PHYSICAL PROPERTIES OF DATE PALM FRUIT OF KUTCHH REGION, GUJARAT STATE

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ABSTRACT

Date palm (Phoenix dactylifera L.) belonging to the family of Arecaceae. The date palm is grown in Kutchh region of Gujarat. The physical properties of dates fruits are necessary for the design of the equipment to handle, transport, process and storage. In this study some physical properties of dates fruits determined as a function of moisture content namely, dimensions, arithmetic and geometric mean diameter, sphericity, surface area, 1000 unit mass, bulk density, true density, porosity, angle of repose and coefficient of static friction. The average axial dimensions length, width and thickness were 33.65, 22.12 and 20.02 mm at a moisture content of 69.5 per cent (W.B.), respectively. In the moisture content from 61.56 to 69.5 per cent (W.B.), studies on fresh date fruits showed that the arithmetic mean diameter increased from 25.03 to 25.26 mm, geometric mean diameter increased from 24.41 to 24.60 mm, thousand date fruits mass increased from 8388 to 8476 g, surface area from 1870.96 to 1900.20 mm^2 and angle of repose from 18.76 to 21.34^o. The bulk density decreased from 491 to 477 kg/m^3, true density from 576 to 533 kg/m^3, porosity from 14.75 to 10.56 per cent and sphericity from 0.737 to 0.731. The static coefficient of friction was least in case of steel and glass, while it is highest for wood.

KEY WORDS: Date palm, kutchh, physical properties

INTRODUCTION

Date palm is the fruits grown on the palm tree belonging to the family of Arecaceae in the genus: *Phoenix* and scientifically named as *Phoenix dactylifera*. Kutchh is the largest Date - palm producing region in India, with a whopping total area under Date-palm farming of 16,000 hectare and production of 1.2 lakh tones (Anonymous, 2012). Pakistan and India hold a significant position in international Dates market, former as a second largest exporter and later being the largest importer of dates. In the western border of India and the coastal belt of Kutchh district of Gujarat contributes about ninety per cent to the total date production of India. More than 1.5 million date palm trees are present in Kutch, spread widely from Anjar to Mandvi including Mundra and other areas (Anonymous, 2017). This seed propagated population represents a huge biodiversity of date palm with fruits of varying qualities. Government initiatives to promote date palm culture especially in Gujarat and Rajasthan states leads to significant increase in area and production of date palm during the last 15 years. In Kutch, for example, the area under cultivation increases from 8,973 ha to 16,000 ha during last ten years. Date Palm Research Centres at Mundra in Kutch, Bikaner and Jodhpur in Rajasthan, Hissar

in Haryana and Abohar in Punjab are working for the promotion of date palm in their respective regions. There is a need for a comprehensive study of the physical properties of date to develop appropriate technologies for its processing.

The development of the technologies will require the properties of this fruit. 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. Date (*Phoenix dactylifera*) is well known for its nutritional contents. It contains 1.9 per cent protein, 70.6 per cent carbohydrates, 2.5 per cent fat, 1.2 per cent minerals and 10 per cent fiber (Mohammad *et al*., 2007). The dates are considered as prime fruit for their nutritional and therapeutic value.

MATERIALS AND METHODS

Physical properties of date fruits

Fresh dates which was harvested in the month of June of variety Zahidi was considered for the study. About 500 kg fresh date of variety zahidi was procured from Main Date Palm Research Station, S.D. Agricultural University, Mundra (Kutchh). Five samples having 100 g. weight were drawn randomly and initial moisture content of fresh date was determined. The dates were cleaned and washed. The dates were sorted by manually to remove foreign matters, leaves and immature dates.

The physical properties of fresh date fruits such as size in terms of length, breadth and thickness, arithmetic mean diameter, geometric mean diameter, sphericity, bulk density, true density, porosity, angle of repose and coefficient of static friction were determined. Ten experiments were carried out for ten replications.

Measurement of size

A sample of randomly selected hundred fruits was used to determine the average size of date fruit at each moisture content level. Mass of individual fruit was determined using an electronic balance with a sensitivity of 0.01 g. Fruit volume was measured by water displacement method. The principal dimensions of date fruits in terms of length, breadth and thickness were measured with help of Vernier calipers (Mitu and Toyo, Japan) of accuracy up to 0.01 mm. The longest dimension in the longitudinal direction was considered as length. The triaxial dimensions are measured for 100 fruits randomly selected from the bulk of date fruits. The average values of 100 observations are reported.

Arithmetic and geometric mean diameter

For determination of arithmetic and geometric mean diameter of dates fruit, values of length, width and thickness were used.

