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Some Physical and Mechanical Properties of Khinjuk

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Abstract: Khinjuk 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 Khinjuk, in order to collect information about identifying some physical and mechanical properties of them. The average grain length, width and thickness were 5.49, 5.09 and 4.08 mm, respectively. The geometric mean diameter, thousand grain kernel and aspect ratio were 5.02 mm, 87.15g and 0.95, respectively. True density, bulk density and porosity were 1.01 kg m^{-3}, 0.55 kg m^{-3} and 45 %, respectively while the static coefficient of friction varied from 0.45 on plywood surface to 0.56 on galvanized iron. The angle of repose for static and emptying were 48.33 and 23.74° degree, respectively. Whereas the failure force and elongation were 42.49 N and 1.35 mm respectively.

Key words: Khinjuk, green pearl, oiling, physical properties and mechanical properties

Introduction

Khinjuk 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 (Valipour, 1995).

Khinjuk has approximately 30% oil and 70% pressed seed (Hosseinzadeh and Tahmasebi, 1995). The oil of Khinjuk include of threbantin and celoufan. The oil is used for colors, pesticides, glues, essences, papers, mineral oils and other industrial applications (Fatahi, 1995). Khanian and Emadi (1995) 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 (Sahay and Singh, 1994; Tabatabaeefar, 2000).

The size and shape are, for instance, important in their electrostatic separation from undesirable materials and in the development of sizing and grading machinery (Mohsenin, 1986). The shape of the material is important for an analytical prediction of its drying behavior (Esref and Halil, 2007).

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 (Ghasemi Varnamkhasti *et al.*, 2007).

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 (Parde *et al.*, 2003). Theories used to predict the pressures and loads on storage structures (Janssen, 1895; Lvin, 1970) 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 (1985). 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 (Mohsenin, 1986).

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

Materials and Methods

The major Khinjuk, one of the popular forest-product in Ilam province, Iran, was obtained to this work, Fig. 1. The

Fig. 1: Khinjuk.

Fig. 2: Apparatus to determine static coefficient of friction

initial moisture content of seeds was determined by oven method (Tabatabaeefar, 2003). 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 (Mohsenin, 1986).

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

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

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

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 (Mohsenin, 1986).

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

The aspect ratio (Ra) was calculated by: (Omobuwajo *et al.,* 1999).

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

The surface area expressed as: (Mohsenin, 1986).

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

The true density is the ratio of mass sample of grains to its pure volume. It was determined by the water displacement method (Mohsenin, 1986). 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 (Deshpande *et al.,* 1993; Gupta and Das, 1997; Konak *et al.,* 2002; Paksoy and Aydin, 2004).

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

$$\epsilon = \frac{P_k - P_b}{P_k} \times 100 \quad (7)$$

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 (Razavi and Milani, 2006).

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 plate was inclined gradually allowing the kernels to follow and assume a natural slope (Tabatabaeefar, 2003). 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 major Khinjuk were evaluated using 25 sample grains and then a Universal Testing Machine (Santam, SMT-5), shown in Fig. 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

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

	Max	Min	Mean	SD*
L, mm	7.58	4.54	5.49	0.730
W, mm	6.45	4.21	5.09	0.490
T, mm	5.65	3.37	4.07	0.470
D_g, mm	5.65	4.40	5.02	0.160
D_p, mm	5.67	4.44	4.97	0.350
D_a, mm	5.72	4.45	5.08	0.350
S, mm^2	100.33	60.64	79.87	10.830
S_p	1.07	0.72	0.89	0.090
R_a	1.28	0.62	0.95	0.160
TKW, g	93.56	80.73	87.15	6.420
ρ_t, g/cm^3	1.03	1.00	1.01	0.010
ρ_b, g/cm^3	0.56	0.55	0.55	0.001
ε %	0.46	0.45	0.45	0.010
F_r, N	64.78	30.25	42.49	7.560
F_d , mm	2.00	0.34	1.35	0.380
F_f	126.47	16.81	36.75	22.380
θ_s, deg	50.00	47.00	48.33	1.530
θ_d, deg	25.92	21.45	23.74	2.240
Plywood, Radian	0.47	0.43	0.45	0.030
Galvanized iron, Rad	0.58	0.51	0.56	0.040
glass, Rad.deg	0.56	0.49	0.53	0.040

