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Note

Physical properties of bay laurel seeds

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A b s t r a c t. The physical properties of bay laurel seeds were determined at different moisture levels. As the moisture content increased, the major, intermediate and minor diameters increased linearly. The sphericity, surface area, true and bulk densities and the angle of repose increased, whereas porosity decreased with increasing moisture content. The coefficients of static and dynamic friction were the highest for galvanized steel, followed by chromium sheet, aluminium sheet and PVC, respectively.

K e y w o r d s: bay laurel, physical properties

INTRODUCTION

Laurus nobilis L. (Lauraceae), commonly known as bay laurel, sweet bay, true laurel or roman laurel, is an evergreen tree up to 10 m in height. It is widely distributed within the Mediterranean region, and it is cultivated in many countries with moderate and subtropical climate (Baytop, 1991). Bay laurel is grown commercially for its aromatic leaves and oils in Turkey, Algeria, Morocco, Portugal, Spain, Italy, France and Mexico. Bay laurel fruits look like a small olive with oval or ellipsoid shape, initially dark-green, afterwards dark-black in colour, 1-2 cm long, and the kernel of the seeds is loose. Laurel seeds are covered with a fleshy pericarp and a hard seed coat is found under the pericarp. The fruits contain much more oil than the leaves (Wren, 1975). The fruits of bay laurel plants contain 24-30% of fixed oil. Fixed oil obtained from the kernel of the fruit includes generally a high amount of lauryl acid. The kernel of the fruit forms about 70% of whole fruit (Eckey, 1954). There are a lot of kinds of ways for using bay laurel plants. Alkaloids, volatile oils and fixed oils occur in many species (Barla *et al*., 2007). Both the volatile and the seed oils are used for cosmetic, food, chemical and medicinal purposes.

Physical properties of bay laurel seed are important for improving the technology related with some operations and equipment design. Determination of these properties is necessary for post-harvest processes such as cleaning, separation, handling, drying, oil extraction process, storage and other processes. Physical properties of seeds are dependent on moisture content. Generally, the morphology and size information is essential for suitable design of the equipment for cleaning and separation. Seed dimensions are also important for the extraction processes (Beis, 1994). Gravimetric properties such as the mass of 1000 seeds, bulk density, true density and porosity are important for the design of equipment related to aeration, drying, storage and transport (Vilche *et al*., 2003). In recent years, many researchers have studied the physical properties of seeds and fruits of different plants such as pine nuts (Ozguven and Vursavus, 2005), calabag nutmeg seed (Omobuwajo *et al*., 2003), fresh oil palm fruit (Owolarafe *et al*., 2007), soybean (Kibar and Ozturk, 2008), cashew nut (Balasubramanian, 2001), fuzzy cotton seeds (Manimehalai and Viswanathan, 2006), rapeseed (Izli *et al*., 2009) and olive (Ozturk *et al*., 2009).

The aim of this research was to investigate bay laurel moisture-depended physical properties.

MATERIALS AND METHODS

Sun dried bay laurel seeds were used in this study. The seeds were cleaned manually to remove all foreign materials and broken seeds. The initial and conditioned moisture content of laurel seed were determined by using the standard hot air oven method, for samples of at least 20 g, at 105°C for 24 h (Sacilik, 2003; Gosling, 2007). To reach the different moisture content, bay laurel seeds were conditioned by adding

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a calculated quantity of distilled water. The samples were sealed in separate polyethylene bags and stored at 5°C in a refrigerator for a minimum of one week to allow uniformity of moisture sample distribution. Before each test, the needed quantities of conditioned seeds were allowed to warm up to room temperature and the moisture was checked using the standard oven-drying method. The moisture contents (M) of seeds used in all experiments were 6.09, 12.29, 19.97, 25.56, and 36.76% w.b.

Randomly selected 150 seeds from each moisture content group were used for determining the size of the laurel seeds. The seed size measurements in term of the major (L), intermediate (W) and minor diameters (T) were carried out with a digital caliper having an accuracy of 0.01 mm. Seed mass measurements were conducted with a precision electronic balance having an accuracy of 0.001 g. The geometric mean diameter (D_g), sphericity ($Ø$) and arithmetic mean diameter (D_a) were calculated at different moisture content levels according to Mohsenin (1980). The surface area (S) of bay laurel seed were determined according to Mohsenin (1980) and Ozguven and Vursavus (2005).

The bulk density (ρ_b) was determined using the mass/volume relationship (Mohsenin, 1980; Omobuwajo *et al*., 2003; Ozguven and Vursavus, 2005). The true density (ρ_t) was determined by using the toluene displacement method in order to avoid absorption of water during the experiment (Sacilik, 2003). The bulk and true densities were evaluated for each moisture content level in five replications. The porosity (ε) and angle of repose (θ) were obtained from formulas given by Mohsenin (1980) and Ozguven and Vursavus (2005), respectively. The method of Beyhan *et al*. (1994) and Sabahoglu *et al*. (2001) was used for determining the coefficients of static and dynamic friction (μ_s and μ_d) for laurel seeds. The experiments at different moisture content of laurel seeds were conducted by using test surfaces of galvanized steel, PVC, aluminium and chromium sheet. All friction experiments were replicated three times for each moisture content with different surfaces.

