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Some physical properties of date fruit (cv. Dairi)

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A b s t r a c t. Most of the date fruit processing methods employed are 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. Objectives of this study are to present basic principles of physical properties of date fruit (cv. Dairi) in order to facilitate the design of some machines for its processing. Dry-basis moisture content of date fruit was found to be 10.45% (10.88% for pitted dates and 7.87% for their pits). Other results showed that linear dimensions varied from 29.8 to 40.2 mm in length, 15.7 to 20.2 mm in width, and 15 to 19.7 mm in thickness. Mean mass and volume of fruit were measured as 5.30 g and 5.49 cm^3, respectively. The projected areas along length (P_L), width (P_W) and thickness (P_T) were 262.71, 498.1, and 513.1 mm^2, respectively. The fruit density and pitted fruit density were measured as 0.97 and 1.18 g cm^{-3}, while bulk density and porosity were 0.49 g cm^{-3} and 49.14%, respectively. The geometric mean diameter, sphericity and surface area were obtained as 22.38 mm, 0.63, and 1577.84 mm^2, respectively. The mean coefficients of static friction were measured as 0.27, 0.32 and 0.4 on plywood, galvanized iron steel, and glass surfaces, respectively.

K e y w o r d s: date fruit, dimensions, physical properties, post-harvest processing

INTRODUCTION

Design of machines and processes for harvesting, handling and storage of agricultural materials and for converting these materials into food and feed requires an understanding of their physical properties.

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 modelling of heat and mass transfer during cooling and drying. Porosity, which is the percentage of air space 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. Many researchers have conducted experiments to find the physical properties of various fruits and crops. 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. 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. Also, Keramat Jahromi *et al*. (2007) obtained some physical properties of date (cv. Lasht).

The objectives of this study were to determine physical properties of date (cv. Dairi) to develop appropriate technologies for its processing. The development of the technologies will require knowledge of the properties of this fruit.

MATERIALS AND METHODS

In this study, the date fruit samples were selected from Dairi cultivar (Fig. 1) 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.

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Fig. 1. Date samples (cv. Dairi).

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 (1984) recommended method.

Mass of individual fruit was determined using an electronic balance with a sensitivity of 0.01 g. Fruit volumes were measured by the water displacement method. Fruits were weighed in air and allowed to float in water. Fruits were lowered with a needle into a beaker containing water and the mass of fruit in the water was recorded. Finally, fruit densities (g cm^{-3}) were calculated by using the following Eq. (1) (Mohsenin, 1986):

$$\rho_f = \frac{M_a}{M_a - M_w}\rho_w, \tag{1}$$

where: ρ_f – fruit density (g cm^{-3}), ρ_w – water density (g cm^{-3}), M_a – fruit mass in air (g), M_w – fruit mass in water (g).

Bulk density was determined using the mass/volume relationship Eq. (2) (AOAC, 1984; Owolarafe *et al.*, 2007) by filling an empty plastic container of predetermined volume and mass with fruits that were poured from a constant height, and weighed:

$$\rho_b = \frac{M}{V}, \tag{2}$$

where: ρ_b – the bulk density (g cm^{-3}), M – bulk mass of fruit (g), V – the plastic container volume (cm^3). This method was based on the work of Fraser *et al.*, (1978), Owolarafe *et al.* (2007), 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 percentages (Jain and Bal, 1997; Owolarafe *et al.*, 2007; Vursavus *et al.*, 2006):

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

Linear dimensions and also projected areas were determined by the image processing method. In order to obtain dimensions and projected areas, WinArea_UT_06 system (Mirasheh, 2006) was used (Fig. 2). The WinArea _UT_06 system comprises the following components:

– Sony photograph camera, model CCD-TRV225E,
– device for preparing media to picture taking,
– capture Card named Winfast, model DV2000,
– computer software programmed with visual basic 6.0.

Captured images from the camera are transmitted to the computer card which works as an analogue 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 has been used and reported by several researchers (Keramat Jahromi *et al.*, 2007; Khoshnam *et al.*, 2007). The 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 mutually perpendicular axes (Fig. 3).

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

$$D_g = (LWT)^{1/3}, \tag{4}$$

$$\Phi = D_g / L, \tag{5}$$

$$S = \pi D_g^2, \tag{6}$$

as reported by Kabas *et al.* (2006) and Mohsenin (1986).

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

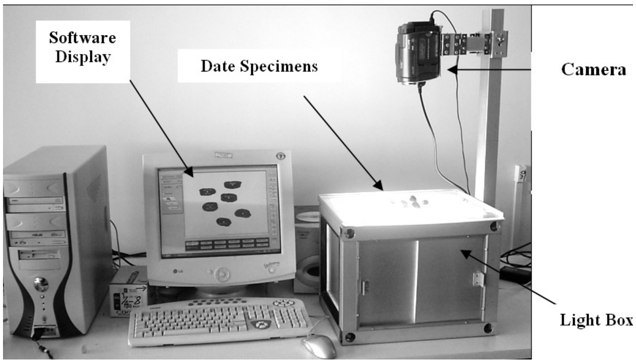

Fig. 2. WinArea_UT_06 system.

