

## Determination of Some Physical Properties of Dried Jujube Fruit

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**ABSTRACT**

*Some physical properties of Iranian Jujube fruit were evaluated. Jujube fruit samples mean values of length, width, thickness were found as 18.005mm, 14.96 mm, 15.26 mm. Arithmetic mean diameter, geometric mean diameter were found as 16.08mm, 16.01 respectively and surface area, Sphericity, porosity, mass, volume, bulk density and true density were also found as: 805.65 mm<sup>2</sup>, 89%, 77.2%, 1.45gr, 2.61 cm<sup>3</sup>, 0.23gr cm<sup>-3</sup>, 0.55gr cm<sup>-3</sup> respectively. Projected area perpendicular to length, width and thickness were measured as, 152.03 mm<sup>2</sup>, 220.02 mm<sup>2</sup>, 271.4mm<sup>2</sup> respectively. With comparison between friction coefficients on different surface for Jujube fruit. The results showed that the static coefficient of friction was more than dynamic coefficient of friction. The tests done on the galvanized steel surface, plywood and glass surface. The most coefficient of friction was found on the plywood surface and the least coefficient of friction was measured on the glass surface.*

**Keywords:** Jujube fruit, Physical properties, Engineering parameters, geometric parameters.

**Introduction**

*Ziziphus jujuba*, commonly called jujube, this plant usually grown in tropical and sub-tropical regions in the world [19]. It is a small deciduous tree or shrub reaching a height of 5–12 metres, usually with thorny branches. The leaves are shiny-green, ovate-acute, 2–7 centimetres long and 1–3 centimetres wide, with three conspicuous veins at the base, and a finely toothed margin. The fruit is an edible oval drupe 1.5–3 centimetres deep ( Figure1). Its precise natural distribution is uncertain due to extensive cultivation, but is thought to be in southern Asia, between Lebanon, northern India, and southern and central China, and possibly also southeastern Europe though more likely introduced there [24]. 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 essential [8]. Some physical properties have been studied for various agricultural products fruits and crops by other researchers such as cocoa bean [4], plum [11], soybean [16], *Jatropha curcas* L. fruits, nuts and kernels [27] pigeon pea [26], olive cultivars [21], wheat [30], caperfruit (*Capparis* spp) [25], nutmeg [5], watermelon seed [15], pistachio nut and its kernel [23], and palm fruit, kernel and nut [9]. Size and shape of potato tubers [29] determined the physical properties of common varieties of Iranian grown potatoes and the relationships among their physical characteristics [31] compared several properties of four orange varieties. [28] used 11 models for predicting mass of apples based on geometrical features [2]. 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 [13].

Objectives of this study is to determine some physical properties of dried Jujube Fruit in order to facilitate the design of some machines for its processing.



**Figure 1: Location of the fruit on the tree**

## MATERIALS AND METHODS

In this study, about 5 kg dried jujube fruits were prepared from local markets in southern Khorasan region in Iran. Then 100 Jujube fruits were selected randomly and transported to the physical laboratory for measurement of some physical properties (Figure 2). The initial moisture content determined through an oven method at  $105 \pm 3$  °C during 24 hours [6].



**Figure 2: samples of dried Jujube Fruit**

For measurement the length (L), width (W) and thickness (T), the samples were using a digital caliper with an accuracy of 0.02 mm and for measurement mass samples were using a digital Balance with an accuracy of 0.01 gr.

The geometric mean diameter ( $D_g$ ), arithmetic mean diameter ( $D_a$ ) 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 [2,18]. The volume of fruit for the samples were calculated using the expression given by [18]. The true density was determined using toluene displacement method [3]. The porosity was computed from the values of the true and bulk density of samples by using the relationship given by [12]. The static coefficients of friction were obtained with respect to three surfaces of glass, plywood and galvanized steel. The experiment was done by using an inclined plane device as described by [10]. 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 [12].

Projected areas were determined by image processing method. To obtain projected areas, WinArea\_UT\_08 system [17] 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 [22, 13, 14]. 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