Sphericity

For determination of sphericity of date fruit is considered to be a triaxial ellipsoid with length, width and thickness as intercepts, respectively. Sphericity of date fruit was calculated using following formula (Mohsenin,1980).

$$\text{Sphericity } (ø) = \frac{(LWT)^{1/3}}{L}$$

Surface area

The surface area of date fruit was determined by analogy with a sphere of the some geometric mean diameter using the following equation.

$$\text{Surface area} = \pi Dg^2$$

One thousand fruit mass

To evaluate the 1000 fruit mass, 10 randomly selected fruits from each moisture level are weighed on a digital electronic balance (K Roy Electronics) having an accuracy of 0.001 g.

Bulk density (ρb)

Bulk density as the ratio of weight of fruits to the volume occupied by the same fruits was measured with help of two cylinders having volume of 1000 and 1500 ml. The bulk density was expressed in kg/m^3.The bulk density of the fruits was determined as follow.

$$\rho b = M/V$$

True density (ρt)

The true density as a function of water content was determined using the toluene displacement method in order to avoid absorption of water during experiment. Toluene was used instead of water because it is less absorbed by fruits, its surface tension is low so that it fills even shallow dips in fruits, its dissolution number is low (Mohsenin,1980). The fruits were used to displace toluene in a measuring cylinder after their masses have been measured. The true density was found as an average of the ratio of their masses to the volume of toluene displaced by the fruit.

Porosity

The porosity is the fraction of the space in the bulk fruits which is not occupied by the fruits. The porosity of bulk fruit was calculated from the values of true density and bulk density using the relationship given by Mohsenin (1980) as follow.

£, % = (1- ρb / ρt) x 100

Angle of repose

The angle of repose is the characteristic of the bulk material which indicates the cohesion among the individual fruits. If higher cohesion between fruits is observed, then the high value of angle of repose is obtained. The angle of repose is the angle from the horizontal at which the material will rest in a pile (Pradhan *et al.,* 2009). The angle of repose of date palm was determined by standard circular platform method. The box having circular platform fitted inside was fitted with fruit. The extra fruit surrounded the platform was remove through discharge hole leaving a free standing cone of fruits on the circular platform. A stainless steel scale was used to measure the height of the cone and angle of repose was calculated by this formula.

$Q = Tan^{-1} (2h)/d$

Coefficient of static friction

The experiment for determination of static coefficient of friction was performed of date fruit using test surfaces against wood, steel and glass surfaces with five replications. Experiment was performed on a tilting platform of 350 mm x 120 mm. An open ended plastic cylinder having 65 mm diameter and 40 mm height was filled with the fruit and placed on the adjustable tilting surface. The platform was raised slightly, so as not to touch the table surface. The platform was inclined gradually with a screw device until the cylinder just started to slide down. The tangent of angle was taken as coefficient of static friction between the surface and date fruits given by μ as under.

μ = tan¢

RESULTS AND DISCUSSION

Physical properties of fresh date fruits at different moisture level is given in Table 1.

Dimensions of date fruits

The dimensions of the fruits are important for drying and storage studies of date fruits. Apart from that, the dimensions could be useful for determining the shape of the fruits. The average dimensions of date palm fruit at different moisture content are presented in Table 1. The mean value of three axial dimensions of 100 fruits measured in one replication at 69.50 and 61.56 per cent moisture content (w.b.) were length : 33.65 and 33.12 mm, width: 22.12 and 22.03 mm, and thickness : 20.02 and 19.95 mm. It was found that the thickness and breadth were very close to each other while the length was higher due to its shape of the date fruits. Jahromi (2007) studied the linear dimensions varied from 33.10 to 42.60 mm in length, 18.20 to 25.30 mm in width and 17.40 to 24.40 mm in thickness. The dimension of the fruit in this study was similar to the other varieties of date fruit studied by Ali *et al*. (2003), Jahromi *et al.* (2007), Ndubisi *et al*. (2015) and Davies (2016). The relationships between the axial dimensions (L, B and T) can be expressed using the regression equation as :

$L=4.2091M-75.97$, $R^2 =0.3156$..... **(i)**

$B=4.69M-34.75$, $R^2 =0.7277$……..... **(ii)**

T=3.14M +2.2083, R^2 =0.7579……**(iii)**

Arithmetic and geometric mean diameter of date fruits

Results indicated that as moisture content increased, the average diameter of fruit is also increased. The arithmetic and geometric mean diameter of fresh date fruit ranged from 24.29 -26.59 mm and 23.51 - 25.96 mm, respectively (Table 1). The results of arithmetic and geometric mean diameter of date fruit in this study was similar to the other varieties of date fruit by Ali *et al*. (2003), Jahromi *et al.* (2007), Ndubisi *et al*. (2015) and Davies (2016). The arithmetic mean diameter and geometric mean diameter are important in designing of separating, harvesting, sizing and grinding machine. The relationships between the arithmetic mean diameter and geometric mean diameter and fruit moisture content can be expressed using the regression equation as

