

Effect of Moisture Content on Some Physical Properties of Barberry

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Abstract: In this paper several physical properties of barberry have been evaluated as a function of moisture content varying from 12.64 to 89.23% (w.b.). With increasing in moisture content from 12.6 to 89.23% (w.b.); the barberry length, width, thickness, geometric mean diameter and surface area was increased from 8.11 to 12.01 mm, 1.81 to 5.81 mm, 1.79 to 5.75 mm, 2.96 to 7.36 mm and 27.69 to 170.13 mm², respectively; the sphericity, volume and barberry mass was increased from 36.61 to 61.46%, 89.34 to 211.79 mm³ and 0.121 to 0.414 g, respectively; the true density and bulk density was increased from 1354.37 to 1954.76 kg/m³ and 700.01 to 1224.67 kg/m³, respectively but porosity was decreased from 48.31 to 37.34%. Coefficient of static friction on glass, galvanize and wood surfaces was increased linearly as moisture content increased from 12.64 to 89.23% (w.b.). Also the highest coefficient of static friction was found on the glass surface.

Key words: Moisture content . Physical properties . Barberry

INTRODUCTION

The barberry (*Berberis vulgaris* L., Var. *asperma* Don, family Berberidaceae) plant also grows in Asia and Europe; In Iran more than 5,000 tones of barberries are produced each year [1]. Barberry has been used extensively as a medicinal plant in traditional medicine. The fruit of the plant has been used as food additive. Khorasan, located at the northeastern Iran, is the production center with about 6,000 hectares of field growing barberry. Each year, more than 4,500 tones are harvested in Khorasan region alone. Barberry cultivation in Khorasan is concentrated in the south of the province, especially around Birjand and Ghayen where environmental condition (i.e. hot weather, low relative humidity, water shortage and soil condition) are unfavorable for the growing of other horticultural crops. Mean yearly precipitation is 190.3 and 173.5 mm in Ghayen and Birjand, respectively. Minimum and maximum temperature are -38, +41°C in Ghayen and -15, +44°C in Birjand. About 85% of production is in Ghayen and about 15% in Birjand. According to evidence the cultivation of seedless barberry in south of province backs to two hundred years ago. Other studies described detailed information about cultivation, taxonomy, propagation, utilization and processing of seedless barberry cultivated in the southern parts of Khorasan, Iran.

The plant is a shrub, 1-3 m tall, spiny, with yellow wood and obovate leaves, bearing pendulous yellow flowers succeeded by oblong red berries [2, 3]. Medicinal properties for all parts of the plant have been reported, including tonic, antimicrobial, antiemetic, antipyretic, antipruritic and cholagogue actions and it has been used in some cases like cholecystitis, cholelithiasis, jaundice, dysentery, leishmaniasis, malaria and gall stones [2, 4, 5]. In spite of extensive applications and numerous properties, the mechanism of action in most of its effects is not exactly clear. Some of these properties may occur due to antihistaminic or anticholinergic effects.

Many studies have been reported on the physical properties of fruits such as rose fruit [6], cornelian cherry [7], fresh okra fruit [8], cherry laurel [9], Juniperus drupacae fruit [10], orange [11], berries [12], wild plum [13], gumbo fruit [14] and caper fruit [15]. No detailed study concerning physical properties of barberry fruit was found in the literature.

The purpose of this study was to investigate the moisture-dependent physical properties of barberry such as dimension properties, surface area, sphericity, volume, mass, true density, bulk density, porosity and coefficient of static friction on various surfaces in range of moisture content varying from 12.64 to 89.23% (w.b.).

Nomenclature

L	Length	M	Mass
W	Width	ρ_T	True density
T	Thickness	ρ_B	Bulk density
D_g	Geometrical mean diameter	P	Porosity
S	Surface area	μ	coefficient of static friction
Φ	Sphericity	Mc	Moisture content
V	Volume		

MATERIALS AND METHODS

The barberry (Fig. 1) used for this study were collected from the region located in varanghrood village in karaj Iran in 2007 and they were cleaned to remove all foreign material. Finally, 2 kg of barberry obtained. All products were kept in the room temperature for two day. Moisture content was immediately measured on arrival. All of the experiments were carried out at a room temperature of $25\pm 3^\circ\text{C}$. All of the samples were tested at the physical and mechanical properties Laboratory of Tehran University, Karaj, Iran.

