

## Some Physical and Mechanical Properties of Iranian Wild Pistachio (*Pistachio mutica L.*)

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**Abstract:** Wild pistachio is oiling crop; therefore, physical and engineering properties are necessitate to determine for processing and equipment design. In this study, some raw material characteristics were determined for Iranian wild pistachio (*Pistachio Mutica L.*), in order to collect information about identifying some physical and mechanical properties of them. The average grain length, width and thickness were 7.62, 8.84 and 6.42 mm, respectively. The geometric mean diameter, thousand grain kernel and aspect ratio were 7.86 mm, 302.28g and 1.17, respectively. True density, bulk density and porosity were  $1.07 \text{ kg m}^{-3}$ ,  $0.5 \text{ kg m}^{-3}$  and 0.5%, respectively while the static coefficient of friction varied from 0.44 on plywood surface to 0.56 on galvanized iron. The angle of repose for static and emptying were 52.5 and 28.86° degree, respectively. Whereas the failure force, elongation and energy were 143.07 N, 1.68 mm and 201.29 kPa respectively.

**Key words:** Wild pistachio • green pearl • oiling • physical properties • mechanical properties

### INTRODUCTION

Wild pistachio is a tree in pistachio "*Pistachio mutica L.*" and has various varieties that grows in altitudes and arid and semiarid mountain lands and in many of Iran's provinces such as: Ilam, Kermanshah, Lorestan, Kurdistan, Azerbaijan Gharbi, Azerbaijan Shaghi, Fars, Kerman, Balouchestan and Khorasan [1]. The vast of Iranian wild pistachio forests is around 2.4 million hectares [2].

Wild pistachio has approximately 30% oil and 70% pressed seed [3]. The oil of wild pistachio include of threbanthin and celoufan. The oil is used for colors, pesticides, glues, essences, papers, mineral oils and other industrial applications [4]. Khanian and Emadi [5] reported that pressed seed has about 44% nutritional material that can be considered as one of the valuable feed for sheep. This forest crop was known in Ilam province as "Green Pearl" due to its important applications and popularity.

The knowledge of some important physical properties such as shape, size, volume, surface area, thousand grain weights, density, porosity, angle of repose, of different grains is necessary for the design of various separating, handling, storing and drying systems [6, 7].

The size and shape are, for instance, important in their electrostatic separation from undesirable materials and in the development of sizing and grading machinery [8]. The shape of the material is important for an analytical prediction of its drying behavior [9].

Bulk density, true density and porosity (the ratio of intergranular space to the total space occupied by the grain) can be useful in sizing grain hoppers and storage facilities; they can affect the rate of heat and mass transfer of moisture during aeration and drying processes. Grain bed with low porosity will have greater resistance to water vapor escape during the drying process, which may lead to higher power to drive the aeration fans. Grain densities have been of interest in breakage susceptibility and hardness studies.

The static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute. Such information is useful in sizing motor requirements for grain transportation and handling [10].

The design of storage and handling systems for grains requires data on bulk and handling properties, friction coefficients on commonly used bin wall materials (galvanized steel, plywood and concrete) and emptying and filling angles of repose [11]. Theories used to predict

the pressures and loads on storage structures [12, 13]. require bulk density, angle of repose and friction coefficients against bin wall materials. Also the design of grain hoppers for processing machinery requires data on bulk density and angle of repose. An example of the use of various bulk and handling properties of grains in the design of storage structures is given by Singh and Moysey [14]. The angle of repose determines the maximum angle of a pile of grain with the horizontal plane. It is important in the filling of a flat storage facility when grain is not piled at a uniform bed depth but rather is peaked [8].

Hence, current study was conducted on investigate some physical and mechanical properties of wild pistachio grain to establish a convenient reference table for its mechanization and processing.

### MATERIALS AND METHODS

The mutica wild pistachio (*Pistachio mutica* L.), one of the popular forest-product in Ilam province, Iran, was obtained to this work, Fig. 1. The initial moisture content of seeds was determined by oven method [15]. A digital caliper was used to determine length, width and thickness of about 50 randomly selected grains. The geometric,  $D_g$ , equivalent,  $D_p$  and arithmetic diameter mean,  $D_a$ , in mm was calculated by Eq(1), Eq(2) and Eq(3), respectively [8,16].

$$D_g = (LDT)^{\frac{1}{3}} \quad (1)$$

$$D_p = \left[ L \frac{(W+T)^2}{4} \right]^{\frac{1}{3}} \quad (2)$$

$$D_a = \frac{(L+W+T)}{3} \quad (3)$$

Thousand Kernel Weight (TKW) was measured by counting 100 seeds and weighing them in an electronic balance to an accuracy of 0.001 g and then multiplied by 10 to give mass of 1000 kernels.

