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Note

Physical properties of psyllium seed

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A b s t r a c t. Physical properties *ie* dimensions, volume, surface area, sphericity, true density, porosity, angle of repose, terminal velocity, static and dynamic friction coefficients on plywood, stainless steel, glass and galvanized iron sheet, force required for initiating seed rupture in horizontal and vertical orientations of psyllium seed at a moisture content of 7.2% (w.b.) were determined.

K e y w o r d s: psyllium seed, physical properties, postharvest technology

INTRODUCTION

Psyllium (*Plantago ovata* Forsk) is an annual plant, cultivated mainly in India. Also, psyllium seed is called Isabgol, meaning 'horse ear' in Indian, which explains the shape of the seed. India dominates the world market in the production and export of psyllium, producing around 39 000 t of psyllium seed every year and providing 85% of psyllium seed to the world market. The mechanical milling/grinding of the outer layer of psyllium seeds (seed coat) provides the main raw material for commercial production of mucilage. Mucilage is a white fibrous hydrophilic material and forms the clear coluorless mucilaginous gel by absorbing water. The extracted gel nature of psyllium seeds has a medicinally active natural polysaccharide composition (Guo *et al.*, 2009).

In order to design proper equipment for the processing, transportation, sorting, separation and storing of psyllium, it is necessary to have reliable information regarding the physical properties of this seed. Designing seed processing equipment without considering engineering specifications of proposed seed may yield poor results (Davies and El-Okene, 2009). Since there is not enough information on the physico-mechanical properties of psyllium seed.

The aim of this investigation was to measure physical properties of psyllium seed at a moisture content of 7.2%.

MATERIALS AND METHODS

Seeds of psyllium were used for all the various experiments in this study (Fig. 1). The seeds were obtained from the local market during September-October, 2009 in Karaj and transported to the laboratory in cooled condition. After removing all foreign matter such as dust, dirt, stones and chaff, as well as immature and broken seeds, the initial moisture content of the seeds was determined by oven drying at 105 ±1°C for 24 h (AOAC, 1990). All the physical and mechanical properties of the seeds were assessed at this moisture (7.2% w.b.). To determine the average size of psyllium, 100 seeds were randomly picked and their three linear dimensions, namely, length, width and thickness, were measured using a digital vernier caliper (SV-03 model, Taiwan) with an accuracy of 0.01 mm. The arithmetic (D_a) and geometric (D_g) mean diameter, sphericity, surface area of psyllium seeds were calculated according to Mohsenin (1986). An electronic balance (Mettler Toledo AT261) with a reading precision of 10 µg was used to determine the mass of psyllium seeds. Bulk density or the ratio of grain mass to the maximum volume (including free and membrane air) of

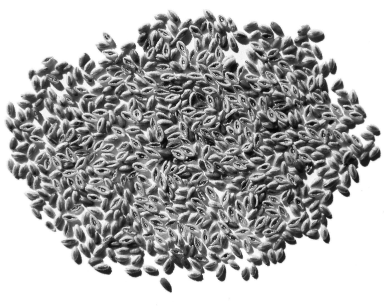

Fig. 1. Psyllium seeds (*Plantago ovata* Forsk).

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grain, and true density or the ratio of grain mass to the net volume (excluding any form of air) of grain in the sample container and angle of repose were determined according to Mohsenin (1986). The porosity of the bulk grain was computed from the values of the true and bulk density of the seeds. The static and dynamic friction coefficients of the samples against three different surfaces, namely, plywood, glass and stainless steel, were determined according to the technique introduced by Chung and Verma (1989). In addition, the fracture resistance properties of psyllium seed was measured by the method used by Fathollahzadeh and Rajabipour (2008).