* Standard deviation

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 Discussion

A summary of the results of several physical and mechanical major Khinjuk parameters is shown in Table 1. The average length, width and thickness were found to be 5.49, 5.09 and 4.08 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 (1986) and highlighted lately by Omobuwajo *et al.* (1999). The geometric mean diameter ranged from 4.4 to 5.65 mm, while the corresponding surface area ranged from 60.34 to 100.33 mm^2. 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 steam. 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 (Omobuwajo *et al.,* 1999). Other mean of the axial dimensions are the equivalent and arithmetic diameter. The sphericity was 89%. The aspect ratio, an indicator of a tendency toward an oblong shape, was 0.95. Thousand kernel weight of major Khinjuk was 87.15 g. The true density, bulk density and porosity were 1.01 gcm^{-3}, 0.55 gcm^{-3} and 45%, respectively. This showed that Khinjuk 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 of static coefficient of friction against galvanized iron sheet, plywood and glass sheet were 0.56, 0.45 and 0.53, 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 (Olajide and Igbeka, 2003). The static and dynamic angle of repose of Khinjuk was 48.33 and 23.74 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 (Mohsenin, 1986). The mean values of the failure force, deformation and energy for Khinjuk were 42.49 N, 1.35 mm/mm and 1.05 N.mm respectively. Lastly, the amount of firmness was found to be 36.75 N/mm.

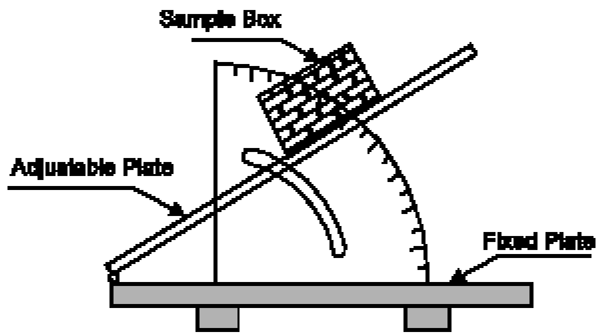

Fig. 3: Apparatus to determine static angle of repose

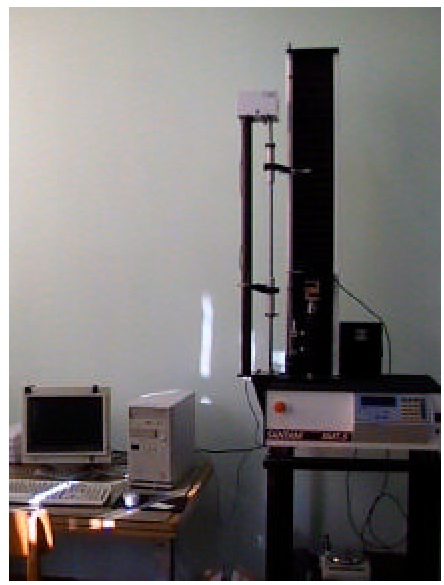

Fig. 4: A Universal Testing Machine (Santam, MRT-5) to determine failure properties of fruits.

Conclusions: Some engineering properties of major variety of Khinjuk; 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.

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References

Deshpande, S.O., S. Bal and T.P. Ojha, 1993. Physical properties of soybean. J. Agric. Eng. Res., 56:89-98.

Esref, I. and U. Halil, 2007. Moisture-dependent physical properties of white speckled red kidney bean grains. J. Food. Eng., 82: 209-216.

Fatahi, M., 1995. Productivity of wild pistachio trees in Kurdistan. The first national seminar of wild pistachio (Green Pearl). Ilam Research Center of National Resources and Animal Consumptions. 4 and 5 November.