The sphericity ( $S_p$ ) defined as the ratio of the surface area of the sphere having the same volume as that of grain to the surface area of grain, was determined using following formula [8].

$$S_p = \frac{(LDT)^{\frac{1}{3}}}{L} \quad (4)$$



Fig. 1: Mutica wild pistachio (*Pistachio mutica* L.)

The aspect ratio (Ra) was calculated by Omobuwajo *et al.* [14].

$$R_a = \frac{W}{L} \quad (5)$$

The surface area expressed as [12]:

$$S_p = \pi (d_g)^2 \quad (6)$$

The true density is the ratio of mass sample of grains to its pure volume. It was determined by the water displacement method [8]. Bulk density is the ratio of the mass sample of grains to its total volume. It was determined by filling a predefined container from a constant height, striking the top level and then weighing the constants [17-20].

The porosity is the ratio of free space between grains to total of bulk grains. That was determined as:

$$\varepsilon = \frac{\rho_k - \rho_b}{\rho_k} \times 100 \quad (7)$$

The coefficient of static friction was determined with respect to different surfaces: plywood, glass and galvanized iron. A hollow metal cube, open at both ends, was filled with the seeds at the desired moisture content and placed on adjustable titling surface (Fig. 2) such that the metal cube did not touches the surface. Then the surface was raised gradually until the filled cube just started to slide down [21].

The static angle of repose was determined by using the apparatus (Fig. 3) consisting of a plywood box of 140-160-35 mm and two plates: fixed and adjustable. The box was filled with the sample and then the adjustable



Fig. 2: Apparatus to determine static coefficient of friction

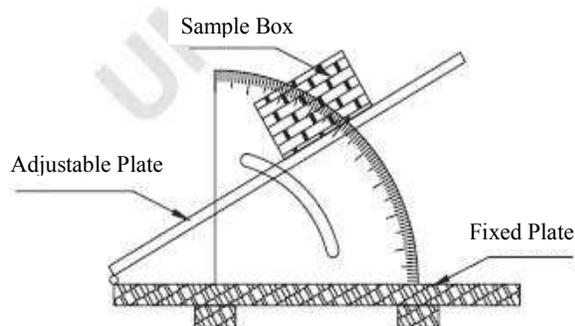


Fig. 3: Apparatus to determine static angle of repose

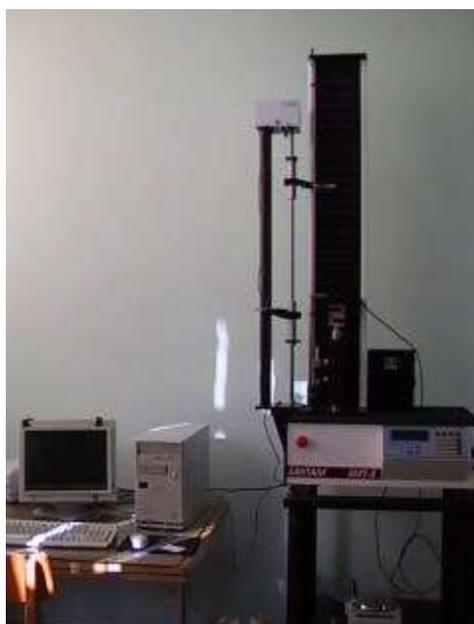


Fig. 4: A universal testing machine (Santam, MRT-5) to determine failure properties of fruits

plate was inclined gradually allowing the kernels to follow and assume a natural slope [15]. The dynamic angle of repose is the angle with the horizontal at which the material will stand when piled. The angle of repose was determined using a hollow cylinder and then trigonometry rules.

Mechanical properties of mutica wild pistachio were evaluated using 25 sample grains and then a Universal Testing Machine (Santam, SMT-5), shown in Figure 4. This machine has three main components, which are a stable forced and moving platform, a driving unit (AC electric motor, electronic variator and reduction unit) and a data acquisition (load cell, PC card and software) system. The machine was equipped with a load cell of 500 N at a compressive rate of 25 mm/min. Failure force and deformation of samples are expressed in terms of the peak of force-deformation curve, failure energy as area under the curve of that. And firmness was calculated as the failure force dividing to the failure deformation.