RESULTS AND DISCUSSION

Table 1 shows a summary of the obtained results for physical and aerodynamic properties of psyllium seeds. The initial moisture content of the seeds was 7.2% (w.b.). These results explain the average value, maximum, minimum and standard deviation of each measurement at this moisture content. The mean seed length, width and thickness were 2.70, 1.33, and 0.72 mm, respectively The geometric and arithmetic mean diameters were 1.37 and 1.58 mm, respectively. The axial seed dimensions have an important role in determining aperture sizes used in the design of grain handling machinery. Furthermore, the geometric mean of axial seed dimensions is useful to define the characteristics of the behaviour of irregular shaped seeds (Mohsenin, 1986). Sphericity is a degree of irregularity for an incompletely spherical shape of a solid grain relative to the same volume of same materials with a complete sphere (Gharibzahedi *et al.,* 2009). While the sphericity of sorrel and black cumin seeds was 68.6 and 56.5%, respectively (Gharibzahedi *et al.,* 2010; Omobuwajo *et al.,* 2000a), our results showed the value of 51.17% for psyllum seed. Thus, the sphericity of the psyllium seed has more tendency to behave as a sphere than sorrel and black cumin seeds.

The mean value of psyllium 1000 seed mass was 1.3 g. The mean bulk density, true density and porosity of psyllium seeds were 647.4, 1350.6 kg m^{-3} and 52.06%, respectively. Therefore, the bulk density of psyllium seed was higher than that of rapeseed (612.1 kg m^{-3}) and cotton seed (642 kg m^{-3}) (Cahsir *et al.,* 2005; Ozarslan, 2002). The true density of psyllium seed was also greater than of sesame seeds (1 222 kg m^{-3}) and black cumin seeds (1 040 kg m^{-3}) (Gharibzahedi *et al.,* 2009; 2010). Although the porosity values of fenugreek, hemp and rapeseeds were 43.4, 46.5 and 48.2% (Altuntas *et al.,* 2005; Cahsir *et al.,* 2005; Sacilik *et al.,* 2003), the porosity of psyllium seeds ranged between 49.55 and 52.35%. Mean angle of repose was 33.8º, indicating that psyllium seeds have medium flowing properties. This value was higher than those for arigo seeds (Davies, 2010), hemp seeds (24.6º) and fenugreek seeds (14.3º) (Altuntas *et al.,* 2005; Sacilik *et al.,* 2003). Angle of repose is a necessary data to design the appropriate slope for grain discharge hoppers. This means that the angle of a grain hopper has to be bigger than the angle of repose for good free flowing during seed discharge. Mean terminal velocity of psyllium seeds was 1.47 m s^{-1}. This value was lower than those for black cumin seed (5.7 m s^{-1}) and ackee apple seed (9.95 m s^{-1}) (Gharibzahedi *et al.,* 2010; Omobuwajo *et al.,* 2000b).

The average static friction coefficients of psyllium seeds with several structural materials including plywood, galvanized iron, stainless steel, and glass were 0.409, 0.404, 0.383, and 0.263, respectively (Table 2). Thus, the plywood sheet had the highest static friction coefficient because it had greater surface roughness in comparison with other mentioned sheet materials. In addition, the mean dynamic friction coefficients against galvanized iron, stainless steel, plywood, and glass sheet were 0.445, 0.353, 0.324, and 0.286, respectively (Table 2). These properties are the key elements for the calculation of compressibility and flow behaviour of materials used for designing seed bins and other storage structures.

T a b l e 1. Physical properties of psyllium seed

Properties	No. of observation	Mean (SD)
Length (mm)	100	2.70 (0.15)
Width (mm)	100	1.33 (0.10)
Thickness (mm)	100	0.72 (0.09)
D_g (mm)	100	1.37 (0.09)
D_a (mm)	100	1.58 (0.08)
Sphericity (%)	100	51.1 (1.20)
Volume (mm^3)	100	1.47 (0.25)
Surface area (mm^2)	100	5.02 (0.60)
1000 seed mass (g)	10	1.30 (0.10)
True density (kg m^{-3})	10	1 350.6 (5.80)
Bulk density (kg m^{-3})	10	647.4 (4.02)
Porosity (%)	10	52.06 (0.09)
Angle of repose (ş)	10	33.8 (0.12)
Terminal velocity (m s^{-1})	10	1.47 (0.04)

T a b l e 2. Static and dynamic friction coefficients of psyllium seed on different surfaces (No. of observations = 10)

