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Biophysical, biomechanical and bioproximate properties of Iranian oak fruit

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Oak fruit (*Quercus Persicae*) is an important forest product due to its food serves as medical properties. This study was conducted to collect and compare information regard to biophysical, biomechanical and bioproximate properties of Iranian oak fruits. For this purpose, oak fruit of Ilam and Karaj regions were considered. Dimensional characteristics, sphericity, thousand kernel weight, true and bulk density and porosity were determined as oak biophysical properties. Failure and deformation force and firmness, static coefficient of friction and angle of repose were measured as biomechanical properties. Also, bioproximate properties include determination of starch, fat, moisture content, protein, ashes and dry matter.

Key words: Physical Properties; Mechanical Properties; bioproximate properties; Oak Fruit; Iran.

Notations

L	Length, mm	θ_e	Empting angle of repose, deg
W	Width, mm	S	Surface area, mm^2
T	Thickness, mm		
TKW	Thousand kernel weight, g	d_{fa}	Failure deformation of oak in a direction, N
D_g	Geometric mean diameter, mm	d_{fb}	Failure deformation of oak in b direction, N
D_p	Equivalent diameter, mm	d_{fbk}	Failure deformation of oak kernel in b direction, N
D_a	Arithmetic diameter, mm	F_{fa}	Failure force of oak in a direction, mm
S_p	Sphericity, %	F_{fb}	Failure force of oak in b direction, mm
ρ_b	Bulk density, kgm^{-3}	F_{fbk}	Failure force of oak kernal in b direction, mm
ρ_t	True density, kgm^{-3}	F_{ia}	Firmness of oak in a direction, N
ε	Porosity, %	F_{ib}	Firmness of oak in b direction, N
Φ	Static coefficient of friction	F_{ibk}	Firmness of oak kernel in b direction, N

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Introduction

Oak is a tree in the genus *Quercus*, of which about 600 species exist on earth. Oak may also appear in the names of species in related genera, notably *Lithocarpus*. The genus is native to the northern hemisphere, and includes deciduous and evergreen species extending from cold latitudes to tropical Asia and the Americas (Anonymous, 2011a). The Iranian oak, *Quercus Persicae*, covered central, southern and southeast regions in Zagros Mountains. Total forests in Iran are about 5 million hectares that Oak trees have a share of 70 % of them (Anonymous, 2011b). More of Oak trees were found in Ilam, Fars, Lorestan, Kohgiluyeh and Boyer-Ahmad and Chaharmahal and Bakhtiari provinces (Anonymous, 2011a). Oak is one of the richest fruit regard to Tannin content (Yousef Elahi and Rouzbehan, 2008). Also oak fruit contains some of other important chemical components such as Pyrvgalyk acid and quercetin Katshyn. For these contents, Oak fruit has medical properties such as Anti-diarrhea and anti-inflammatory and reduce secretions (Anonymous, 2011c).

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 and 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 (Heidarbeigi *et al*., 2008). 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 (Parde *et al.*, 2003).

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 (Ghasemi Varnamkhasti *et al*., 2007). Theories used to predict the pressures and loads on storage structures (Lvin, 1970 and Janssen 1895) 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).

Current study was conducted to determine and compare some biophysical and biomechanical properties of oak fruits in two regions of Iran, Ilam Karaj. Also bioproximate properties of oak fruits were researched to determine and compare their food components.

Materials and methods

In this research, the oak fruits of Ilam and Karaj regions in Iran were obtained. A caliper was used to determine length, width, and thickness of about 50 randomly selected grains. The geometric mean diameter, D_g, was calculated by Eq (1) (Mohsenin, 1986):

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

Thousand kernel weight (TKW) was measured by counting 100 seeds and weighing them in an electronic balance to an accuracy of 0.01 g and then multiplied by 10 to give mass of 1000 kernels (Kheiralipour *et al.*, 2008).
The surface area expressed as (Mohsenin, 1986):

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

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):

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

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 (Paksoy and Aydin, 2004).

The porosity is the ratio of free space between grains to total of bulk grains. That was determined as (Heidarbeigi *et al.*, 2008):

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

Biomechanical properties of studied oak fruits were evaluated using 25 sample grains and then a Universal Testing Machine. Failure force and deformation of samples were determined. These biomechanical properties are expressed in terms of the peak of force-deformation curve. Firmness was calculated as the failure force dividing to the failure deformation. Failure force, Failure deformation and firmness for oak fruits were individually measured in L (length) and W (width) directions. Biomechanical properties in W direction were determined for both oak and oak kernel.

An especial apparatus was used for determination coefficient of static friction respect to plywood and galvanized iron sheets (Kheiralipour *et al*., 2008). The empting angle of repose is the angle with the horizontal at which the material will stand when piled. This angle was determined using a hollow cylinder and then trigonometry rules.

For studied fruits, protein, starch, fat, moisture content, ashes and dry matter were considered as bioproximate analyses achieved by AOAC standard methods.