Ghasemi Varnamkhasti, M., H. Mobli, A. Jafari, S. Rafiee, M. Heidary Soltanabadi and K. Kheiralipour, 2007. Some Engineering Properties of Paddy (var. Sazandegi). Int. J. Agric. and Biol., 5: 763-766.

Gupta, R.K. and S.K. Das, 1997. Physical properties of sunflower seeds. J. Agric. Eng. Res., 66: 1-8.

Hosseinzadeh, J. and M. Tahmasebi, 1995. Economic-social values of wild pistachio in Ilam province. The first national seminar of wild pistachio (Green Pearl). Ilam Research Center of National Resources and Animal Consumptions. 4 and 5 November.

Janssen, H.A, 1895. Versuche uber getreidedruck in silozellen. Z. vereines Deutscher Ingenieure, 39: 1045-1049.

Khanian, S.E. and M.H. Emadi, 1995. using pressed seed of wild pistachio for feeding Iranian sheep. The first national seminar of wild pistachio (Green Pearl). Ilam Research Center of National Resources and Animal Consumptions. 4 and 5 November.

Konak, M., K. Carman and C. Aydin, 2002. Physical properties of chick pea seeds. Bio - systems. Eng., 82: 73-78.

Lvin, J.B., 1970. Analytical evaluation of pressures of granular materials on silo walls. Powder Tech, 4: 280-285.

Mohsenin, N.N., 1986. Physical Properties of Plant and Animal Materials, seconded. Gordon and Breach Science Publishers, New York.

Olajide, J.O. and J.C. Igbeka, 2003. Some physical properties of groundnut kernels. J. Food Eng., 58: 201-4.

Omobuwajo, O.T., A.E. Akande and A.L. Sann, 1999. Selected physical, mechanical and aerodynamic properties African Breadfruit (Treculia Africana) seeds. J. Food. Eng., 40: 241-244.

Paksoy, M. and C. Aydin, 2004. Some physical properties of edible squash (*Cucurbita pepo* L.) seeds. J. Food Eng., 65: 225-231.

Parde, S.R., A. Johal. D.S. Jayas and N.D.G. White, 2003. Physical properties of buckwheat cultivars. Canadian Bio - systems. Eng. Technical Note.

Razavi, S. and E. Milani, 2006. Some physical properties of the watermelon seeds. Afr. J. Agric. Res., 13: 65-69.

Sahay, K.M. and K.K. Singh, 1994. Unit Operations of Agricultural Processing. 1st Edn. Vikas Publishing House Pvt. Ltd., New Delhi, India.

Singh, D. and E.B. Moysey, 1985. Grain bin wall pressures. Theoretical and experimental. Canadian Agric. Eng., 27: 43-48.

Tabatabaeefar, A., 2000. Physical Properties of Iranian Potato. Proceedings of the International Agricultural engineering Conference, Bangkok Thailand, December 4-7: 501-506.

Tabatabaeefar, A., 2003. Moisture-dependent physical properties of wheat. Int. Agrophysics, 17: 207-211.

Valipour, P., 1995. economical investigation of wild pistachio. The first national seminar of wild pistachio (Green Pearl). Ilam Research Center of National Resources and Animal Consumptions. 4 and 5 November.

Notations

L	length, mm	Φ	static coefficient of friction
W	width, mm	θ_s	static angle of repose, deg
T	thickness, mm	θ_d	dynamic angle of repose, deg
TKW	thousand kernel weight, g	S	surface area, mm^2
D_g	geometric mean diameter, mm	R_a	aspect ratio
D_p	equivalent diameter, mm	M	moisture content, %
D_a	arithmetic diameter, mm	F_d	Failure deformation, N
S_p	sphericity, %	F_f	Failure force, mm
ρ_b	bulk density, kgm^{-3}	E_f	Failure energy, N.mm
ρ_t	true density, kgm^{-3}	F_i	Firmness, N
ε	porosity, %		