International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:6, No:9, 2012

Some Physical and Mechanical Properties of Russian Olive Fruit

D. Zare, F. Salmanizade, H. Safiyari

Abstract**—**Physical and mechanical properties of Russian olive fruits were measured at moisture content of 14.43% w.b. The results revealed that the mean length, width and thickness of Russian olive fruits were 20.72, 15.73 and 14.69mm, respectively. Mean mass and volume of Russian olive fruits were measured as 1.45 g and 2.55 cm^3, respectively. The sphericity, aspect ratio and surface area were calculated as 0.81, 0.72 and 8.96 cm^2, respectively, while arithmetic mean diameter, geometric mean diameter and equivalent diameter of Russian olive fruits were 17.05, 16.83 and 16.84 mm, respectively. Whole fruit density, bulk density and porosity of jujube fruits were measured and found to be 1.01 g/cm^3, 0.29 g/cm^3 and 69.5%, respectively. The values of static coefficient of friction on three surfaces of glass, galvanized iron and plywood were 0.35, 0.36 and 0.43, respectively. The skin color (L*, a*, b*) varied from 9.92 to 16.08; 2.04 to 3.91 and 1.12 to 3.83, respectively. The values of rupture force, deformation, energy absorbed and hardness were found to be between 12.14-16.85 N, 2.16-4.25 mm, 3.42-6.99 N mm and 17.1-23.85 N/mm.

Keywords**—**Mechanical and Physical properties, Russian olive fruits, friction coefficient

I. Introduction

THE Russian olives (*Elaeagnus angustifolia* L.) are deciduous shrubs in the genus Hippophae, family Elaeagnaceae that typically range from 0.5 to 6 m in height with equivalent spread. It has been used for centuries in both Europe and Asia as food, and for its pharmaceutical properties, while its place of origin is in Iran. Tropical application of sea buckthorn oil has been reported for skin therapy including sun, heat, chemical and radiation burns, eczema and poorly healing wounds. Oil from the Russian olive fruit is rich in vitamin E, carotenoids, phytosterols and essential fatty acids, all of which have beneficial medicinal properties for the treatment of internal and topical maladies.

The importance of understanding the physical properties of fruits is to design of machines and processes for harvesting, handling and storage of agricultural materials and for converting these materials into foods. Some of these properties include the size, shape, sphericity, bulk density, true density, porosity, geometric mean diameter, projected area, surface area, mass, volume, etc. The knowledge related to shape and physical dimensions, is useful in sorting and sizing of fruits and determining how many fruits can place in shipping containers.

D. Zare is with Department of Agricultural Engineering, Shiraz University, Shiraz, Iran (P. O. Box: 7144165186, e-mail: dzare@shirazu.ac.ir).

F. Salmanizade is graduate student in Department of Agricultural Engineering, Shiraz University, Shiraz, Iran.

H. Safiyari, is graduate student in Department of Agricultural Engineering, Shiraz University, Shiraz, Iran (e-mail: safiyari.hasan@gmail.com).

Knowing the bulk and fruit density of agricultural materials would be valuable in design of silos and storage bins, separation from undesirable materials, and grading [1]. Coefficient of static friction play an important role in inclination angle of conveyor and storage bin [2]. Koocheki *et al*. evaluated some physical properties of watermelon seed as a function of moisture content and variety [3]. Keramat Jahromi *et al.* determined some physical properties for data fruit at a moisture content of 10.45% (dry basis) [4]. Ozturk *et al.* evaluated some physical properties of olive cultivars [5]. Davies determined some physical properties of arigo seeds at a moisture content of 10.3% (wet basis) [6]. Altuntas *et al* determined physical and chemical properties of persimmon fruit (cv. Fuyu) [7]. Ercisli *et al* determined physical and mechanical properties of nuts and kernels of 12 common hazelnut genotypes to optimize hazelnut mechanization and processing [8]. Also, in recent years some studies were conducted to determine physical and mechanical properties of fruits and seeds such as wheat [9], sheanut [10], African nutmeg [11], orange [12], oil palm [13], kariya seeds [14].

The aim of this study was conducted to investigate the principle dimensions (Length, Width, and Thickness), arithmetic mean diameter, geometric mean diameter, equivalent diameter, sphericity, aspect ratio, surface area, fruit mass, volume, true and bulk densities, porosity, angle of repose, coefficient of static friction on different surfaces, color characteristics ($L*$, $a*$, $b*$) and rupture force, deformation, energy absorbed and hardness of Russian olive fruits.