RESULTS AND DISCUSSIONS

Table 1 presents some seed dimensions, and the geometric and arithmetic mean diameters of bay laurel seeds at different moisture content levels. In the moisture content range of 6.09-36.76%, all the laurel seed dimensions increased linearly. All the diameters of laurel seed, except for length, were significantly related with the moisture content of seed. Statistically, there was no difference for the length of laurel seeds with increasing moisture content. Arithmetic and geometric mean diameters increased from 11.51 to 12.00 and from 11.42 to 11.82 mm, respectively. The relations between the diameters of seed (W, T, D_a and D_g) and seed moisture content (M) are given in the following regression equations:

$$W = 10.253 + 0.009\,M \quad R^2 = 0.83, \tag{1}$$

$$T = 9.611 + 0.016\,M \quad R^2 = 0.83, \tag{2}$$

$$D_a = 11.42 + 0.015\,M \quad R^2 = 0.90, \tag{3}$$

$$D_g = 11.284 + 0.012\,M \quad R^2 = 0.77. \tag{4}$$

The relation between sphericity and moisture content of laurel seed was found to be significant, and the relations and regression equations are presented in Fig. 1a. The sphericity of laurel seed increased from 0.775 to 0.802 when the moisture content increased from 6.09 to 36.76% w.b.

The laurel seed surface area relation with the moisture content is given in Fig. 1b. The figure indicates that the surface area increases linearly with increase in the moisture content. Regression equations can be found in Fig. 1b.

The dependence of bulk and true densities of laurel seeds on moisture content is given in Fig. 1c. As seen in the figure, both densities increased with increasing moisture content. The relations of the bulk and true densities to moisture were found to be linear and given as follows:

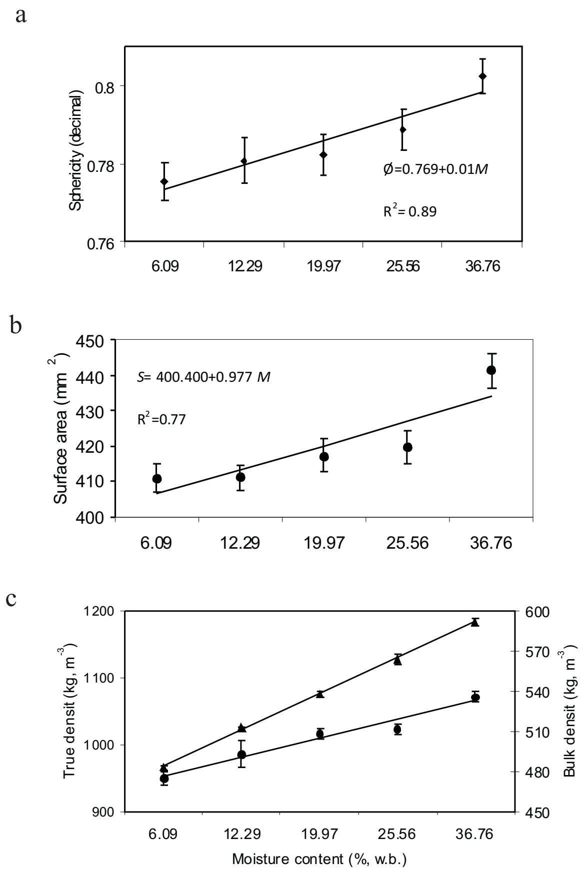
$$\rho_b = 462.574 + 3.730\,M \quad R^2 = 0.99, \tag{5}$$

$$\rho_t = 931.341 + 3.870\,M \quad R^2 = 0.96. \tag{6}$$

T a b l e 1. Changes of laurel seed diameters with moisture content

Moisture content (%, w.b.)	Diameters (mm)				
	Major (L)	Intermediate (W)	Minor (T)	Arithmetic mean $(L+W+T)/3$	Geometric mean $(LWT)^{1/3}$
6.09	14.55±0.098	10.28±0.066	9.69±0.063	11.51	11.42
12.29	14.64±0.109	10.34±0.063	9.89±0.061	11.62	11.42
19.97	14.79±0.125	10.48±0.171	9.86±0.074	11.71	11.50
25.56	14.55±0.125	10.53±0.698	9.94±0.066	11.73	11.53
36.76	14.96±0.111	10.98±0.083	10.23±0.072	12.00	11.82