The barberries were divided into five batches in order to obtain five moisture levels for the experiments. For reaching the desired water contents of the barberries, the moisture of fruit samples were measured at six days intervals after barberries harvesting. The first water content of fruits was 89.23%, then after 6 days the water content of barberries had fallen down to 70.11, 53.11 38.09 and 12.64% (w.b.), respectively. Moisture contents of the fruits were determined by using a standard method [16].



Fig. 1: Barberry

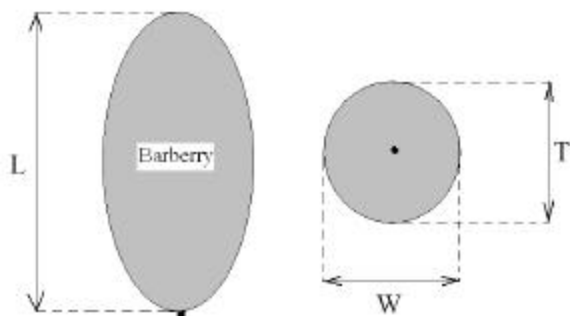


Fig. 2: Three major perpendicular dimensions of barberry

For determining the average size of the barberries, their three linear dimensions namely, length (L), width (W) and thickness (T) were measured using a digital micrometer having accuracy of 0.01 mm (Fig. 2).

Barberry mass (m) was measured with an electronic balance with accuracy of 0.001 g. The geometric mean diameter (D_g), volume (V), surface area (S), sphericity (Φ) and True density (ρ_T) were calculated using the following equations [17, 18].

$$D_g = (LWT)^{0.333} \tag{1}$$

$$V = \pi(LWT) / 6 \tag{2}$$

$$S = \pi D_g^2 \tag{3}$$

$$\Phi = D_g / L \tag{4}$$

$$\rho_T = m / V \tag{5}$$

The bulk density (ρ_B) in kg/m^3 is the ratio of the mass sample of the barberries to its total volume. It was determined by filling a 1000 ml container with barberries from a height of about 15 cm, striking the top level and then weighing the contents [19]. Also percentage of porosity (P) calculated by following equation [18]:

$$P = (1 - (\rho_B / \rho_T)) * 100 \tag{6}$$

Coefficient of static friction (μ) of barberries on tree surface including wood, glass and galvanize plate were determined. For determining coefficient of friction, the product was put on the surface with changeable slip (Fig. 3). When the product started its motion, tangent of slope angle calculated as the coefficient of friction [20].

RESULTS AND DESCUSSION

The mean of barberry physical properties in different moisture content compared by Duncan's multiple rang test. Comparing average data by Duncan method related to dimension, weight, volume, sphericity, surface area, true density, bulk density, porosity and coefficient of static friction on various surfaces are shown in Table 1.

Geometrical properties

Dimensions, geometric mean diameter and surface area: The three axial dimensions of the barberry at different moisture contents were shown on Fig. 4. From this it is clear that as the moisture content was increased

Table 1: Physical properties of barberry at various moisture content

	Moisture content (%wb)					
	12.64	38.09	53.11	70.11	89.23	
Length (mm) ^a	8.11 (0.012) ^c	8.75 (0.018)	9.68 (0.014)	11.25 (0.024)	12.01 (0.021)	
Width (mm) ^a	1.81 (0.003)	2.01 (0.004)	2.23 (0.011)	4.24 (0.008)	5.81 (0.008)	
Thickness (mm) ^a	1.79 (0.006)	2.27 (0.008)	2.65 (0.012)	4.02 (0.013)	5.75 (0.009)	
Geometric mean diameter (mm) ^a	2.96 (0.002)	3.41 (0.006)	3.84 (0.009)	5.74 (0.007)	7.36 (0.007)	
Surface area (mm ²) ^a	27.69 (2.75)	36.58 (4.07)	46.49 (8.01)	103.70 (18.41)	170.13 (25.04)	
Sphericity (%) ^a	36.61 (7.23)	39.012 (6.24)	37.47 (9.20)	52.01 (9.237)	61.46 (11.927)	
Volume (mm ³) ^a	89.34 (18.67)	154.61 (19.81)	193.24 (15.55)	208.21 (21.63)	211.79 (35.04)	
Weight (gr) ^a	0.121 (0.002)	0.211 (0.003)	0.343 (0.008)	0.398 (0.007)	0.414 (0.009)	
True density (kg/m ³) ^a	1354.370 (201.03)	1364.72 (198.01)	1774.99 (211.32)	1911.53 (197.79)	1954.76 (207.29)	
Bulk density (kg/m ³) ^b	700.010 (7.01)	738.07 (9.22)	988.11 (11.36)	1059.21 (11.91)	1224.67 (14.43)	
Porosity (%)	48.310	45.92	44.33	44.59	37.34	
Coefficient of static friction on:	Glass ^b	0.290 (0.011)	0.34 (0.026)	0.37 (0.037)	0.38 (0.029)	0.41 (0.01)
	Galvanize ^b	0.230 (0.031)	0.27 (0.026)	0.32 (0.021)	0.35 (0.064)	0.37 (0.051)
	Wood ^b	0.240 (0.020)	0.3 (0.022)	0.33 (0.015)	0.34(0.023)	0.39 (0.035)

