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The Volumetrical, Geometrical and Frictional Properties of Silver Berry (*Elaeagnus angustifolia* L.) Fruits

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Abstract – The volumetrical, geometrical and frictional properties of silver berry fruits (*Elaeagnus angustifolia* L.) determined. The mean values of the fruit mass, porosity, fruit volume, fruit and bulk densities values of silver berry fruits were found as 1.056 g, 71.65%, 1.131 cm^3, 934.44 kg/m^3 and 264.70 kg/m^3, respectively. The mean values of the surface area, sphericity and geometric mean diameter were 5.46 cm^2, 71.40% and 12.99 mm, respectively. The mean values of dynamic and static coefficient of friction against mild steel, chipboard, rubber, galvanized steel, and plywood surfaces were determined and the highest dynamic and static coefficients of friction values of silver berry fruits were found for rubber surface. The angle of repose was found as 7.37° for silver berry fruits.

Keywords –
Oleaster, Surface Area, Angle Of Repose, Static Coefficient Of Friction.

1. Introduction

Silver berry (*Elaeagnus angustifolia* L.) is called wild and Russian olives and oleaster. Siver berry common names comes from its similarity in appearance to olive. It is cultivated from southern Russia and Kazakhstan to Turkey and Iran. Silver berry is a generally small tree but it grows to 5–7 m height. The leaves, buds and stems have a dense covering of silvery to rusty scales. Its leave sizes varied between 4 and 9 cm (long), 1 and 2.5 cm (broad). The flowers are aromatic. Its fruits (orange-red covered in silvery scales)are small cherry-like drupe (1-1.7 cm long), but the red fruits are lightly sweet-tart (approximately 2.5 cm long and 1.7 cm diameter). The fruit of silver berry have very rich vitamins (A, C and E), flavonoids and other bio-active compounds. The fruits are sweet and edible. The fruit skins are extremely thin. The dried fruits weighed 21 to the ounce. The shrub can fix nitrogen in its roots, enabling it to grow on bare mineral substrates. For rheumatoid arthritis and joint pains, the fruit dried powders is used mixed with milk [1, 2, 3].

The oil from the seeds of silver berry fruits is used with syrup as an electuary in the treatment of catarrh and bronchial affections. The juice of the flowers of silver berry has been used in the treatment of malignant fevers. The fruit of many members of this genus is a very rich source of minerals and vitamins, especially in vitamins C, E, A, and bio-active compounds and flavanoids [4]. It is also a fairly good source of essential fatty acids, which is fairly unusual for a fruit. It is being investigated as a food that is capable of reducing the incidence of cancer and also as a means of halting or reversing the growth of cancers [5].

The volumetrical, geometrical and frictional properties of silver berry fruits are to be known for harvesting, storing, handling, granding and processing in design and improve of relevant machines. The porosity, bulk density and angle of repose of silver berry fruits affect the structural loads at silo design, and they are important in designing of storage and transporting structures. The coefficient of friction of the silver berry fruits against the various surfaces is also necessary in designing of the storing, transporting and conveying structures.

In recent years, the volumetrical, geometrical and frictional properties for the different agricultural materials have been studied such as fresh palm, date fruit medlar, service tree, and juniper berries by [6, 7, 8, 9, 10](Owolarafe et al. [6]; Jahromi et al. [7]; Altuntas et al. [8]; Altuntas et al. [9]; Altuntas [10]. However, studies conducted on the volumetrical, geometrical and frictional properties of silver berry fruits have not been adequately studied. The objective of this study was to investigate the volumetrical, geometrical and frictional properties for silver berry fruits such as sphericity, size dimension, mass, geometric mean diameter, porosity, bulk density, fruit density, volume, the dynamic and static coefficients of friction on the different surfaces and angle of repose.

