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# Determination of Some Physical and Mechanical Characteristics of Date Fruit and Nut (Cv. Mazafati)

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Knowing some physical and mechanical characteristics is an important factor for automating the activities associated with the date. Some physical and mechanical characteristics of date fruit and its nut were evaluated (Mazafati variety). Date samples mean values of width, length, thickness, projected area perpendicular to width, length and thickness were measured as, 22.73mm , 34.60mm, 18.15mm, 710.78mm2, 411.32mm2, 732.21mm2 respectively. Geometric mean diameter, arithmetic mean diameter, sphericity, surface area, porosity, mass, volume, bulk density and true density were also measured as: 24.21mm, 25.16mm, 70%, 1840.80 mm2, 48.67%, 13.10kg, 11.23 cm3, 0.63gr cm-3, 1.17gr cm-3. In mass modeling, results showed that date volume has the highest correlation (0.88) with mass, and then the arithmetic mean diameter has the highest correlation of (0.82). Date thickness correlation index was very low with mass (0.22). The maximum and minimum deformation force for date samples was found perpendicular to length and thickness direction by average values of 11.52N and 8.02N. Deformation force showed decline procedure with its pressure in direction of length, width and thickness. Results also showed that the rotation coefficient of friction was more than static coefficient of friction and static coefficient of friction was more than dynamic coefficient of friction. Highest coefficient of friction was on the rubber surface and lowest on the galvanized steel surface.

**Keywords:** Date fruit, nut, physical and mechanical characteristics, Mazafati variety

## Introduction

Iran is the second world producer with 31% date production. Mazafati is the most valuable variety (Anon, 2012).To develop appropriate equipment for harvesting, handling, conveying cleaning, delivering, separating, packing, storing, drying and processing of agricultural products, the detailed knowledge of physical properties of crops are essentia (Davies and EI-Okene, 2009; Aviara *et al*., 1999). Most of the date fruit post-harvest processing methods employed is still traditional. Therefore there is a need for a full study of the physical properties of the dates to develop appropriate technologies for its processing.

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Some physical properties have been studied for various agricultural products fruits and crops by other researchers such as soybean (Manuwa and Afuye, 2004), bambara groundnut (Adejumo *et al*., 2005), caperfruit (Capparisspp) (Sessiz *et al*., 2005), cocoa bean (Bart-Plange and Baryeh, 2003), pigeon pea (Shepherd and Bhardwaj, 1986), locust bean seed (Ogunjimi *et al*., 2002), plum (Ertekin *et al*., 2006), gumbo fruit (Akar and Aydin, 2005), wheat (Tabatabaeefar, 2003), nutmeg (Burubai *et al*., 2007), pistachio nut and its kernel (Razari *et al*., 2007), arigo seed (Davies, 2010), and palm fruit, kernel and nut (Davies, 2012). Tabatabaeefar (2002) determined the physical properties of common varieties of Iranian grown potatoes and the relationships among their physical characteristics. Topuz *et al* (2005) compared several properties of four orange varieties. Tabatabaeefar and Rajabipour (2005) used 11 models for predicting mass of apples based on geometrical features. Asoegwu *et al* (2006) determined some physical properties of African oil bean seeds to obtaining relevant data for the design of tools, equipment, machines and systems for their processing. Kermat Jahromi *et al* (2007) determined dimensions and projected areas of date (Barhi variety) by image processing technique.

**Objectives:** The objectives of this study is to determine some physical and mechanical properties of Mazafati date fruit in order to facilitate the design of some machines for its processing. In addition an attempt was made to model relationships between mass and other features.

## Materials and methods

In this study, about 1000 Mazafati date samples in Rotab ripenning stage were selected from local markets in Saravan (important city in Mazafati date production in Iran). At this stage fresh dates are at their best. The hard skin begins to soften at the tip and turn brown, (moving up?) the fruit as they continue to ripen. As the fruit softens, the tannins break down and the dates become juicier and sweeter. The fruits were transported, individually to the physical laboratory. All experiments were carried out at a temperature range of 23–29 ℃ in four days. In order to obtain the moisture content, samples were kept in an oven for 3 days at 105 ℃. The moisture content were found 81.9% w.b. for fruit and 24.5% w.b. for nuts.