II. Material and Methods

In this study, about 20 kg Russian olive fruits were prepared from Bojnourd region, Iran. Before measuring properties of grains, foreign matters such as dust and stones, were removed manually from the rest of fruits. The initial moisture content of fruits was determined through an oven method at 105 ± 3 ^{0}C during 24 hours. The principle dimensions (Length (L), width (W), thickness (T)) of selected randomly 50 Russian olive fruits were measured using a digital micrometer having the accuracy of 0.001mm [15].

The arithmetic mean diameter, D_a, and geometric mean diameter, D_g, of the fruits were calculated by using the following relationships [15]:

$$D_a = \frac{L+W+T}{3} \quad (1)$$

$$D_g = LWT^{\frac{1}{3}} \quad (2)$$

The equivalent diameter (D_p) for a fruit, was calculated by Mohsenin [15]:

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

Surface area, aspect ratio of the shape and sphericity were determined according to the Mohsenin's method. The porosity of Russian olive fruit was computed from the values of true density and bulk density of the fruits [15]:

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad (4)$$

Where: ε is the porosity (%); ρ_b is the bulk density (kg/m^3); and ρ_t is the true density (kg/m^3). Reported values of all density characteristics are means of 20 replications.

The angle of repose was determined by using an open-ended cylinder of 15 cm diameter and 50 cm height. The cylinder was placed at the center of a circular plate having a diameter of 70 cm and filled with fruit or kernel. The cylinder was raised slowly until it formed a cone on the circular plate. The height of the cone was recorded by using a movable pointer fixed on a stand having a scale of 0-1 cm precision. The angle of repose, θ, was calculated using the formula:

$$\theta = tan^{-1}(\frac{2H}{d}) \quad (5)$$

Where: *H* is the height of the cone (cm) and *d* is the diameter of cone (cm). Other researchers have used this method [15]. The reported value is mean of 20 replications.

The static coefficient of friction for jujube fruits was determined with respect to three test surfaces, plywood, glass, and the galvanized iron sheet. For this purpose a cylinder with diameter and depth of 75mm and 50mm was filled with grains. The cylinder was mounted on the surface and the slope of the surface was increased gradually. When the cylinder started sliding down, the angle (α) was measured. The value of static friction coefficient (μ_s) was calculated using equation below [15]:

$$\mu_s = tg\alpha \quad (6)$$

The color of Russian olive fruits in terms of L*, a*, b* values was determined using a Minolta colorimeter (CR-3000 Model). L* denotes the lightness or darkness; a* is green or red; and b* is blue or yellow color of the samples. The color was measured at three points of each sample. Measurements were conducted on the skin and were computed as the means of three replications [16].

The mechanical properties for one compression axis (in line with the longitudinal) of Russian olive fruits was determined by a quasi-static loading device that performed with an Instron Universal Testing Machine (Model Santam SMT-20).The device consists of a lower plate that a single fruit was placed on this plate and upper plate moved up with a fixed speed of 3mm min^{-1} and initial distance of 10 mm from the surface of sample compressing the Russian olive between two parallel plates until it ruptured. A load cell connected to a stationary upper plate and sensed the force applied to the sample which increased with time and transmitted the data to a computer (Fig 1).

The test was repeated fifty times. Rupture force and deformation measured at rupture point [20]. The area under the load-deformation curve given the energy absorbed during the loading up to rupture [1], and hardness, *Q*, was calculated by dividing the rupture force by the deformation at rupture [2].

Fig. 1 Apparatus for the measurement of mechanical properties

III. RESULTS AND DISCUSSION

Wet basis moisture content of Russian olive fruits samples was found to be 14.34%. Results showed that the mass and volume varied from 0.71 to 2.36 g and from 1.06 to 4.34 cm^3, with mean values of 1.45 g and 2.55 cm^3, respectively. These conclusions were supported by Ercisli et al. for hazelnut cultivars [8]. Dimensions of Russian olive fruits varied from 14.08 to 26.82 mm in length, 11.38 to 18.99 mm in width, and 11.29 to 17.59 mm in thickness, with average values of 20.72, 15.73, and 14.69 mm, respectively. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin [15]. These dimensions can be used in designing machine components and parameters. The major axis has been found to be useful by indicating the natural rest position of the fruit. The importance of sphericity and aspect ratio is in determining the shape of fruit. The average sphericity of Russian olive fruits was 0.81, which sphericity is reported by Mohsenin in the range of 0.32-1 [15]. The mean aspect ratio was obtained as 0.72, with variation of 0.53 to 0.98. The surface area of Russian olive fruits varied from 5.04 to 12.86 cm^2 with mean values of 8.96 cm^2. Similar conclusion was obtained by Ercisli et al. for hazelnut cultivar [8].