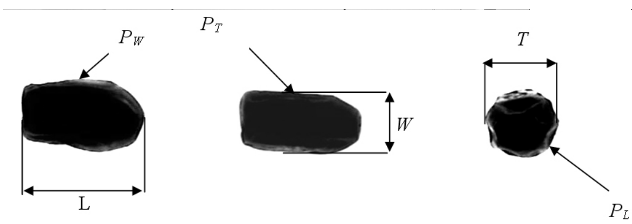

Fig. 3. Three major dimensions and projected areas of date fruit.

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).

RESULTS AND DISCUSSION

Dry-basis moisture content of date fruit samples was found to be 10.45% (10.88% for pitted dates and 7.87% for their pits). Results showed that mass and volume varied from 3.75 to 7.01 g and from 3.75 to 7.36 cm^3, with mean values of 5.3 g and 5.49 cm^3, respectively. Dimensions varied from 29.8 to 40.2 mm in length, 15.7 to 20.2 mm in width, and 15 to 19.7 mm in thickness, with average values of 35.68, 18.07, and 17.42 mm, respectively. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin (1986). These dimensions can be used in designing machine components and parameters. For example, they may be useful in estimating the number of fruits to be engaged at a time. The major axis has been found to be useful by indicating the natural rest position of the fruit. The mean projected areas along length, width, and thickness were obtained as 262.71, 498.1 and 513.1 mm^2, with variation of 198 to 342, 365 to 632, and 396 to 633 mm^2, respectively. Whole fruit density and pitted fruit density were measured and found to be between 0.82 to 1.09 and 1.17 to 1.19 g cm^{-3}, and with average values of 0.97 and 1.18 g cm^{-3}, respectively. Bulk density and porosity obtained were found to be 0.49 g cm^{-3} and 49.14%, respectively. The geometric mean diameter, sphericity and surface area varied from 19.54 to 25.03 mm, 0.58 to 0.69, and 1200.04 to 1968.26 mm^2, while mean values were 22.38 mm, 0.63, and 1577.84 mm^2, respectively. Also, values of mean coefficient of static friction on plywood, galvanized iron steel, and glass surfaces were obtained as 0.27, 0.32 and 0.40, respectively. Results of analysis showed that the surface of materials had a significant difference ($p<0.01$) on the static coefficient of friction. The static coefficient of friction on galvanized iron steel was higher than that on plywood and lower than that of glass 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.

T a b l e 1. Some physical properties of date fruit (cv. Dairi)

Properties		Number of observations	Values			Standard deviations
			Minimum	Maximum	Mean	
Mass (g)		100	3.75	7.01	5.30	0.65
Volume (cm^3)		100	3.75	7.36	5.49	0.79
Length, *L* (mm)		100	29.80	40.20	35.68	2.18
Width, *W* (mm)		100	15.70	20.20	18.07	0.97
Thickness, *T* (mm)		100	15.00	19.70	17.42	0.94
Projected area along, *L* (mm^2)		100	198.00	342.00	262.71	27.14
Projected area along, *W* (mm^2)		100	365.00	632.00	498.10	50.31
Projected area along, *T* (mm^2)		100	396.00	633.00	513.10	51.84
Fruit density (g cm^{-3})		100	0.82	1.09	0.97	0.06
Pitted density (g cm^{-3})		4	1.17	1.19	1.18	0.01
Geometric mean diameter (mm)		100	19.54	25.03	22.38	1.07
Sphericity (%)		100	0.58	0.69	0.63	0.02
Surface area (mm^2)		100	1200.04	1968.26	1577.84	149.67
Bulk density (g cm^{-3})		3	0.46	0.53	0.49	0.04
Porosity (%)		3	45.00	52.00	49.00	3.00
Static coefficient of friction	Plywood	3	0.25	0.29	0.27	0.02
	Galvanized iron steel	3	0.31	0.34	0.32	0.02
	Glass	3	0.38	0.42	0.40	0.02

CONCLUSIONS

1. Mass and volume varied from 3.75 to 7.01 g and from 3.75 to 7.36 cm^3.

2. Dimensions varied from 29.8 to 40.2 mm in length, 15.7 to 20.2 mm in width, and 15 to 19.7 mm in thickness.

3. Fruit density and pitted fruit density found to be between 0.82 to 1.09 and 1.17 to 1.19 g cm^{-3}.

4. Bulk density and porosity obtained were found to be 0.49 g cm^{-3} and 49.14%.

5. Geometric mean diameter, sphericity and surface area varied from 19.54 to 25.03 mm, 0.58 to 0.69, and 1200.04 to 1968.26 mm^2.

6. The static coefficient of friction on galvanized iron steel was higher than that on plywood and lower than that of glass surface.

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