The principal axial dimension (Figure 1), the length (L), width (W) and thickness (T) for 1000 randomly fruits and nuts of samples were measured using a digital caliper with an accuracy of 0.01 mm.

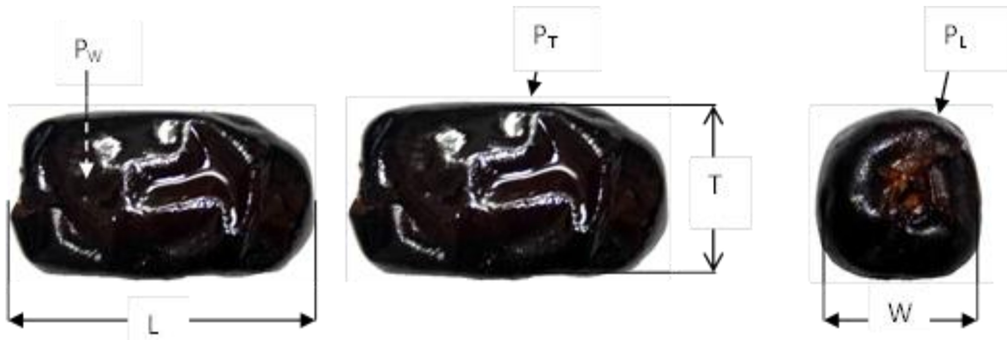


**Figure 1.** Three major dimensions and projected areas of Mazafati date fruit

The geometric mean diameter (Dg), arithmetic mean diameter (Da) porosity (packing factor), bulk density, sphericity(f), surface area (S) of the varieties were calculated using the formula given by Mohsenin (1986). The arithmetic mean diameter (AMD), and geometric mean diameter (GMD), were calculated using expressions given by Asoegwu *et al*. Mohsenin and Eke *et al* (2007). The volume of fruit and nut for the samples were calculated using the expression given by Mohsenin (1986). The true density was determined using toluene displacement method (Bagherpour *et al.*, 2010). The porosity was computed from the values of the true and bulk density of samples by using the relationship given by Gharibzahedi *et al* (2010). The static coefficients of friction were obtained with respect to four surfaces of aluminum, galvanized steel, rubber and plywood. The experiment was done by using an inclined plane device 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; Gharibzahedi *et al.*, 2010).

Projected areas, were determined by image processing method. To obtain projected areas, WinArea- _UT_08 system (Mirasheh, 2006) was used. 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 1.5%. This method have been used and reported by several researchers (Rafiee *et al.*, 2006, Kermat Jahromi *et al.*, 2007 and Khoshnam *et al.*, 2007).

Rupture stresses along three major dimension of date samples were measured by a texture analyzer machine (Universal Testing Machine). A date sample was compressed between two parallel plates of the machine along the three axes until rupture occurred (rupture point). At this moment deformation force was recorded. The absorbed energy by the sample at rupture was determined by calculating the area under the force-deformation curve using the formula given by (Bagherpour *et al*., 2010). The average toughness were calculated by dividing the average deformation energy on volume (Mohsenin, 1986). The results are shown in Table 1. Regression analysis was carried out using Microsoft Excel 2007 software to determine the relationship between mass and other physical properties.