D_a=4.61M-49.80, R^2 =0.7268…….. **(iv)**

D_g=4.33M-40.25, R^2 =0.7496……... **(v)**

Sphericity

The value of sphericity for different moisture content varied from 0.730 to 0.737 (Table-1). This parameter is most important in designing in hopper to handle the fruit. It indicates that date fruit is oval to cylindrical in shape. On the contrary, the date fruit could be as cylindrical considering the close value of breadth and thickness, both quite low as compared length of the date fruit. However, the exact shape of the date fruit can be described as ‘´oval to cylindrical with thickest portion in both end. The shape of the date fruit in this study found similar to Ali *et al*. (2003), Jahromi *et al.* (2007), Ndubisi *et al*. (2015) and Davies (2016). The relationship between sphericity and moisture content of date fruit can be represented by following equation.

Ø=219.29M-93.25, R^2 =0.7899…… **(vi)**

Surface area

In present investigation, calculated data for the surface area of fresh date fruit has been presented in Table 1. The surface area of the date fruit increased from 1870.96 to 1900.20 mm^2 as moisture content increased from 61.56 to 69.5 % (w.b.). Similar trend have been also reported by Ali *et al*. (2003), Jahromi *et al.* (2007), Ndubisi *et al*. (2015) and Davies (2016).The relationship between surface area of date fruit and moisture content can be expressed by the following relationship.

S_a=0.0283M+12.76, R^2 =0.7297…… **(vii)**

One thousand fruit mass

As seen in the Table1, one thousand date fruits mass showed an increment from 8388 to 8476 g with increasing the moisture content in the range of 61.56 to 69.5 per cent. The weight of one fruit of date was 8.48 g. The weight of flesh date fruit was 7.24 g and weight of date pit was 1.24g. The percentage of flesh and pit were 85.37 per cent and 14.63 per cent, respectively. The flesh and pit ratio was 5.84:1. Similar trend have been reported by Ali *et al*. (2003), Jahromi *et al.* (2007), Ndubisi *et al*. (2015) and Davies (2016). The relationship between one thousand fruits mass and moisture content of the date can be expressed by the following relationship.

M_{1000}=0.0069M + 7.31, R^2 =0.6755... **(viii)**

Bulk density

The values of bulk density of the date fruits at different moisture content are calculated are presented in Table 1. The bulk density varied from 491 to 477 kg/m^3 indicated a decreasing trend with increase in the moisture content from 61.56 to 69.5 per cent (w.b.). Davies (2016) reported that the bulk density of date was 512.91 kg/m^3. Similar trend have also been reported Ali *et al*. (2003), Jahromi *et al.* (2007) and Ndubisi *et al*. (2015). They also reported that the bulk density of the date fruit increased with the moisture content decreased. The relationship between bulk density and moisture content of the date can be expressed by the following relationship.

$Þ_b$=-10.26M+112.73, R^2 =0.6023… **(ix)**

True density

The value of true density of the date fruits at different moisture content are calculated and presented in Table 1. The true density decreased from 576 to 533 kg/m^3, when the moisture content increased from 61.56 to 69.5 per cent (w.b.). Davies (2016) reported that the true density of date was 953.71 kg/m^3. Similar trend have also been reported Ali *et al*. (2003), Jahromi *et al.* (2007) and Ndubisi *et al*. (2015). The relationship between true density and moisture content of the date can be expressed by the following relationship.

Þ$_t$=-01754M+ 163.75, R^2 =0.6274……**(x)**

Porosity

The value of porosity of the date fruits at different moisture content are calculated and presented in Table 1. The porosity varied from 10.56 and 14.75 per cent in the moisture content in the range of 61.56 and 69.5 per cent (w.b.). The porosity of date fruit is important because it shows the resistance of the fruits to air flow during drying process. Davies (2016) reported the porosity of date was 34.10 per cent. Similar trend have also been reported Ali *et al*. (2003), Jahromi *et al.* (2007) and Ndubisi *et al*. (2015). The relationship between porosity and moisture content of the date can be expressed by the following relationship.

£=06559M+ 53.77, R^2 =0.343…… **(xi)**

Angle of repose

The variation of the angle of repose with moisture content is given in Table 1. The angle of repose increase 18.76 to 21.34^o as moisture content increases from 61.56 to 69.5 per cent. Ndubisi *et al*. (2015) reported that the angle of repose of fruit and kernel was found to be 19.82^o and 34.94^o (digila), 18.07^o and 33.36^o (krikri), 21.93^o and 29.0^o (sukur) and 25.49^o and 20.93^o (trigal). The relationship between angle of repose and moisture content of the date can be expressed by the following relationship.