^aAverage of 50 tests, ^b Average of 3 tests, ^c Standard deviation values in parentheses



Fig. 3: The device for determining coefficient of static friction

from 12.64 to 89.23% (w.b.), the dimensions of the three axes and geometric mean diameter increased. Similar trends have been reported by Sessiz *et al.* [15], Razavi *et al.* [21] for caper fruit and pistachio respectively. The relationship between length, width, thickness and moisture content of barberry were given by following equations:

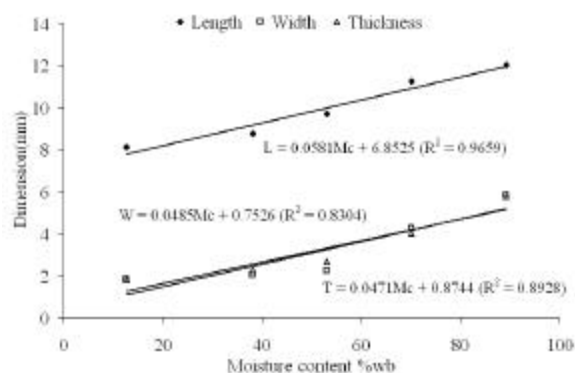


Fig. 4: Effect of moisture content on symmetrical dimensions

$$L = 0.0581Mc + 6.8525 \quad (R^2 = 0.9659) \quad (7)$$

$$W = 0.0485Mc + 0.7526 \quad (R^2 = 0.8304) \quad (8)$$

$$T = 0.0471Mc + 0.8744 \quad (R^2 = 0.8928) \quad (9)$$

Surface area: The variation of the surface area with change of the barberry moisture content is plotted in Fig. 5. This figure indicates that the surface area increases with increase in barberry moisture content. The relationship between surface area and moisture content of barberry was found to be as follows:

$$S = 0.0337Mc^2 - 1.5704Mc + 42.768 \quad (R^2 = 0.992) \quad (10)$$

Kabas *et al.* [22], Sessiz *et al.* [15] and Razavi *et al.* [21] obtained a similar results working with Cactus pear, Caper fruit and pistachio, respectively.