## Results and Discussion

The average dry-basis moisture content of date fruit samples was found to be 25.78% (dry-basis). Results showed that mass and volume varied from 8.68 to 18.20g and from 7.01 to 16.04g/cm3 with mean values of 13.10g and 11.23g/cm3, respectively. The averages of the tri-axial dimensions of the fruits and nuts are given in Tables 2 and 3. For date fruits, dimensions varied from 25.10 to 41.62mm in length, 19.05 to 27.32mm in width, and 12.02 to 23.21 mm in thickness. The average projected areas perpendicular to length, width, and thickness were obtained as 411.32, 710.78 and 732.21 mm2. The average values of true density, bulk density and porosity were found as 1.17 g/cm3, 0.63 g/cm3 and 48.67%, respectively. The arithmetic and geometric mean diameter, varied from 21.00 t0 28.67mm and 20.52 to 25.17 mm with mean values of 25.16 and 24.21mm respectively. Sphericity and surface area varied from 0.63% to 0.74%, and 1322.12 to 2491.87 mm2 while mean values were 0.69%, and 1840.80 mm2, respectively. Mean coefficient of static, dynamic and rotation friction, on galvanized steel, plywood, rubber and aluminum surfaces, has been shown in Figure 2. Result of analysis showed that the static, dynamic and rotation coefficient of friction for dates and nuts on rubber surface were higher than plywood, aluminum and galvanized steel surfaces.

**Table 1.** Some mechanical properties of date fruit (Mazafati variety)

| | **The average deformation force (N)** | **The average rupture stress (Mpa)** | **The average deformation energy (mj)** | **The average toughness ($j/mm^3$)** |
|---|---|---|---|---|
| Along length direction | 11.252 | 0.0423 | 22.5 | 2.332 |
| Along width direction | 8.193 | 0.0112 | 21.43 | 2.135 |
| Along thickness direction | 8.025 | 0.0123 | 21.65 | 2.113 |

**Table 2.** Some physical parameters of date fruit (Mazafati variety)

| properties (date) | min | max | mean | Equations | $R^2$ |
|---|---|---|---|---|---|
| Length(mm) | 25.10 | 41.62 | 34.60 | $M = 2.775e^{0.0444L}$ | 0.73 |
| Width(mm) | 19.05 | 27.32 | 22.73 | M = 20.16Ln(W) - 49.807 | 0.54 |
| Thickness(mm) | 12.02 | 23.21 | 18.15 | M = 0.5408T + 3.2824 | 0.22 |
| Projected area perpendicular to L ($mm^2$) | 342.21 | 568.09 | 411.32 | | |
| Projected area perpendicular to W ($mm^2$) | 525.23 | 890.90 | 710.78 | | |
| Projected area perpendicular to T ($mm^2$) | 544.43 | 908.06 | 732.21 | | |
| Arithmetic mean diameter(mm) | 21.00 | 28.67 | 25.16 | $M = 0.016 D_a^{2.0774}$ | 0.82 |
| Geometric mean diameter(mm) | 20.52 | 25.17 | 24.21 | $M = 0.0265 D_g^{1.9431}$ | 0.73 |
| Sphericity (%) | 61 | 86 | 70 | $M = 0.0022 m^2 - 0.06 \phi + 1.14$ | 0.23 |
| Surface area $(mm^2)$ | 1322.12 | 2491.87 | 1840.80 | M = 12.399Ln(S) - 80.039 | 0.72 |
| Porosity (%) | 45.65 | 51.69 | 48.67 | $M = 0.4567\varepsilon + 12.20$ | 0.68 |
| Mass (gr) | 8.68 | 18.20 | 13.10 | | |
| Volume ($cm^3$) | 7.01 | 16.04 | 11.23 | $M = 4.9376e^{0.0854V}$ | 0.88 |
| Bulk density $(grcm^{-3})$ | 0.64 | 0.69 | 0.63 | $M = 0.5634 \rho_b + 17.70$ | 0.79 |
| True density $(grcm^{-3})$ | 1.01 | 1.40 | 1.17 | $M = 0.0045 \rho_t^2 - 0.113 \rho_t + 1.862$ | 0.54 |