Whole fruit density and Bulk density were measured and found to be between 0.66 to 1.48 and 0.27 to 0.33 g/cm^3, and with average values of 1.01 and 0.29 g/cm^3, respectively. The porosity obtained was found to be 69.5%. Values of mean coefficient of static friction on glass, galvanized iron steel and plywood surfaces were obtained as 0.35, 0.36 and 0.43, respectively.

Results of analysis showed that static coefficient of friction on plywood surfaces had a significant difference ($p<0.05$) with static coefficient of friction of galvanized iron steel and glass. The static coefficient of friction on galvanized iron steel was higher than that of glass and lower than that of plywood surface. This is due to the frictional properties between the fruits and surface materials.

The knowledge related to static coefficient of friction of fruits on different surfaces, is useful in the separation process and would be valuable in transportation of the fruits. A summary of results of the determined physical parameters is shown in Table I and II.

TABLE I
SOME PHYSICAL PROPERTIES OF RUSSIAN OLIVE FRUIT

Properties	No. of samples	Mean	SD
Mass(g)	50	1.45	0.32
Length (mm)	50	20.72	2.60
Width (mm)	50	15.73	1.60
Thickness (mm)	50	14.69	1.40
Arithmetic mean diameter (mm)	50	17.05	1.57
Geometric mean diameter (mm)	50	16.83	1.53
Equivalent diameter (mm)	50	16.84	1.54
Sphericity	50	0.81	0.06
Aspect ratio	50	0.72	0.09
Volume (cm^3)	50	2.55	0.69
Surface area (cm^2)	50	8.96	1.61

TABLE II
CHOSEN PROPERTIES OF RUSSIAN OLIVE FRUIT AT 14.43% (w.b.)

Properties	Values	Max	Min	SD
Bulk density(kg/m³)	0.29	0.33	0.27	0.02
True density(kg/m³)	1.01	1.48	0.66	0.25
Porosity (%)	69.5	81.73	57.72	7.89
Angle of repose(deg)	20.5	24	18.5	3.04
Static coefficient of friction:				
Plywood	0.43	0.58	0.31	0.05
Galvanized iron	0.36	0.49	0.07	0.03
Glass	0.35	0.51	0.04	0.05

The mean skin color (L*, a*, b*) values of Russian olive fruits are presented in Table III. The values of L*, a*, b* varied from 9.92 to 16.08; 2.04 to 3.91 and 1.12 to 3.83, respectively.

TABLE III
COLOR CHARACTERISTICS OF RUSSIAN OLIVE FRUIT

Parameter	Mean	SD
L	12.40	2.06
a	2.73	0.63
b	2.39	0.83

The values of rupture force, deformation, energy absorbed and hardness were found to be between 3.97-30.73 N, 1.10-4.82 mm, 3.01-63.49 N mm and 1.79-7.16 N mm^{-1}. Mechanical properties such as rupture force, hardness and energy used for rupturing fruits are useful information in designing the dehulling machine [2]. A summary of results of the some mechanical properties of Russian olive fruits at longitudinal axis is shown in Table IV.

TABLE IV
SOME MECHANICAL PROPERTIES OR RUSSIAN OLIVE AT LONGITUDINAL AXIS

	Rupture force (N)	Deformation (mm)	Energy absorbed (N mm)	Hardness (N/mm)
No. of sample	50	50	50	50
Mean	14.64	3.01	4.99	20.02
Max	16.85	4.25	6.99	23.85
Min	12.14	2.16	3.42	17.1
SD	1.34	0.47	0.71	1.79