b



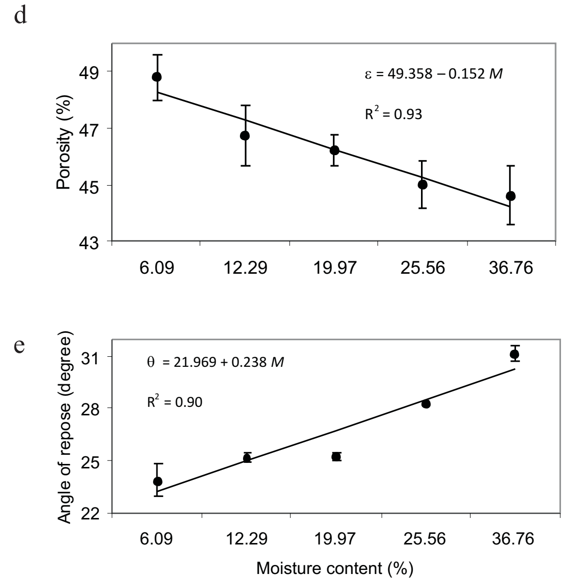


Fig. 1. Sphericity (a), surface area (b), ▲bulk and ●true densities (c), porosity (d) and angle of repose (e) of laurel seeds as a function of moisture content.

The variation of porosity as dependent on moisture content is plotted in Fig. 1d. The calculated porosity decreased from 48.8 to 44.6% w.b. while the moisture content increased from 6.09 to 36.76%. The linear relation between porosity and moisture content can be seen in Fig. 1d.

The test results of the angle of repose for laurel seeds increased from 23.87 to 31.16° with the increase of moisture content from 6.09 to 36.76% w.b. (Fig. 1e). The relation can be expressed by means of the equation given in Fig. 1e.

The friction coefficients for bay laurel seeds *versus* moisture content and test surfaces are shown in Table 2. Both coefficients of friction were the greatest against galvanized steel, followed by chromium sheet, aluminium sheet and PVC, respectively. The highest coefficient of static friction was recorded against galvanized steel at 19.97% w.b. moisture content (0.736), and the lowest value was

T a b l e 2. Coefficients of static and dynamic friction of laurel seeds

Moisture content (% w.b.)	Coefficient of friction*	Surfaces			
		Galvanized steel	Chromium sheet	Aluminum sheet	PVC
6.09	μ_s	0.541±0.009	0.491±0.008	0.443±0.007	0.361±0.016
	μ_d	0.477±0.005	0.454±0.004	0.413±0.003	0.364±0.002
12.29	μ_s	0.720±0.032	0.580±0.009	0.499±0.006	0.505±0.009
	μ_d	0.645±0.008	0.534±0.005	0.456±0.004	0.453±0.004
19.97	μ_s	0.737±0.035	0.673±0.015	0.533±0.038	0.512±0.012
	μ_d	0.666±0.009	0.621±0.005	0.490±0.007	0.463±0.004
25.56	μ_s	0.567±0.025	0.503±0.059	0.443±0.037	0.452±0.018
	μ_d	0.511±0.004	0.430±0.005	0.386±0.007	0.413±0.004
36.76	μ_s	0.458±0.013	0.402±0.034	0.352±0.026	0.367±0.016
	μ_d	0.367±0.005	0.359±0.006	0.294±0.005	0.326±0.004

*μ_s – static and μ_d – dynamic coefficient of frictions.

T a b l e 3. Regression equations related to coefficients of static (μ_s) and dynamic (μ_d) friction of laurel seeds

Surfaces	Regression equations	R^2
Galvanized steel	μ_s = -0.0544M^2+0.4035M - 0.0298	0.90
	μ_d = -0.0571M^2+0.3071M +0.240	0.95
Chromium sheet	μ_s = -0.0460M^2+0.2502M + 0.2849	0.87
	μ_d = -0.0414M^2+0.3018M + 0.0179	0.80
Aluminum sheet	μ_s = -0.0298M^2+0.2144M + 0.1326	0.96
	μ_d = -0.0292M^2+0.2031M + 0.1215	0.95
PVC	μ_s = -0.0375M^2+0.2959M - 0.6910	0.94
	μ_d = -0.0292M^2+0.2031M + 0.1215	0.95

measured against PVC at 6.09% moisture (0.363). The highest coefficient of dynamic friction was recorded against galvanized steel at 19.97% w.b. moisture (0.666), and the lowest value was measured against aluminium sheet at 36.76% w.b. moisture content (0.293).

Regression equations related to the coefficients of static and dynamic friction for bay laurel and R^2 values are presented in Table 3.

The statistical analysis of experimental data showed that the moisture content, friction surface and interactions of moisture and surface had highly significant ($P < 0.01$) effects on the coefficients of friction.

CONCLUSIONS

1. The physical characteristics of bay laurel seeds were expressed in linear regression equations as a function of moisture content with high correlation, except for length.

2. The sphericity and surface area varied from 0.775 to 0.802 and 410.9 to 441.4 mm^2, respectively.

3. The bulk and true densities increased with moisture content increase from 482.6 to 592.0 and 949.4 to 1072.3 kg m^{-3}, respectively, whereas porosity decreased from 48.8 to 44.6% w.b.

4. The angle of repose increased from 23.87 to 31.16° in the range of moisture content between 6.09 and 36.76% w.b.

5. The coefficients of static and dynamic friction were the highest for galvanized steel, followed by chromium sheet, aluminium sheet and PVC, respectively. In other words, galvanized steel surface offered the maximum friction.

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