Surfaces	Mean (SD)
Static coefficient of friction	
Plywood	0.409 (0.03)
Stainless steel	0.383 (0.02)
Glass	0.263 (0.01)
Galvanized iron sheet	0.404 (0.02)
Dynamic coefficient of friction	
Plywood	0.324 (0.01)
Stainless steel	0.353 (0.05)
Glass	0.286 (0.06)
Galvanized iron sheet	0.445 (0.04)

T a b l e 3. Mechanical properties of psyllium seed (No. of observations = 10)

Orientation	Mean (SD)
	Force (N)
Horizontal	19.74 (0.09)
Vertical	7.63 (0.03)
	Energy (mJ)
Horizontal	1.09 (0.02)
Vertical	0.96 (0.01)

The mean values of force and energy required to initiate rupture in psyllium seed in the horizontal and vertical axes in loading process were 19.74 N and 1.09 mJ and 7.63 N and 0.96mJ, respectively (Table 3). These results indicate that psyllium seeds have more tendencies to be in horizontal rather than vertical orientation. More clearly, if the seeds are forced to be loaded in the vertical orientation, the contact area of psyllium seeds with the contacting plates is smaller than in the horizontal situation, and this results in greater stresses of the seeds with their contacting surface.

CONCLUSIONS

1. Mean values of surface area, sphericity, true density, porosity, angle of repose and terminal velocity were: 5.02 mm^2, 51.1%, 1350.6 kg m^{-3}, 52.06%, 33.8°, and 1.47 m s^{-1}.

2. The static and dynamic friction coefficients of psyllium seed on plywood, stainless steel, glass and galvanized iron sheet were: 0.409 and 0.324; 0.383 and 0.353; 0.263 and 0.286; 0.404 and 0.445.

3. The mean values of force required for initiating seed rupture in horizontal and vertical orientations at loading rate of 10 mm min^{-1} were 19.74 and 7.63 N.

REFERENCES

AOAC, **1990.** Official Methods of Analysis. Washington, DC, USA.

Altuntas E., Ozgoz E., and Taser O.F., 2005. Some physical properties of fenugreek seeds. J. Food Eng., 71(1), 37-43.

Cahsir S., Marakoglu T., Ogut H., and Ozturk O., 2005. Physical properties of rapeseed. J. Food Eng., 69, 61-66.

Chung J.H. and Verma L.R., 1989. Determination of friction coefficients of beans and peanuts. Trans. ASAE., 32, 745-750.

Davies R.M., 2010. Some physical properties of arigo seeds. Int. Agrophys., 24, 89-92.

Davies R.M. and El-Okene A.M., 2009. Moisture-dependent physical properties of soybeans. Int. Agrophysics, 23, 299-303.

Fathollahzadeh H. and Rajabipour A., 2008. Some mechanical properties of barberry. Int. Agrophysics, 22, 299-302.

Gharibzahedi S.M.T., Mousavi S.M., Moayedi A., Taheri Garavand A., and Alizadeh S.M., 2010. Moisture-dependent engineering properties of black cumin seed. Agric. Eng. Int.: the CIGR Ejournal, 12(1), 194-202.

Gharibzahedi S.M.T., Mousavi S.M., Razavi S.H., and Akavan-Borna M., 2009. Determination of nutritional and physical properties of sesame seed. Proc. 4nd Int. Conf. Rural Development, October 15-17, Kaunas, Lithuania.

Guo Q., Cui S.W., Wang Q., Goff D.H., and Smith A., 2009. Microstructure and rheological properties of psyllium polysaccharide gel. Food Hydrocolloids, 23, 1542-1547

Mohsenin N.N., 1986. Physical Properties of Plant and Animal Materials. Gordon and Breach Sci. Press, New York, USA.

Omobuwajo T.O., Sanni L.A., and Balami Y.A., 2000a. Physical properties of sorrel seeds. J. Food Eng., 45, 37-41.

Omobuwajo T.O., Sanni L.A., and Olajide J.O., 2000b. Physical properties of ackee apple seeds. J. Food Eng., 45, 43-48.

Ozarslan C., 2002. PH – postharvest technology: physical properties of cotton seed. Biosyst. Eng., 83, 169-174.

Sacilik K., Ozturk R., and Keskin R., 2003. Some physical properties of hemp seed. Biosys. Eng., 86, 191-198.