## RESULTS AND DISCUSSIONS

A summary of the results of several physical and mechanical mutica wild pistachio parameters is shown in Table 1. The average length, width and thickness were found to be 7.62, 8.84 and 6.42 mm, respectively. The importance of these and other Characteristics axial dimensions in determining aperture sizes and other parameters in machine design have been discussed by Mohsenin [8] and highlighted lately by Omobuwajo *et al.* [22]. The geometric mean diameter ranged from 7.22 to 8.51 mm, while the corresponding surface area ranged from 163.55 to 227.17 mm<sup>2</sup>. The geometric mean of the axial dimensions is useful in the estimation of the projected area of a particle moving in the turbulent or near-turbulent region of an air stream. This projected area of the particle is generally indicative of its pattern of behavior in a flowing fluid such as air, as well as the ease of separating extraneous materials from the particle during cleaning by pneumatic means [22]. Other mean of the axial dimensions are the equivalent and arithmetic diameter. The sphericity was 96%. The aspect ratio, an indicator of a tendency toward an oblong shape, was 1.12. Thousand kernel weight of mutica wild pistachio was 302.28 g. The true density, bulk density and porosity were 1.07 gcm<sup>-3</sup>, 0.49 gcm<sup>-3</sup> and 50%, respectively. This showed that pistachios were heavier than water. This characteristic can be used to design separation or cleaning process for grains since lighter fractions will float. The average values

Table 1: Several physical and mechanical properties of mutica wild pistachio variety

Property	No. of					
	sample	Max	Min	Mean	SD*	CV**
L, mm	50	9.52	6.55	7.62	0.65	0.09
W, mm	50	10.11	8.38	8.84	0.45	0.05
T, mm	50	7.55	5.96	6.42	0.34	0.05
D <sub>b</sub> , mm	50	8.51	7.22	7.55	0.26	0.03
D <sub>p</sub> , mm	50	8.55	7.28	7.62	0.26	0.03
D <sub>s</sub> , mm	50	8.56	7.30	7.63	0.26	0.03
S, mm <sup>2</sup>	50	227.17	163.55	186.35	12.99	0.07
S <sub>p</sub>	50	1.13	0.85	0.96	0.07	0.07
R <sub>a</sub>	50	1.44	0.93	1.12	0.05	0.04
TKW, g	3	308.39	296.12	302.28	4.98	0.02
ρ <sub>v</sub> , g/cm <sup>3</sup>	3	1.11	1.03	1.07	0.04	0.04
ρ <sub>b</sub> , g/cm <sup>3</sup>	3	0.57	0.53	0.55	0.03	0.05
ε, %	3	0.52	0.48	0.50	0.01	0.02
F <sub>β</sub> , N	25	187.85	109.45	143.07	24.12	0.17
F <sub>d</sub> , mm	25	2.66	1.06	1.68	0.42	0.25
E <sub>β</sub> , N.mm	25	198.85	62.03	121.89	40.99	0.34
F <sub>i</sub>	25	136.08	51.54	88.69	20.35	0.23
θ <sub>s</sub> , deg	3	54	51.5	52.5	1.32	0.03
θ <sub>d</sub> , deg	3	29.20	28.44	28.86	0.39	0.01
φ						
Plywood,						
Radian	3	0.45	0.42	0.44	0.01	0.02
Galvanized						
iron, Rad	3	0.60	0.53	0.56	0.04	0.07
glass,						
Rad.deg	3	0.50	0.48	0.49	0.01	0.02

\* Standard deviation \*\* Coefficient of variation

of static coefficient of friction against galvanized iron sheet, plywood and glass sheet were 0.56, 0.44 and 0.49, respectively. The static coefficient of friction is used to determining the angle at which chutes must be positioned in order to achieve consistent flow of material through it [23]. The static and dynamic angle of repose of wild pistachio was 52.5 and 28.86 degree. The angle of repose determines the maximum angle of a pile of grain in the horizontal plane and is important in the filling of a flat storage facility when grain is not piled at a uniform bed depth rather is peaked [8]. The mean values of the failure force, deformation and energy for wild pistachio were 143.07 N, 1.68 mm/mm and 121.89 N.mm respectively. Lastly, the amount of firmness was found to be 88.69 N/mm.

### CONCLUSIONS

Some engineering properties of mutica variety of wild pistachio; which may be useful in designing much of the

equipment used for harvest and postharvest processing, in particular oil extracting, were determined in this paper. The researchers recommended that other engineering properties and processing of wild pistachio, particularly, oil extracting, be worked to provide fairly comprehensive information in design parameters.

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