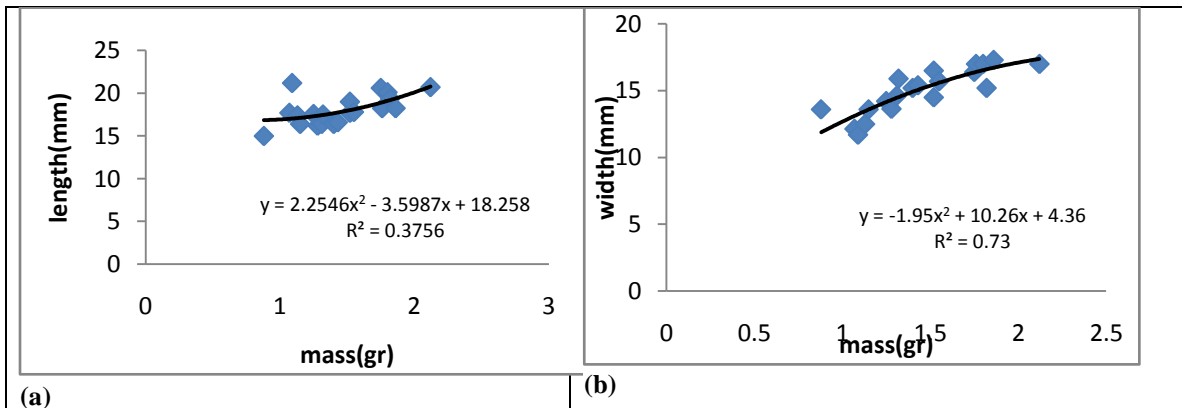
The average moisture content of jujube fruit samples was found to be 15.5%. Results showed that mass varied from 0.88 to 1.86 gr and dimensions varied from length 15 to 20.7 mm, width 13.6 to 17 mm and thickness 13.9 to 17.6 respectively. The arithmetic and geometric mean diameter, varied from 14.17 to 18.43 mm and 14.15 to 18.36 mm respectively. Sphericity and surface area were 89% to 94%, and 629.06 to 1058.97 mm<sup>2</sup> respectively. The averages of the tri-axial dimensions of the fruits are given in Tables 1. The average projected areas perpendicular to length, width, and thickness were obtained as 152.03 mm<sup>2</sup>, 220.02 mm<sup>2</sup>, 271.4 mm<sup>2</sup> respectively. The average values of true density, bulk density and porosity were found as 0.55 g/cm<sup>3</sup>, 0.23 g/cm<sup>3</sup> and 77.2% respectively. Mean coefficient of static on plywood, galvanized steel and glass surfaces, were found as 0.37, 0.35 and 0.31 respectively. Also mean coefficient of dynamic

on plywood, galvanized steel and glass surfaces, were found as 0.34, 0.32 and 0.27 respectively. Results showed that the static, and dynamic coefficient of friction for jujube on plywood surface were higher than galvanized steel and glass surfaces.

**Table 1: Some physical parameters of jujube fruit**

Properties (jujube)	Min	Max	Mean
Length(mm)	15	20.7	18.005
Width(mm)	13.6	17	14.956
Thickness(mm)	13.9	17.6	15.262
Projected area perpendicular to L (mm <sup>2</sup> )	150	154.02	152.03
Projected area perpendicular to W (mm <sup>2</sup> )	217.03	223	220.02
Projected area perpendicular to T(mm <sup>2</sup> )	268.3	273.3	271.4
Arithmetic mean diameter(mm)	14.16	18.43	16.08
Geometric mean diameter(mm)	14.15	18.36	16.01
Sphericity (%)	85	95	89
Surface area (mm <sup>2</sup> )	629.06	1058.97	805.65
Porosity (%)	72.2	82.3	77.2
Mass (gr)	0.88	2.12	1.45
Volume (cm <sup>3</sup> )	2	3.5	2.61
Bulk density (grcm <sup>-3</sup> )	0.18	0.28	0.23
True density (grcm <sup>-3</sup> )	0.41	0.62	0.55
<b>Static coefficient of friction:</b>			
Plywood	0.29	0.39	0.37
Galvanized iron	0.29	0.38	0.35
Glass surface	0.25	0.36	0.31

Regression equations and correlation of coefficient of Jujube fruit mass model based on the length, width, thickness, arithmetic mean diameter, geometric mean diameter and volume are drawn in Figure3.