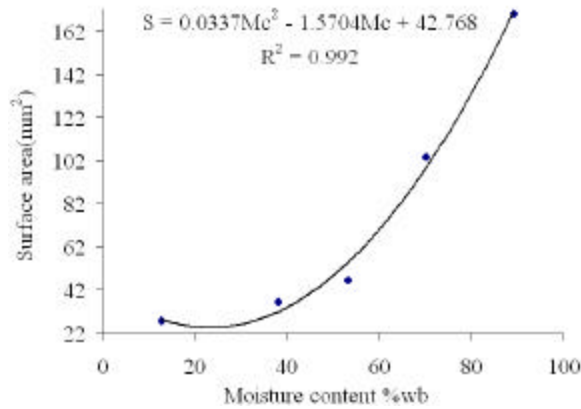


Fig. 5: Effect of moisture content on Surface area

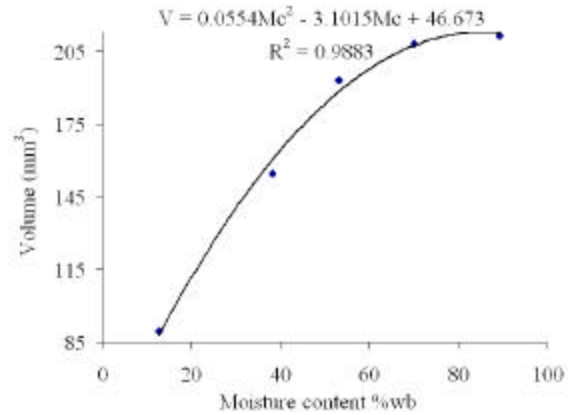


Fig. 7: Effect of moisture content on volume

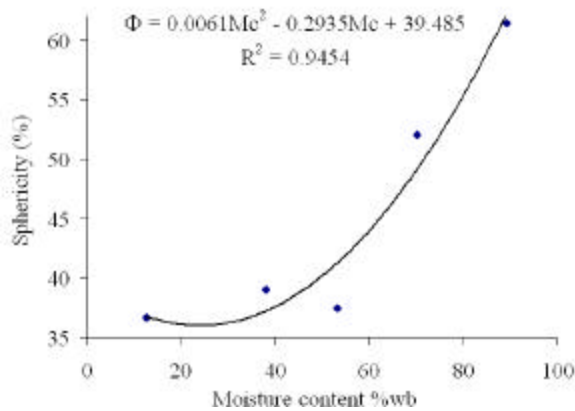


Fig. 6: Effect of moisture content on sphericity

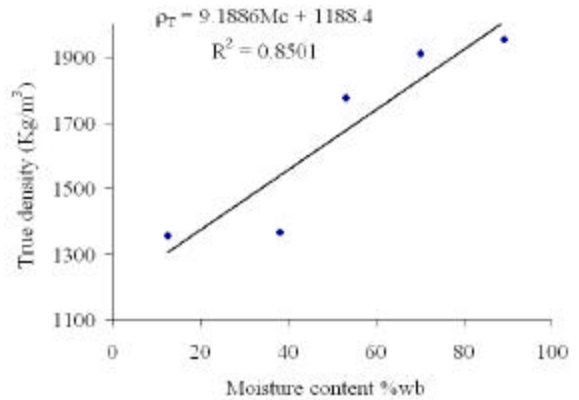


Fig. 8: Effect of moisture content on true density

Sphericity: The relationship between sphericity and moisture content of barberry is shown in Fig. 6. The values of the sphericity for different moisture levels varied from 36.61 to 61.46%. This relationship can be represented by the following equation:

$$\Phi = 0.0061Mc^2 - 0.2935 Mc + 39.485 \quad (R^2 = 0.9454) \quad (11)$$

The sphericity of the barberry was lower than these reported for cherry laurel [9], gumbo fruit [14] and Caper fruit [15].

Gravimetric properties: Mass and volume: As reported on the Table 1, the mass of barberry varied from 0.121 to 0.414 gr. The relationship between the mass and the moisture content was found to be the following:

$$W = 0.0026 Mc + 0.1874 \quad (R^2 = 0.9844) \quad (12)$$

The barberry volume variation with the change of moisture content is shown in Fig. 7. The volume

increases with increasing moisture content. When the moisture content changed from 12.64 to 89.23%, the volume was increased from 89.34 to 211.79 mm³. This relationship can be written as:

$$V = 0.0554Mc^2 - 3.101Mc + 46.673 \quad (R^2 = 0.9883) \quad (13)$$

Similar results for mass and volume have been reported by Kabas *et al.* [22] for Cactus pear and Sessiz *et al.* [15] for Caper fruit.

True density: The true density of barberry increased from 1354.37 to 1954.76 kg/m³ as moisture content increased from 12.64 to 89.23% (w.b.) (Fig. 8). The variations in true density with moisture content of barberry can be represented by the following relationship:

$$\rho_T = 9.1886Mc + 1188.4 \quad (R^2 = 0.8501) \quad (14)$$

The positive linear relationship of true density with moisture content was also observed by Calisir and

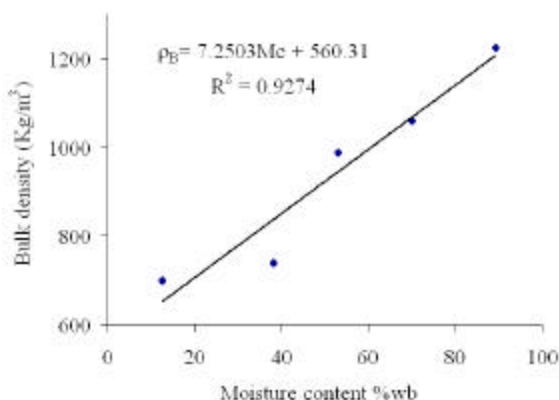


Fig. 9: Effect of moisture content on bulk density

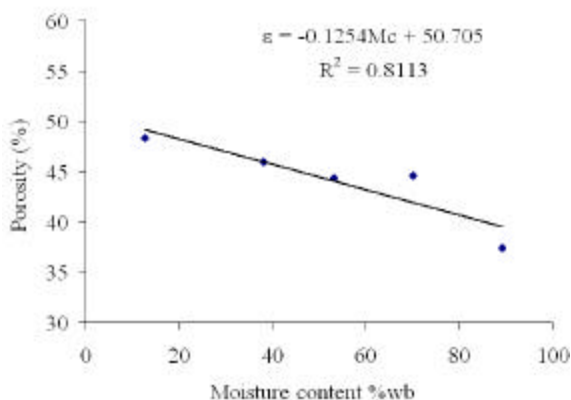


Fig. 10: Effect of moisture content on porosity

Aydin [9] for cherry laurel, Chandrasekar and Viswanathan [23] for coffee and Akar and Aydin [14] for gumbo fruit.