2. Materials and Methods

Silver berry fruits (*Elaeagnus angustifolia* L.) used for experiments were obtained from a special market in Tokat, Turkey. The silver berry fruit samples were manually cleaned to remove dust, dirt, broken and immature fruits, and all foreign matter. The moisture content of the Silver berry fruit samples was determined by oven drying at 105 ± 1 °C for 24 h [11]. Each of the fruit samples was replicated three times and the mean moisture content of silver berry was found as 41.27% d.b. (dry basis)

Volumetrical characteristics

The volumetrical characteristics of silver berry fruits such as mass, volume fruit and bulk densities, and porosity were determined. The fruit mass was measured using an electronic balance ((Kern EW 620-3 NM, Germany) with 0.001 g accuracy. The fruit density and volume of silver berry fruits were determined using the liquid displacement method. Toluen (C_7H_8) was used rather than water because it is absorbed by silver berry fruit samples to a lesser extent [12]. The bulk density was determined with a weight per hectolitre tester which was calibrated in kg/m^3 [13]. The porosity (P) of silver berry fruits was determined to the method presented by Mohsenin [12].

Geometrical properties

To determine of geometrical properties of the silver berry fruits, one hundred sample fruits were randomly selected and length, width and thickness were measured using a dial-micrometer (INSIZE 3109-25E, China) to an accuracy of 0.01 mm. The sphericity (Φ) and the geometric mean diameter (D_g), and surface area (S) of silver berry fruits were determined methods presented by Mohsenin [12].

Dynamic and static coefficient of friction

The dynamic and static coefficient of friction of silver berry fruits fruits were measured by a friction device. The experiment was conducted on silver berry fruits using friction surfaces such as rubber, galvanized metal, plywood, mild steel and chipboard. The friction measuring device is formed by a friction surface, an electronic unit, and a metal box. The electronic unit covers electronic variator, the mechanical force unit, PC, electronic ADC card and loadcell [11]. The force of friction was measured by the loadcell, and converted by the ADC card, and data were recorded in a computer. While the box continued to slide over the friction surface at 0.02 m/s velocity, the dynamic and static coefficient of frictions were measured. The maximum value of friction force was obtained when box started moving, and this was used to calculate the static coefficients of friction of silver berry fruits. The average value of coefficient of friction was used to calculate the dynamic coefficients of friction [14]. For each experiment, the sample box was emptied and refilled with a different sample at the same moisture content [10].

The angle of repose

To determine the angle of repose of silver berry fruits, bottomless and topless cylinder with 500 mm height and 300 mm diameter was used. The cylinder was placed at the center of a raised circular plate and was filled with silver berry fruits and the cylinder was raised slowly until it formed a cone on a circular plate. The angle of repose (θ) of silver berry fruit samples was calculated from the measurement of the height of the cone and the diameter of cone [11].

Statistical analyses were conducted with Microsoft Excel and SPSS 13.0 Software [15]. Results from the experiments were analysed based on fundamental statistics (mean, minimum, maximum, correlation coefficient and etc.).

3. Result and Discussion

Volumetrical properties

The values of volumetrical properties of silver berry fruits were given in Table 1. The fruit and bulk density and porosity for silver berry fruits were changed from 911.94 to 972.92 kg/m^3, 255.23 to 273.00 kg/m^3 and 70.06 to 72.99%, respectively (Table 1). The fruit mass varied from 0.46 to 2.12 g for silver berry fruits. The fruit volume of silver berry changed from 1.086 to 1.158 cm^3.

Haciseferogullari et al. [16] reported that the fruit mass, fruit volume, of wild medlar was reported as 12.0 g, 13.7 cm^3 at 72.2% dry basis moisture content. The bulk and fruit densities and porosity of wild medlar were reported as 379.9 kg/m^3, 1031.1 kg/m^3, and

63.1% by Haciseferogullari et al. [16], respectively. The bulk and fruit densities and porosity of silver berry fruits were found lower than wild medlar.

Table 1. Volumetrical properties (fruit mass, volume, porosity, bulk and fruit density) of silver berry fruits.