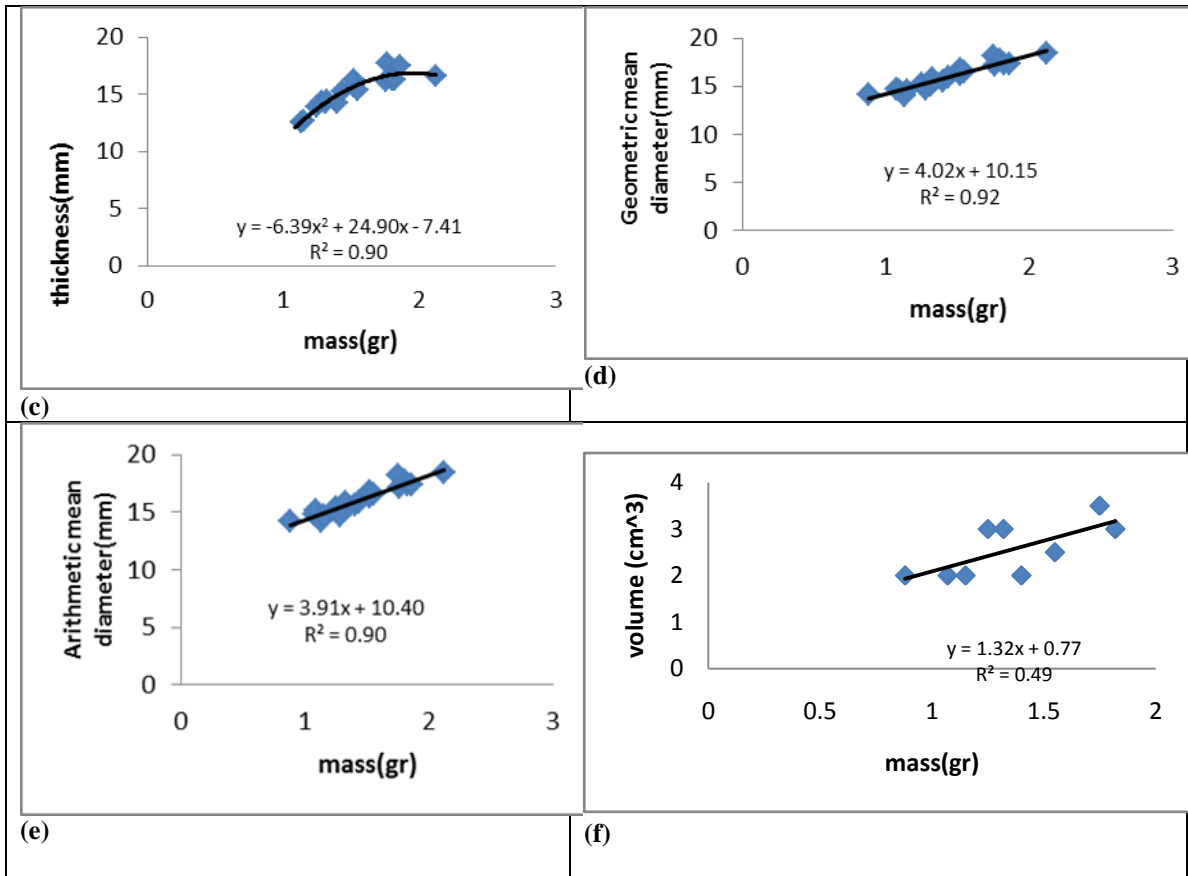


Figure 3: Jujube length, width, thickness, Arithmetic mean diameter, Geometric mean diameter and volume model based on the mass

According to the graphs plotted in Figure 3 and regression equations, we conclude that the highest correlation coefficient was between the geometric mean diameter by the mass (0.92) and the lowest correlation coefficient was between the lengths by the mass (0.38).

Table 2: Regression equations and correlation coefficient ( $R^2$ )

	Regression equations	correlation coefficient ( $R^2$ )
Relation between length and mass	$L = 2.25m^2 - 3.59m + 18.26$	0.38
Relation between width and mass	$W = -1.95m^2 + 10.26m + 4.36$	0.73
Relation between thickness and mass	$T = -6.39m^2 + 24.90m - 7.41$	0.90
Relation between Arithmetic mean diameter and mass	$Da = 3.91m + 10.40$	0.90
Relation between Geometric mean diameter and mass	$Dg = 4.02m + 10.15$	0.92
Relation between volume and mass	$V = 1.32m + 0.77$	0.49

## CONCLUSION

Some physical properties of dried Jujube Fruit were determined by several equipments. The following results are the most important. Mean values of Length, Width, Thickness, Projected area perpendicular to length, width and thickness were found as, 18.005mm, 14.96 mm, 15.26 mm, 152.03 mm<sup>2</sup>, 220.02 mm<sup>2</sup>, 271.4mm<sup>2</sup> respectively. Arithmetic mean diameter, Geometric mean diameter were 16.08mm, 16.01 respectively and surface area, sphericity, Porosity, mass, volume, bulk density and true density were found as: 805.65 mm<sup>2</sup>, 89%, 77.2%, 1.45gr, 2.61cm<sup>3</sup>, 0.23gr cm<sup>-3</sup>, 0.55gr cm<sup>-3</sup> respectively. Mean Values of coefficient of static friction on plywood, galvanized steel, and glass surfaces were obtained as 0.37, 0.35 and 0.31, respectively. Mean values of coefficient of dynamic friction on plywood, galvanized steel, and glass surfaces were obtained as 0.34, 0.32 and 0.27, respectively. Most of the coefficient of friction was on the plywood surface and least of the coefficient of friction was on the glass surface. The most correlation of coefficient was found between geometric mean diameter and mass (0.92).

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