Results and discussions

Biophysical properties

A summary of the results of several biophysical properties of Ilam and Karaj oak fruit were shown in Table 1. The average length, width and thickness of Ilam oak were found to be 47.74, 17.19 and 16.50 mm, respectively. These values for Karaj oak were small, compare with Ilam oak variety. The geometric mean diameter for Ilam oak was 23.72 and for Karaj variety was 21.06, while the corresponding surface area was 1633.73 and 1398.20 mm^2, respectively. The importance of these dimensional characteristics 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 sphericity of Karaj oak, 0.54 was more than Ilam oak, 0.5. Thousand kernel weight of Ilam oak was 8815.34±210.65 g wile the corresponding value for Karaj variety was 5468.00±314.24. The true density, bulk density and porosity were 1.11 gcm^{-3}, 0.61 gcm-3 and 43.96 %, respectively, for Ilam oak fruit. True density, bulk density of Karaj oak was more than but its porosity was slightly small than that of Ilam oak. This showed that oak fruit is heavier than water. These characteristics can be used to design separation or cleaning process for grains since lighter fractions will float.

Biomechanical properties

A summary of the results of several biomechanical properties of Ilam and Karaj oak fruit was shown in Table 2. The average values of static coefficient of friction of Ilam oak fruit against plywood and galvanized iron sheet were 0.35 and 0.40, respectively. Therese this values were 0.32 and 0.33 for Karaj oak fruit. Static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of material through it (Olajide and Igbeka, 2003).

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 empting angle of repose of Ilam and Karaj oak fruits was 23.7 and 16.38 degree, respectively. The values of the failure force, deformation and firmness for Ilam oak in a direction were 292.40±39.18 N, 6.57±1.76 mm, and 47.44±12.81 N/mm respectively. While the corresponding values were 330.95±72.42 N, 5.59±1.50 mm, and 66.08±30.15 N/mm for Karaj oak fruit.

The mean values of the failure force and firmness for all two oak varieties in b direction were more than those in a direction. But, deformation value of all two varieties in b direction was small than this value in a direction. Lastly, the amount of failure force, deformation and firmness of oak kernel in b direction were found to be 361.93±36.20 N, 3.60±0.45 mm, and 101.19±9.54 N/mm, and 319.14±68.20 N, 3.88±1.13 mm and 87.58±28.74 N/mm for Ilam and Karaj variety.

Bioproximate properties

Bioproximate properties for Ilam and Karaj oak fruits were reported in Table 3. The mean protein of Ilam oak fruit was measured as 4.13 %. This value is around 40 % more than that of Karaj oak. Obtained moisture content for Karaj oak fruit was 7.25% whereas the corresponding value for Ilam oak fruit was around two times of that. Also the fat value of Ilam oak was two time of corresponding value for Karaj oak. But, there was observed that the amount of starch, ash and dry matter values of Ilam oak were less than those values in Karaj oak.

Table 1. Several biophysical properties of oak fruits

	Ilam oak fruit		**Karaj oak fruit**	
Biophysical properties	Mean	Standard deviation	Mean	Standard deviation
L, mm	47.74	5.98	39.36	4.26
W, mm	17.19	2.47	15.69	1.03
T, mm	16.50	2.43	15.19	1.01
D_g, mm	23.72	2.93	21.06	1.32
S, mm^2	1633.73	412.29	1398.20	178.40
S_p	0.50	0.07	0.54	0.04
TKW, g	8815.34	210.65	5468.00	314.24
ρ_t, g/cm^3	1.11	0.13	1.30	0.03
ρ_b, g/cm^3	0.61	0.13	0.74	0.01
ε, %	43.96	0.17	43.5	0.02

Table 2. Several biomechanical properties of oak fruits

	Ilam oak fruit		**Karaj oak fruit**	
Biomechanical properties	Mean	Standard deviation	Mean	Standard deviation
F_{fa}, N	292.40	39.18	330.95	72.42
F_{fb}, N	385.37	50.13	395.48	51.66
F_{fbk}, N	361.93	36.20	319.14	68.20
d_{fa}, mm	6.57	1.76	5.59	1.50
d_{fb}, mm	3.47	0.47	4.36	0.95
d_{fbk}, mm	3.60	0.45	3.88	1.13
F_{ia}, N/mm	47.44	12.81	66.08	30.15
F_{ib}, N/mm	111.85	11.75	92.46	10.97
F_{ibk}, N/mm	101.19	9.54	87.58	28.74
θ_e, deg	23.70	1.18	16.38	1.39
ϕ				
Plywood, Rad	0.35	0.10	0.32	0.02
Galvanized iron, Rad	0.40	0.08	0.33	0.04

Table 3. Several bioproximate properties of oak fruits

	Ilam oak fruit		Karaj oak fruit	
Bioproximate properties	Mean	Standard deviation	Mean	Standard deviation
Protein, %	4.13	0.01	2.96	0.03
Starch, %	54	-	58	-
Fat, %	8.04	0.04	3.98	0.03
Moisture content, %	14.75	0.01	7.25	0.01
Ash, %	1.43	0.06	1.77	0.06
Dry matter, %	85.25	0.01	92.75	0.01

Conclusion

Some biophysical and biomechanical properties of two Iranian oak fruit were measured and compared. These properties may be useful in designing much of the equipment required for postharvest processing. Also, follow statements were concluded: All biophysical properties of Ilam oak were more than those of Karaj oak fruit except than Sphericity and true and bulk density. All biomechanical properties of Ilam oak variety were more than those of Karaj variety except than failure force of oak in a and b directions, failure deformation of oak and oak kernel in b direction and firmness of oak in a direction. All measured biomechanical properties of two oak varieties were more than those of oak kernel varieties except than failure deformation. The protein, fat and moisture content of Ilam oak were more than that of Karaj oak, but starch, ash and dry matter had reverse results.

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