**Table 3.** Some physical parameters of date fruit nut (Mazafati variety)

| properties (nut) | min | max | mean | Equations | $R^2$ |
|---|---|---|---|---|---|
| Length(mm) | 15.50 | 26 | 21.48 | M = 1.3818Ln(L) - 3.3524 | 0.69 |
| Width(mm) | 5.50 | 10.50 | 8.25 | M = 1.1787Ln(W) - 1.601 | 0.57 |
| Tickness (mm) | 3 | 8.5 | 6.29 | $M = 0.1075T^{1.136}$ | 0.57 |
| Arithmetic mean diameter(mm) | 8.33 | 14.50 | 12 | $M = 0.0028 \times D_a^{2.3074}$ | 0.89 |
| Geometric mean diameter(mm) | 6.60 | 12.41 | 10.34 | $M = 0.0073 \times D_g^{2.0444}$ | 0.84 |
| Sphericity (%) | 0.38 | 0.64 | 0.48 | $M = 0.02\ln(\varphi) + 0.486$ | 0.02 |
| Surface area $(mm^2)$ | 136.94 | 483.54 | 335.81 | $M = 0.0023 S^{1.0222}$ | 0.80 |
| Porosity (%) | 38.2 | 47.1 | 42.5 | $M = 0.0028 \varepsilon^{2.3074}$ | 0.45 |
| Bulk density $(grcm^{-3})$ | | | | $M = 0.2368 \rho_b + 32.21$ | 0.66 |
| True density $(grcm^{-3})$ | | | | $M = 0.1344 \rho_t + 24.22$ | 0.62 |

