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The geometric, volumetric and frictional properties of Juniper berries

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Abstract

The aims of this study are to investigate the geometric, volumetric and frictional properties of Juniper berries fruits such as size dimension, sphericity, bulk density, angle of repose, volume, fruit density, porosity, and the static and dynamic coefficients of friction on the different surfaces at a moisture content of 14.07% (dry basis). The mean values of height, diameter, geometric mean diameter and sphericity were 7.82 mm, 8.60 mm, 8.31 mm 96.66%, respectively. The bulk and fruit densities, angle of repose, porosity, fruit mass and fruit volume values were found as 105,8 kg m-3, 816.4 kg m-3, 28.61°, 86.97%, 0.23 g and 283.11 mm^3, respectively. The mean values of static and dynamic coefficient of friction against galvanized steel, chipboard, plywood, mild steel and rubber surfaces were determined and the highest static and dynamic coefficients of friction values of juniper berries were found for rubber surface.

Keywords

Juniper Communis, Fruit, Engineering Properties

1. Introduction

A juniper berry is the female seed cone produced by the various species of junipers. It is not a true berry but a cone with unusually fleshy and merged scales, which give it a berry-like appearance. The cones from a handful of species, especially Juniperus communis, are used as a spice, particularly in European cuisine, and also give gin its distinctive flavour. According to one FAO document, juniper berries are the only spice derived from conifers, although tar and inner bark (used as a sweetener in Apache cuisines) from pine trees is sometimes considered a spice as well (Wikipedia, 2014).

There are six species of junipers which can be eaten. Juniper berries has many health benefits and it can be used as urinary antiseptic. Juniper berries can also be used for arthritis and slow healing wounds. A juniper berry is not actually a berry in the sense that berries are a form of fruit. However, the juniper berry is actually the seed cone of the juniper plant. It is considered to be a berry due to its scales. Due to the many juniper health benefits, these berries are used in treating a variety of ailments from rheumatism, arthritis, to cystitis and catarrh. The berries may also be crushed and applied topically to slow-healing wounds as they are a powerful antiseptic. Washing joints with a tea made of juniper berries helps to relieve pain and soreness from them (Diethealthclub, 2014).

Juniper berries are often included in herbal blends which are meant to cleanse the kidneys and the liver, since they help to flush toxins from the body. Juniper berries are generally considered a "safe" medication except for pregnant women, who may suffer from increased contractions of the uterus, or those suffering from chronic kidney ailments. Some indigenous North American tribes also knew the diuretic properties of juniper berries (Chineseherbs,2014).

The geometric, volumetric and frictional properties of Juniper berries are to be known for design and improve of relevant machines and facilities for harvesting, storing, handling, granding and processing. Bulk density and porosity of juniber berries affect the structural loads at silo and the angle of repose of Juniper berries is important in designing of storage and transporting structures. The coefficient of friction of the Juniper berries against the various surfaces is also necessary in designing of conveying, transporting and storing structures.

In recent years, engineering properties (geometric, volumetric and frictional properties) have been studied for the different agricultural materials such as hazelnuts (Aydin, 2002), Turkish mahaleb (Aydin et al., 2002); and pine nut (Özgüven and Vursavuş, 2005), peanut and its kernel (Dilmac and Altuntas, 2012). However, studies conducted on the geometric, volumetric and frictional properties of Juniper berries have not been adequately studied. The objective of this study was to investigate the geometric, volumetric and frictional properties of size dimension, sphericity, bulk density, angle of repose, volume, fruit density, porosity, and the static and dynamic coefficients of friction on the different surfaces for Juniper berry fruits.

2. Materials and Methods

Juniper berries used for experiments were obtained from one of the the farmer orchard of Tokat (39°51' N and 40°55' E), situated in the Middle Black Sea Region in Turkey, in 2012. The samples were cleaned manually to remove all foreign matter, dust, dirt, broken and immature nuts. The moisture content of the samples was determined by oven drying at 105 ± 1 °C for 24 h. Each of the samples was replicated three times and the mean moisture content of Juniper berries was found as 14.07% d.b. (dry basis) (Altuntas and Demirtola, 2007). To determine of geometric properties of the Juniper berries, one hundred berry fruits were randomly selected and height and diameter were measured using a dial-micrometer to an accuracy of 0.01 mm. The geometric mean diameter D_g and sphericity Φ of Juniper berries were determined methods presented by Mohsenin (1986).