Volumetrical properties	Mean	Maximum	Minimum	SD *
Fruit mass, M (g)	1.056	2.120	0.460	0.368
Fruit volume, V (cm^3)	1.131	1.158	1.086	0.051
Porosity, P (%)	71.65	72.99	70.06	1.419
Bulk density, ρ_b (kg/m^3)	264.70	273.00	255.23	7.571
Fruit density, ρ_t (kg/m^3)	934.44	972.92	911.94	33.48

SD*, Standard deviation

The bulk and fruit densities and porositiy for Japan flowering crabapple were reported as 658.5 kg/m^3, 1031.1 kg/m^3 and 35.9%, by Altuntas and Karaosman [17], respectively. The fruit and bulk density densities of silver berry fruits were found lower than Japan flowering crabapple fruits; while, the porosity of silver berry fruits was found higher than Japan flowering crabapple fruits. The mean fruit mass, fruit and bulk densities, volume and porosity for juniper berries were reported as 0.23 g, 816.4 kg/m^3, 105.8 kg/m^3, 0.28 cm^3, and 87.0% by Altuntas [10], respectively. The fruit mass, volume, the fruit and bulk density densities of silver berry fruits were found higher than juniper berry fruits.

Geometrical properties

The values of geometrical properties of silver berry fruits were given in Table 2. The length, width and thickness of silver berry fruits ranged from 12.75 to 26.18 mm, 8.08 to 17.39 mm, 7.16 to 16.49 mm, respectively (Table 2). The sphericity and geometric mean diameter values of silver berry fruits were found from 60.87 to 85.00% and 9.15 to 13.09 mm, respectively. Surface area of silver berry fruits was varied from 2.59 to 11.09 cm^2.

Table 2. The geometrical properties (length, width, thickness, sphericity, geometric mean diameter and surface area) of silver berry fruits.

Geometrical properties	Mean	Maximum	Minimum	SD*
Length, L (mm)	18.19	26.18	12.75	2.94
Width, W (mm)	11.48	17.39	8.08	2.19
Thickness, T (mm)	10.62	16.49	7.16	2.05
Sphericity, Φ (%)	71.40	85.00	60.87	4.40
Geometric mean diameter, D_g (mm)	12.99	13.09	9.15	2.27
Surface area, S (cm^2)	5.46	11.09	2.59	1.97

SD*, Standard deviation

The relationship between length (L), width (W), thickness (T), sphericity (Φ), geometric mean diameter (D_g) and surface area (S) of silver berry fruit and the correlation coefficients (R) for these relations were determined as follows:

$$L = 1.60W = 1.73T = 1.44D_g = 3.73S \quad (1)$$

The relations between L/W L/T L/D_g, and L/S have been found to be statistically significant, whereas, L/Φ has not been found to be statistically significant (Table 3).

Table 3. The correlation coefficient of silver berry fruits.

Particulars	Ratio	Degress of freedom	Correlation coefficient (R)
Silver berry fruit			
L/W	1.599	98	0.8954 **
L/T	1.730	98	0.8803 **
L/D_g	1.406	98	0.9320 **
L/Φ	0.256	98	-0.0206 [ns]
L/S	3.558	98	0.9245 **

[ns] non significant, ** Significant at 1% level.

Haciseferogullari et al. [16] reported that the sphericity and the geometric mean diameter of wild medlar were evaluated as 0.90 and 28.9 mm at 72.2% dry basis moisture content. The size dimension such as fruit length, width and thickness were reported as 30.25 mm and 19.94 mm and 15.66 mm for the fresh palm by Owolarafe et al. [6], respectively. The mean surface area, the volume of fruits and the sphericity for medlar were reported as 29.7 cm^2, 0.97 and 15.3 cm^3 by Altuntas et al. [8], respectively. The sphericity of silver berry fruits are lower than reported for medlar [16, 8]. The mean goemetric mean diameter, surface area, the fruit volume, and the sphericity of Japan flowering crabapple were reported as 34.0 mm, 36.5 mm^2 , 21.1 mm^3, and 97.7%, by Altuntas and Karaosman, [17], respectively. The sphericity and geometric mean diameter of Juniper berries were reported as 8.30 mm, 96.7%, respectively by Altuntas [10], respectively. The sphericity of silver berry fruits were found lower than Juniper berry fruits; while, the geometric mean diameter of silver berry fruits was found higher than Juniper berry fruits.