Bulk density: The values of bulk density of barberry at different moisture levels varied from 700.01 to 1224.67 kg/m³ (Fig. 9) and indicated an increase in bulk density with increasing in moisture content. Similar results for bulk density have been reported by Chandrasekar and Viswanathan [23] for coffee, Calisir and Aydin [9] for cherry laurel, Akar and Aydin [14] for gumbo fruit, Kabas *et al.* [22] for Cactus pear and Sessiz *et al.* [15] for Caper fruit.

Porosity: The variation of porosity values depending on moisture content in barberry is shown in Fig. 10. The porosity values of barberry at moisture contents of 12.64 and 89.23%wb varied between 48.31 and 37.34%. The relationship between porosity value and moisture content was found to be as follows:

$$\epsilon = -0.1254 Mc + 50.705 \quad (R^2 = 0.8113) \quad (15)$$

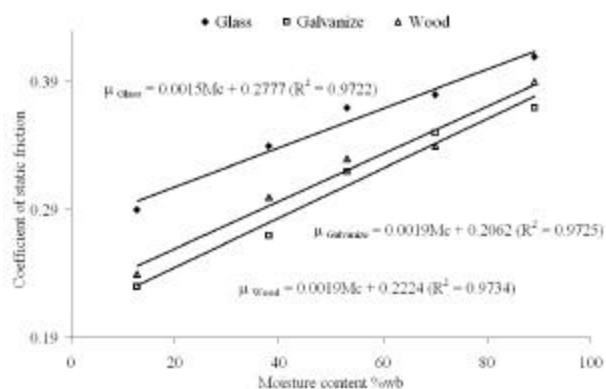


Fig. 11: Effect of moisture content on coefficient of static friction

Chandrasekar and Viswanathan [23] for coffee, Calisir and Aydin [9] for cherry laurel, Kabas *et al.* [22] for Cactus pear and Sessiz *et al.* [15] for Caper fruit stated that as the moisture content increased so the porosity value decreased.

Frictional properties: Coefficient of static friction: Fig. 11 shows the static coefficient of friction for barberry determined with respect to glass, galvanize and wood sheets at different moisture contents. As the moisture content of barberry increased, the Coefficient of static friction increased linearly. The relationships between these coefficients against various surfaces and moisture contents of barberry are shown in below equations:

$$\mu_{\text{Glass}} = 0.0015Mc + 0.2777 \quad (R^2 = 0.9722) \quad (16)$$

$$\mu_{\text{Galvanize}} = 0.0019Mc + 0.2062 \quad (R^2 = 0.9725) \quad (17)$$

$$\mu_{\text{Wood}} = 0.019Mc + 0.2224 \quad (R^2 = 0.9734) \quad (18)$$

The reason for the increased coefficient of static friction at higher moisture content may be owing to higher the water present in the barberry offering a higher cohesive force on the surface of contact. the increased Coefficient of static friction with increasing in moisture content also have been reported by Chandrasekar and Viswanathan [23] for coffee, Calisir and Aydin [9] for cherry laurel, Akar and Aydin [14] for gumbo fruit and Kabas *et al.* [22] for Cactus pear.

CONCLUSION

The investigations of various physical properties of barberry revealed the following.

- The length, width, thickness and geometric mean diameter of barberries increased linearly with increasing of moisture content.
- As the moisture content increased from 12.64 to 89.23% (w.b.), the surface area of barberry increased from 27.69 to 170.13 mm².
- The mean value of the barberries sphericity increased from 36.61 to 61.46%, as the moisture content increased from 12.64 to 89.23% (w.b.).
- True and bulk density increased with increase of moisture content but porosity decreased with increase in moisture content.
- The coefficient of static friction has maximum value on glass surface compared with galvanized and wood. Coefficient of static friction on all the surfaces increased linearly as moisture content increased from 12.64 to 89.23% (w.b.).

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