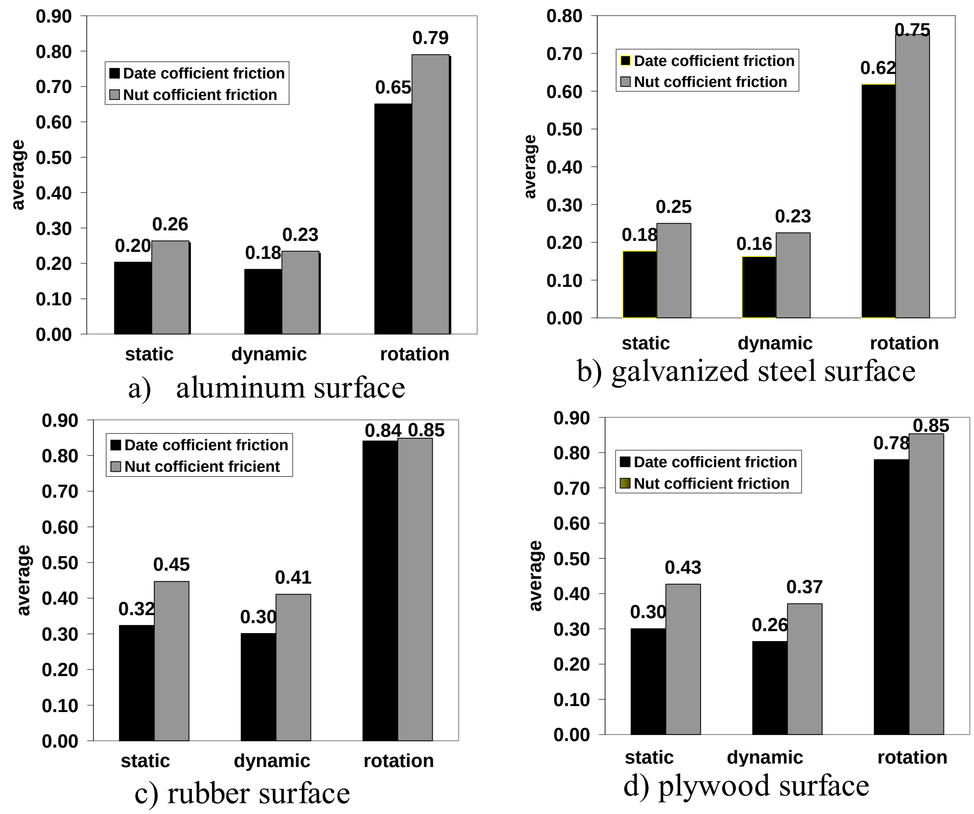


**Figure 2.** Coefficient of friction of dates and nuts on different surfaces

Date fruit affluence results in Figure 3. Showed that about 43% of date samples had length of 32 to 36 mm, 40% of date samples had width of 21 to 23 mm, 71% of dates had thickness of 16 to 20 mm and 56% of dates had mass of 10 to 14 gr. These results for the nuts was also showed that 57% of nut samples had length of 21 to 24 mm, 70% of nut samples had width of 7 to 9 mm, 67% of dates had thickness of 5 to 7 mm and 52% of dates had mass of 0.8 to 1.1 gr. The importance of these results is discussed in the discussion section. It was found that the projected area, perpendicular to thickness, showed higher values than that of other areas.