Dynamic and static coefficient of friction

The values of static and dynamic coefficients of friction against the various test surfaces for mild steel, chipboard, rubber, galvanized metal, and plywood for silver berry fruits were presented in Table 4. The dynamic coefficients of friction mean values against mild steel chipboard, rubber, galvanized steel and plywood surfaces for silver berry fruits were, 0.259, 0.281, 0.558, 0.277, 0.473, respectively. The static coefficients of friction mean values of silver berry fruits against mild steel, chipboard, rubber, galvanized steel, and plywood surfaces were 0.37, 0.611, 0.281, 0.525 and 0.330, respectively. According to these results, dynamic coefficient of friction of silver berry fruits is lower than static coefficients of friction.

Table 4. The coefficient of friction (dynamic and static) values for silver berry fruits

	Coefficient of friction			
Friction surfaces	Dynamic	SD*	Static	SD*
Mild steel	0.259	0.013	0.281	0.020
Chipboard	0.281	0.013	0.330	0.010
Rubber	0.558	0.051	0.611	0.038
Galvanized metal	0.277	0.114	0.366	0.066
Plywood	0.473	0.043	0.525	0.033

SD*: Standard deviation

The static and dynamic coefficients of friction of Juniper berries were reported as 0.31 and 0.25 for chipboard; 0.22 and 0.16 for galvanized steel, 0.29 and 0.20 for mild steel; 0.26 and 0.25 for plywood; 0.54 and 0.47 for rubber surfaces by Altuntas [10], respectively. The static coefficient of friction of the cornelian cherry were reported between 0.93 and 0.96 for rubber; 0.89 and 0.91 for plywood; 0.79 and 0.85 for steel surfaces by Demir and Kalyoncu [18], respectively. The static and dynamic coefficient of frictions was higher for silver berry fruits againts rubber surface than the other friction surfaces. Similar results were found for cornelian cherry fruits by Demir and Kalyoncu [18]; and Juniper berry fruits by Altuntas [10].

The angle of repose

The angle of repose for silver berry fruits changed from 6.59 to 9.14°. Altuntas [10] reported that the mean angles of repose varied from 21.88 to 32.41° for Juniper berries respectively. The mean angle of repose for silver berry fruits is considerably lower than that reported for Juniper berry fruits by Altuntas [10]. Aydin et al [19] reported that the mean angle of repose of mahaleb were changed 25° to 30.5°. The angle of repose of silver berry fruits was lower than mahaleb.

4. Conclusions

The volumetrical, geometrical and frictional properties for silver berry fruits measured will serve to improve of relevant machines and facilities for harvesting, storing, food handling, granding and processing. The following conclusions are drawn from the investigation on the volumetrical, geometrical and frictional properties of silver berry fruits:

- The bulk and fruit densities were ranged from and 255.23 to 273.00 kg/m^3 and 911.94 to 972.92 kg/m^3, respectively.

- The surface area, the geometric mean diameter and sphericity were found as 5.46 cm^2, 12.99 mm, and 71.40%, respectively. The relations between L/Φ has not been found to be statistically significant, whereas, L/D_g, *L/T, L/S and L/W* have been found to be statistically significant.

- The dynamic and static coefficients of friction of silver berry fruits among on the different friction surfaces were greater at rubber surface compared to the mild steel, plywood, chipboard and galvanized metal friction surfaces.

-The angle of repose of silver berry fruits varied from 6.59° to 9.14°.

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