickness (T), mm		100	19.90	26.90	23.13	1.31
Projected area along L, mm		100	337.00	537.00	462.80	46.88
Projected area along W, mm		100	541.00	852.00	716.33	67.22
Projected area along T, mm		100	537.00	917.00	749.86	75.41
Fruit density, g/cm^3		100	0.67	0.95	0.82	0.07
Pitted density, g/cm^3		6	1.18	1.32	1.25	0.06
Geometric mean diameter, mm		100	23.57	31.45	27.87	1.40
Sphericity, %		100	0.66	0.77	0.73	0.02
Surface area, mm^2		100	1745.39	3107.00	2446.70	243.20
Bulk density, g/cm^3		3	0.44	0.45	0.44	0.00
Porosity, %		3	43.79	46.00	44.90	1.10
Static coefficient of friction	Plywood	3	0.34	0.55	0.44	0.09
	Galvanized iron steel	3	0.34	0.40	0.38	0.02
	Glass	3	0.34	0.53	0.43	0.09

Conclusions

The average mass and volume for date (cv. Mazafati) were found to be 8.39g and 10.31cm^3, respectively. The fruit density and pitted fruit density were measured as 0.82 and 1.25g/cm^3, respectively. The bulk density and porosity were 0.44 g/cm^3 and 44.90%, respectively. The average of linear dimensions obtained as 38.47mm in length, 24.37mm in width, and 23.13mm in thickness. The mean projected area along length, width, and thickness were determined as 462.80, 716.33 and 749.86mm^2, respectively. The geometric mean diameter, sphericity and surface area were calculated as 27.87mm, 0.73, and 2446.70mm^2, respectively. The mean coefficients of static friction were measured as 0.38, 0.43 and 0.44 on galvanized iron steel, plywood, and glass surfaces, respectively.

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References

Akar, R. and C. Aydin. (2005). Some physical properties of gumbo fruit varieties, J. of Food Eng. 66, 387–393.

AOAC. (1984). Official methods of analysis. 14th edition. Association of Official Analytical Chemists, Washington D.C.

Dutta, S.K., Nema V.K. and Bhardwaj R.K. (1988). Physical properties of grain. J. of Agr. Eng. Res. 39, 259-268.

Fraser, B.M., Vermaand S.S. and Muir, W.E. (1978). Some physical properties of fababeans. J. of Agr. Eng. Res. 23, 53-57.

Jain, R. K. and Bal S. (1997). Properties of pearl millet. J. of Agr. Eng. Res. 66, 85-91.

Kabas, O., Ozmerzi A. and Akinci, I. (2006). Physical properties of cactus pear (Opuntia ficus India L.) grown wild in Turkey. J. of Food Eng. 73: 198-202.

Karababa, E. (2006). Physical properties of popcorn kernels. J. of Food Eng. 72, 100–107.

Kashaninejad, M., Mortazavi A., Safekordi A. and Tabil L.G. (2006). Some physical properties of Pistachio (Pistacia vera L.) nut and its kernel. J. of Food Eng. 72, 30–38.

Keramat Jahromi, M., Rafiee S., Jafari, A. and Tabatabaeefar A. (2007). Determination of dimension and area properties of date (Barhi) by image analysis. International Conference on Agricultural, Food and Biological Engineering and Post Harvest Production Technology, Khon Kaen, 21-24 January, Thailand.

Khoshnam, F., Tabatabaeefar A., Ghasemi Varnamkhasti and M., Borghei, A. (2007). Mass modeling of pomegranate (Punica granatum L.) fruit with some physical characteristics. Scientia Horticulturae. 114 , 1, 21-26

Mirasheh, R. (2006). Designing and making procedure for a machine determining olive image dimensions. Master of Science Thesis, Tehran University.

Mohsenin, N.N. (1986). Physical properties of Plant and Animal Materials. 2nd edition; Gordon & Breach Science Publishers: New York.

Owolarafe, O.K. and Shotonde, H.O. (2004). Some physical properties of fresh okro fruit. J. of Food Eng. 63, 299–302.

Owolarafe, O.K., Olabigeand, T.M. and Faborode, M.O. (2007). Macro-structural characterisation of palm fruit at different processing conditions. J. of Food Eng. 78, 1228-1232.

Paksoy, M. and Aydin, C. (2004). Some physical properties of edible squash (Cucurbita pepo L.) seeds. J. of Food Eng. 65, 225–231.

Stroshine, R. (1998). Physical Properties of Agricultural Materials and Food Products. Course manual. Purdue Univ. USA.

Suthar, S. H. and Das S. K. (1996). Some physical properties of karingda seeds. Journal of Agricultural and Engineering Res. 65, 15–22.

Topuz, A., Topakci, M., Canakci, M., Akinci, I. and Ozdemir F. (2005). Physical and nutritional properties of four orange varieties. Journal of Food Engineering 66, 519-523.
Vursavus, K., Kelebek, H. and Selli, S. (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.

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