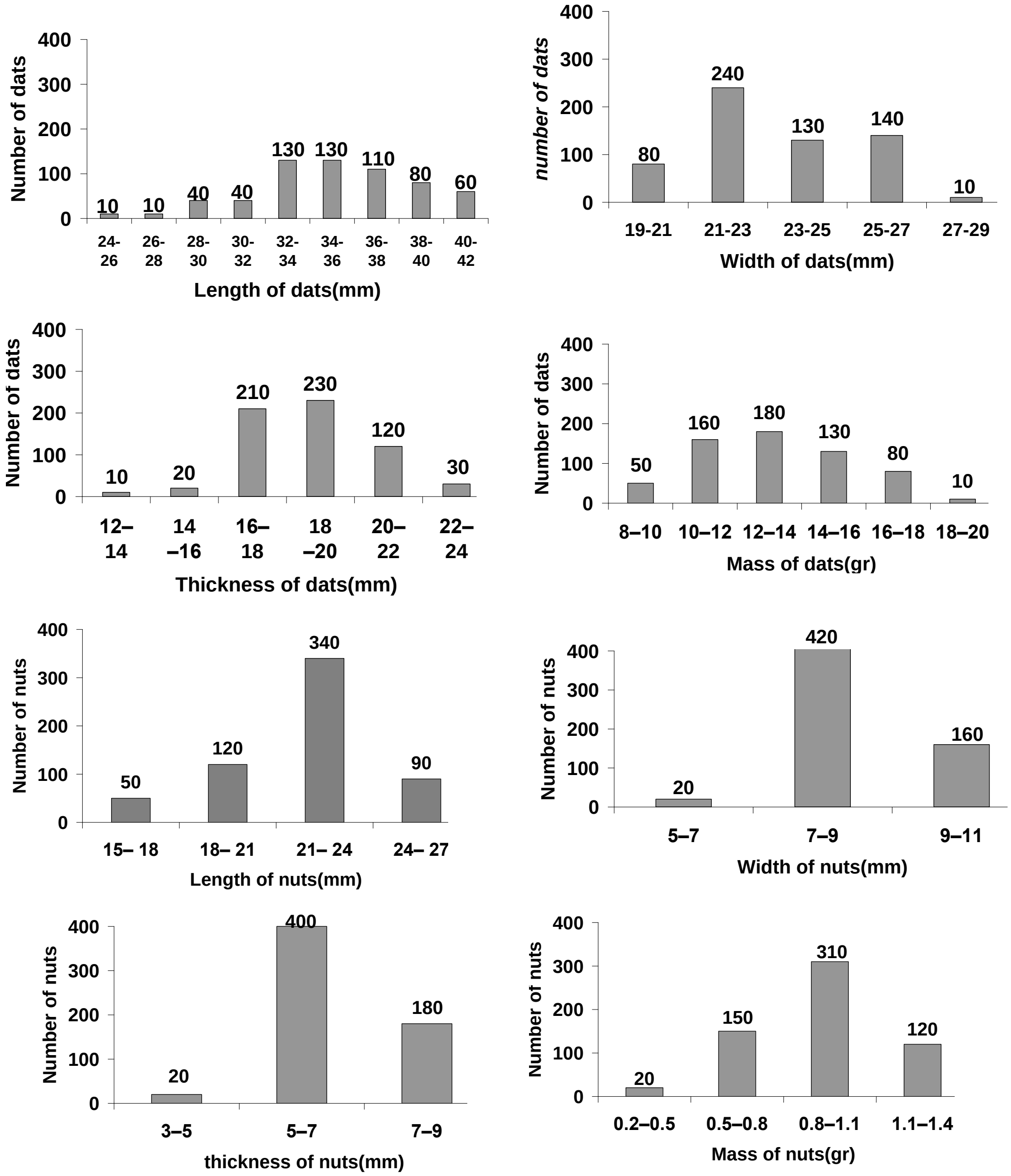


**Figure 3.** Affluence of some physical properties of dates and nuts in different measurements

The results of physical properties are especially important for manufactories in designing of post harvest machines, for example one of the most important machines in date sorting industry is worked based on size of date fruits, these results can help to design improved sorter machines for different varieties of dates and can help to factories to produce packaging system in different size.

The importance of dimensions is in determining the aperture size of different machines in harvesting and post harvest industry as discussed by Mazloumzadeh *et al* (2008), they used some dimensional properties of date fruit for developing a fuzzy inference system for evaluation of alternative date harvesting machines. Mazloumzadeh *et al* (2009) was also used some dimensional properties of dates for applying precision agriculture in a date palm orchard. The major dimensions can also be used in separation of materials as discussed by Mohsenin (1986). Alavi (2012) used two parameters of length and freshness for classifying Mazafati date fruit. Major dimensions may be useful in estimating the number of fruits to be engaged at a time. Tabatabaeefar *et al* (2000), reported that among the systems that sorted oranges based on one dimension, the system that applies intermediate diameter is suitable with nonlinear relationship.

Weight of fruit is another important characteristic that can be used in advance in post harvest industry. Customers choose fruits with equal mass and uniform shape. Mass grading of date fruit can reduce packaging and transportation prices, and also may provide an optimum packaging design (Stroshine and Hamann., 1994). For example Khoshnam *et al*., (2007) showed grading fruit based on weight reduces packing and handling costs and also provides suitable packing patterns. Another important notice in these area is that sizing by weighing mechanism can be used for the irregular shape product. Since intelligent sizing mechanism is expensive, therefore mechanical sizing mechanism can be used. Determining relationships between some physical properties as dimensions, mass and projected areas may be useful and applicable (Marvin *et al*., 1987). In the case of mass modeling, Tabatabaeefar *et al* (2000) determined models for predicting mass of grown orange from its dimensions, volumes and projected areas.

Coefficient of friction between date fruits and different materials is very important notice in determining angle of transporting conveyor of fruits in a factory for different uses such as separation process. The differences between four surfaces in this study are due to the frictional properties between the fruits and surface materials.

## Conclusion

Some physical and mechanical properties of Mazafati date and nuts were determined by several equipment. the most important results on determination of Some physical and mechanical properties of Mazafati date and nuts showed that, Mean values of Length, Width, Thickness, Projected area perpendicular to length, width and thickness were found as, 34.60mm, 22.73mm, 18.15mm, 411.32mm2, 710.78mm2, 732.21mm2. Arithmetic mean diameter, Geometric mean diameter, sphericity, surface area, Porosity, mass, volume, bulk density and true density were found as: 25.16mm, 24.21mm, 70%, 1840.80 mm2, 48.67%, 13.10kg, 11.23 cm3, 0.63gr cm-3, 1.17gr cm-3. The best relationship was between mass and volume with R2 as 0.88 (highest R2 value among all the models) and then arithmetic mean diameter of dates with R2 as 0.82. The maximum of static, dynamic and rotation coefficient of friction for date and nut samples was found on rubber surface. The minimum of static, dynamic and rotation coefficient of friction for date and nut samples was found on galvanized steel surface. The maximum and minimum deformation force for date samples was found along length and thickness direction by average values of 11.52N and 8.02N. Deformation force showed decline procedure with its pressure in direction of length, width and thickness.

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