¢=0.8714M + 48.67, R^2 =0.2484 …… **(xii)**

Coefficient of static friction

The coefficient of static friction of date fruit against three types of structural surfaces was determined. The results are shown in Table 1. It was found that the coefficient of static friction of date fruits varied from 0.31-0.35 (wood surfaces), 0.30-0.33 (steel surfaces) and 0.25-0.27 (glass surfaces). Wood sheet had the highest static coefficient friction, because it had greatest surface roughness with respect to other structural materials. This parameter is important for designing pneumatic conveying systems, screw conveyors, hoppers. It is also used in the calculation of compressibility and flow behaviour of materials used for designing seed bins and other storage structures (Davis, 2016). The coefficient of static friction is higher in case of wood followed by steel and glass, which indicated that glass and steel had relatively smother surfaces. The relationship between coefficient of static friction and moisture content of the date can be expressed by the following relationship.

μ_w=283.57M-28.04, R^2 =0.7143…… **(xiii)**

μ_s=397M-57.54, R^2 =0.6…… **(xiv)**

μ_g=397M-37.69, R^2 =0.4…… **(xv)**

CONCLUSION

The average length of the fresh Zahidi variety of date fruit was 33.65 mm; breadth was 21.68 and thickness was 20.56 mm. It was found that the thickness and breadth were very close to each other, while the length was higher due to its shape of the date fruits. The average value of the surface area of the date fruit was obtained 1886.32 mm^2. The weight of one fruit of date was 8.48 g.The weight of flesh date fruit was 7.24 g and weight of date pit was 1.24 g. The percentage of flesh and pit were 85.37 per cent and 14.63 per cent, respectively. The average value of bulk density was 460 kg/m^3. The average value of true density was 560 kg/m^3. The average value of porosity was 20.7 per cent. The angle of repose increase 15.23-22.37^o, as moisture content increases from 61.56 to 69.5 per cent. The

average values of angle of repose of date fruit was 19.34^{o}. The average value of coefficient of static friction were 0.33 (wood surfaces), 0.31 (steel surfaces) and 0.26 (glass surface), respectively.

REFERENCES

Ali, I. H.; Amar Nishad, M. T. and Khaled, A. M. A. (2003). Development of a neural network classifier for date fruit varieties using some physical attributes. *Res. Bull., Agric. Res. Center, King Saud Univ.*, 126: 5-18.

Anonymous (2012). The Gujarat : An English Quarterly Magazine. 3(2): 20. (http://gujaratinformation.net/downloads/guj_pak_july_2012.pdf).

Anonymous (2017). https://agrihunt.com/articles/horti-industry/comparative-analysis-of-date-palm-culture-in-india-and-pakistan/

Davies, R. M. (2016). Studies on some post harvest engineering properties date palm fruit and kernel in relevant to primary processing. *J. Sci. Res. Eng. Technol*., 1(1): 1-13.

Jahromi, M. K.; Jafari, A.; Rafiee, S.; Keyhani, A. R.; Mirasheh, R. and Mohtasebi, S. S. (2007). Determining some physical properties of date fruit (cv. Lasht). *Agric. Eng. Int*.: *The CIGR Ejournal*, 8: 7-19.

Mohammad, A.; Shahzad, Z. and Ahmad, Y. A. (2007). Dates, an important export commodity. Business Recorder, Weekend Magazine. 21st July, 2007. Lahor, Pakistan.

Mohsenin, N. N. (1980). Physical properties of plant and animal materials. Gordon and Breach Science publishers, New York.

Ndubisi, A. A.; Mary, E. O. and Abubakar, A. L. (2015). Moisture dependent physical properties of *Detarium microcarpum* seed. *Agric. Eng. Int: CIGR J.*, 17(4): 311-326.

Pradhan, R. C.; Naik, S. N.; Bhatnagar, N. and Vijay, V. K. (2009). Moisture-dependent physical properties of jatropha fruit. *Industrial Crops Products*, 29: 341-347.

Table1: Physical properties of fresh date fruits

Physical Property	Moisture Content (%w.b.)	
	69.50	**61.56**
Length(mm)	33.65	33.12
Breadth (mm)	22.12	22.03
Thickness (mm)	20.02	19.95
Arithmetic mean, mm	25.26	25.03
Geometric mean, mm	24.60	24.41
Sphericity	0.730	0.737
Surface Area, mm^2	1900.20	1870.96
Bulk density, kg/m^3.	477	491
True density, kg/m^3	533	576
Porosity,%	10.56	14.75
1000 fruit mass, g	8476	8388
Angle of repose, in degree	21.34	18.76
Coefficient of static friction		
wood	0.34	0.31
steel	0.32	0.27
glass	0.26	0.24

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