IV. CONCLUSION

1. Dimensions of Russian olive fruits varied from 15.29 to 21.69 mm in length, 13.14 to 20.45 mm in width, and 13.11 to 18.76 mm in thickness, with average values of 18.88, 16.79, and 15.9 mm, respectively
2. The average arithmetic and geometric mean diameter, equivalent diameter, sphericity, aspect ratio and surface area were: 17.05, 16.83, 16.84 mm, 0.81, 0.72 and 8.96 cm^2, respectively, at moisture content of 14.34% (w.b.).
3. Fruit mass was between 0.71 and 2.36 g and volume was from 1.06 to 4.34 cm^3. Bulk density found to be between 0.27 and 0.33 kg/m^3 while True density varied from 0.66 and 1.48 kg/m^3. The porosity obtained was found to be was 69.5 %.
4. The angle of repose of Russian olive fruit was 20.5° (±3.04°).
5. Values of mean coefficient of static friction on glass, galvanized iron steel and plywood surfaces were obtained as 0.35, 0.36 and 0.43, respectively. The static coefficient of friction on galvanized iron steel was higher than that of glass and lower than that of plywood surface.
6. The values of L*, a*, b* varied from 9.92 to 16.08; 2.04 to 3.91 and 1.12 to 3.83, respectively.
7. The average rupture force (N), Deformation (mm), energy absorbed (Nmm) and hardness (N/mm) were between 12.14-16.85, 2.16-4.25, 3.42-6.99 and 17.1-23.85 respectively.

REFERENCES

[1] E. Altuntas, M. Yildiz, “Effect of moisture content on some physical and mechanical properties of faba bean (*Viciafaba* L.) grains,” J. Food Eng., vol. 78, pp.174-183, 2007.
[2] P. Sirisomboon, P. Kitchaiya, P. Pholpho, W. Mahuttanyavanitch, “Physical and mechanical properties of *Jatropha curcas* L. fruits, nuts and kernels,” J. Food Eng., vol. 97, pp. 201-207, 2007.
[3] A. Koocheki, S.M.A. Razavi, E. Milani, T.M. Moghadan, M. Abedini, S. Alamatiyan, “Physical properties of watermelon seed as a function of moisture content and variety,” Int. Agrophysics, vol. 21: pp. 349-359, 2007.
[4] M. Keramat Jahromi, A. Jafari, S. Rafiee, A.R. Keyhani, R.Mirasheh, S.S. Mohtasebi, “Determining some physical properties of date fruit (cv. Lasht),” Agric. Eng. Int.: the CIGR Ejournal. Manuscript FP 07 019, IX, 2007.
[5] I. Ozturk, M. Kara, F. Uygan, F. Kalkan, “Restitution coefficient of chick pea and lintel seeds,” Int. Agrophysics, vol. 24, pp. 209-211, 2010.
[6] P.C. Corr�a, F. Schwanz da Silva, C. Jaren, P.C. Afonso Júnior, I. Arana, “Physical and mechanical properties in rice processing,” J. Food Eng., vol. 79, pp.137–142, 2007.
[7] E. Altuntas, R. Cangi, C. Kaya, “Physical and chemical properties of persimmon fruit,” Int. Agrophysics,” vol. 25, pp.89-92, 2011.
[8] S. Ercisli, I. Ozturk, M. Kara, F. Kalkan, H. Seker, O. Duyar, Y. Erturk,

"Physical properties of hazelnuts," Int. Agrophysics, vol. 25, pp. 115-121, 2011.
[9] A. Tabatabaeefar, "Moisture-dependent physical properties of wheat," Int. Agrophysics, vol. 12, pp. 207-211, 2003.
[10] N.A. Aviara, F.A. Oluwole, M.A. Haque, "Effect of moisture content on some physical properties of sheanut (Butyrospernum Paradoxum)," Int. Agrophysics, vol. 19, pp. 193-198, 2005.
[11] W. Burubai, A.J. Akor, A.H. Igoni, Y.T. Puyate, "Some physical properties of nutmeg," Int. Agrophysics, vol. 21, pp. 123-126, 2007.
[12] M. Sharifi, S. Rafiee, A. Keyhani, A. Jafari, H. Mobli, A. Rajabipour, A. Akram, "Some physical properties of orange (var. Tompson)," Int. Agrophysics, vol. 21, pp. 391-397, 2007.
[13] R. Akinoso, A.O. Raji, "Physical properties of fruit, nut and kernel of oil palm," Int. Agrophysics, vol. 25, pp. 85-88, 2011.
[14] B.S. Ogunsina, I.O. Olaoye, A.O. Adegbenjo, B.D. Babawale, "Nutritional and physical properties of kariya seeds," Int. Agrophysics, vol. 25, pp. 97-100, 2011.
[15] N.N. Mohsenin, "Physical Properties of Plant and Animal Materials," Gordon& Breach, New York, USA, 1996.
[16] S.N. Jha, A.R.P. Kingsly, S. Chopra, "Physical and mechanical properties of mango during growth and storage for determination of maturity," J. Food Eng., vol. 72, pp. 73-76, 2006.