The volumetric characteristics of Juniper berries such as bulk and fruit densities, porosity, angle of repose were determined. Fruit density of a Juniper berry fruit is defined as the ratio of the fruit mass of a sample of a Juniper berry fruit to the solid volume occupied by the sample. The Juniper berries volumes and fruit density were determined using the liquid displacement method. Toluen (C_7H_8) was used rather than water because it is absorbed by Juniper berry fruit to a lesser extent. Toluen surface tension is low, so that it fills even shallow dips in a Juniper berry fruit and their dissolution power is low (Mohsenin, 1986). The bulk density is the ratio of the fruit mass of to total volume of a Juniper berry fruit sample and it was determined with a weight per hectolitre tester which was calibrated in kg m^{-3} (Celik and Ercisli, 2009). The porosity (P) of Juniper berry fruit was determined by the following equation:

$$P = \left[1 - \frac{\rho_b}{\rho_f}\right] \times 100 \tag{1}$$

Where, ρ_b and ρ_f the bulk density and the fruit density, respectively (Mohsenin, 1986).

In order to determine the angle of repose of Juniper berry fruits, topless and bottomless cylinder with 300 mm diameter and 500 mm height was used. The cylinder was placed at the center of a raised circular plate and was filled with Juniper berry fruits. The cylinder was raised slowly until it formed a cone on a circular plate. The angle of repose (θ) of Juniper berry fruit was calculated from the measurement of the height of the cone and the diameter of cone (Kaleemullah & Gunasekar, 2002).

The frictional properties of Juniper berry fruits such as static and dynamic coefficient of friction were determined. The coefficient of friction of Juniper berry fruits was measured by a friction device. The measuring device of friction force is formed by a metal box, a friction surface, and an electronic unit, which covers the mechanical force unit, electronic variator, loadcell, electronic ADC (Analog digital converter) card, and PC (Personel computer) (Altuntas and Demirtola, 2007). Friction force was measured by the loadcell, converted by the ADC card, and data were recorded in a computer (Figure 1).

The static and dynamic coefficients of friction were calculated using the following equation:

$$\mu = \left[\frac{F}{N_f}\right] \tag{2}$$

where, μ is the coefficients of friction, F is the measured friction in N, and N_f is the normal force in N.

The maximum value of friction force was obtained when box started moving, and this was used to calculate the static coefficients of friction of Juniper berry fruits. While the box continued to slide over the friction surface at 0.02 m/s velocity, the dynamic coefficients of friction were measured. The average value of coefficient of friction was used to calculate the dynamic coefficients of friction. The experiment was conducted on Juniper berry fruits using friction surfaces of galvanized metal, chipboard, mild steel, plywood and rubber. For each experiment, the sample box was emptied and refilled with a different sample at the same moisture content (Altuntas and Demirtola, 2007).

Statistical analyses were conducted with Microsoft Excel software.

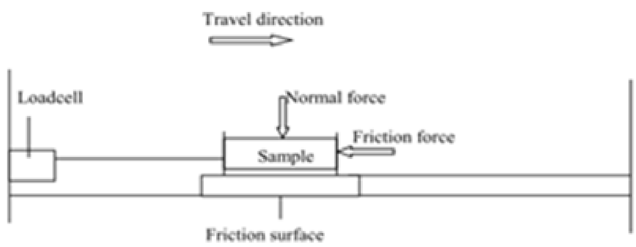

Figure 1. *A shematic appearance of the measuring device of friction force for Juniper berries fruits.*

3. Results and Discussion

Frequency distribution curves of Juniper berries fruits height, diameter and fruit were given in Figure 2. About 83%

of Juniper berries fruits have a height ranging from 5.88 to 9.88 mm, about 82% diameter ranging from 6,88 to 10.63 mm, about 87% fruit mass ranging from 0.087 to 0.463 g, respectively (Figure 2). The values of geometric, volumetric properties of Juniper berries were given in Table 1. The height, diameter and geometric mean diameter of Juniper berries ranged from 5.97 to 9.70 mm, 6.96 to 10.50 mm and 6.81 to 9.88 mm, respectively (Table 1). The sphericity values of Juniper berries were found 91.28 to 99.92%, respectively. Bart-Plange et al. (2012) reported that the sphericity decreased marginally from 64.02 to 63.66% and 77.90 to 77.68% at moisture content range of 5.0% to 9.0% wb for cashew nut and kernel respectively. The sphericity values of Juniper berries are higher than reported for cashew nut and kernel (Bart-Plange et al. (2012). And also the sphericity of Juniper berries values are similar for reported that the sphericity of mahaleb increased from 0·841 to 0·867 with increase the moisture range from 2·9 to 10·2% d.b. Aydın et al. (2002).

Table 1. *Some geometric and volumetric properties of Juniper berries.*

Geometric and volumetric properties	Mean	Minimum	Maximum	SEM *
Height, H (mm)	7.816	5.970	9.700	0.074
Diameter, D (mm)	8.602	6.690	10.500	0.069
Geometric mean diameter, D_g (mm)	8.305	6.814	9.881	0.060
Sphericity, Φ (%)	96.69	91.28	99.91	0.317
Bulk density, ρ_b (kg m^{-3})	105.79	103.56	109.58	0.570
Fruit density, ρ_t (kg/m^{-3})	816.41	736.04	887.65	44.00
Angle of repose, θ (°)	28.61	21.88	32.41	0.957
Porosity, P (%)	86.97	85.63	88.08	0.717
Fruit mass, M (g)	0.229	0.101	0.457	0.007
Fruit volume, V (cm^3)	283.11	258.84	312.16	0.016

SEM*, Standard error of the mean

Table 2. *The static and dynamic coefficient of friction values for Juniper berries*

Friction surfaces	Coefficients of friction			
	Static	SEM*	Dynamic	SEM*
Galvanized metal	0,22	0,006	0,16	0,003
Chipboard	0,31	0,010	0,25	0,011
Plywood	0,26	0,003	0,20	0,003
Mild steel	0,29	0,002	0,22	0,003
Rubber	0,54	0,018	0,47	0,017

SEM*, Standard error of the mean

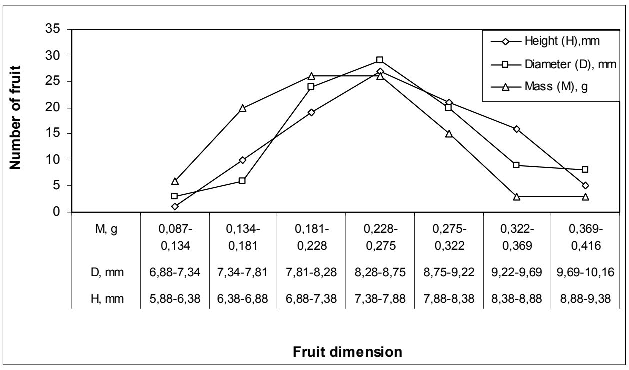

Figure 2. *Frequency distribution curves of Juniper berries fruits height, diameter and unit seed mass*

The bulk density and fruit density were changed between 103.56 to 109.58 kg m^{-3} and 736.04 to 887.65 kg m^{-3} for Juniper berries, respectively (Table 1). The fruit mass of Juniper berries varied from 0.10 to 0.45 g. The volume of Juniper berry fruits changed from 258.84 to 312.16 mm^3. Bart-Plange et al (2012) reported that the kernel volume and nut volume of cashew fruits varied from 101.47 to 110.83 mm^3 and 312.54 to 332.94 mm^3 in magnitude with an increase the moisture content changed from 5.0% to 9.0% wet basis, respectively. Aydın et al. (2002) reported that the bulk density decreased from 616 to 566 kg m −3, kernel density from 1250 to 1110 kg m −3.The volume values of Juniper berries are higher than reported for cashew kernel, whereas volume of juniper berries was found to be higher that reported for cashew nut (Bart-Plange et al., 2012).

The mean angles of repose for Juniper berries varied from 21.88 to 32.41°, respectively. Aydın et al. (2002) reported that the sphericity of mahaleb increased from 0·841 to 0·867, and angle of repose from 25 to 30·5° with increase the moisture range from 2·9 to 10·2% d.b. The mean angle of repose for Juniper berries are considerably higher than that reported for locust bean as 20.32° at 10.25% d.b. moisture content by Ogunjimi et al. (2002), and for faba bean as mean 13.94° at 9.89% d.b. moisture content by Altuntaş and Yıldız (2007). And also, mean angle of repose of Juniper berries are similar for mahaleb as 25° to 30.5° by Aydin et al (2002). The porosity was ranged from 85.63 to 88.08% for Juniper berries. Aydın et al. (2002) reported that the porosity ranged from 49.0 to 50.7.

The values of static and dynamic coefficients of friction against the various test surfaces for galvanized metal, chipboard, plywood, mild steel and rubber for Juniper berries were given in Table 2. The mean values of static coefficients of friction against galvanized steel, chipboard, plywood, mild steel and rubber surfaces for Juniper berries were 0.22, 0.31, 0.26, 0.29 and 0.54, respectively. The mean values of dynamic coefficients of friction against galvanized steel, chipboard, plywood, mild steel and rubber surfaces for Juniper berries were 0.16, 0.25, 0.20, 0.22, 0.47 for Juniper berries, respectively. From these results, static coefficient of friction is higher than dynamic coefficients of friction for Juniper berries. The static and dynamic coefficient of frictions was higher for Juniper berries againts rubber surface than the other frciton surfaces. Similar results were found for lentil seed by Carman (1996); for kidney bean, dry pea and black-eyed pea seeds by Altuntas and Demirtola (2007).

4. Conclusions

The geometric, volumetric and frictional properties for Juniper berries 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 geometric, volumetric and frictional properties of Juniper berries. The geometric properties such as the geometric mean diameter and sphericity were 8.31 mm 96.66%, respectively. The fruit density values were higher than bulk density for Juniper berries. Among on the different friction surfaces, the static and dynamic coefficients of friction of Juniper berries were greater at rubber surface compared to the galvanized metal, chipboard, plywood, and mild steel surfaces.

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