Effect of moisture content on some physical properties of Grass pea (Lathyrussativus L.)

Sarajeh.H., Ebrahimi.M.A*, Khanali.M, Behboudi .O , Mohammadi .K

(Department of Agricultural Machinery Engineering, University College of Agriculture and Natural Resources, University of Tehran, Islamic Republic of Iran.)

Abstract: In this study, physical and engineering properties such as length, diameter, size, 1000 seed mass, sphericity, surface area, volume, true density and bulk density of grass pea were determined. Determination of physical and engineering properties of grain and agricultural products is important in the design of harvesting, handling, and processing equipment. Physical and engineering properties of grass pea were performed over moisture content range from 10.65% to 19.92% (d.b.). Increasing of moisture content was found to increase mass of 1000 seeds kernel surface area, kernel volume, and static friction coefficient, while decreasing bulk density, true density, and porosity. Kernel length, width, thickness, and effective mean diameter increased from 6.342 to 6.43 mm, 5.48 to 5.87 mm, 5.16 to 5.21 mm, and 5.64 to 5.81 mm, respectively. The 1000 seed mass was found to increase from 115.27 to 123.75 g volume was found to increase from 45.55 to 105 mm^3 and sphericity from 0.89 to 0.90, respectively. Bulk density, true density, and porosity were found to decrease with moisture content increase from 783.11 to 700.44 kg/m3, 2486.60 to 1180.62 kg/m3, and 46.65% to 45.59%, respectively. Static friction coefficients were found to increase as moisture content increases. Static friction coefficient between grass pea seeds and plywood, glass and galvanized iron steel surface ranging from 0.274 to 0.502, 0.302 to 0.431 and 0.334 to 0.414, respectively. The largest increase in static friction coefficient with moisture content was observed for plywood surface.

Keywords: Physical properties, moisture content, grass pea, bulk density.

Citation: Sarajeh, Hossein,Mohammad AliEbrahimi, MajidKhanali,OmidBehboudi, andKeyvanMohammadi.2014. Effect of moisture content on some physical properties of Grass pea (Lathyrussativus L.). Agric Eng Int: CIGR Journal, 16(4):261-267.

1 Introduction

Grass pea (Lathyrussativus L.) is an annual leguminous crop cultivated in Eurasia, North America, temperate parts of South America and East Africa for animal or human consumption (Smartt, 1990).Physical and engineering properties are important in many problems associated with the design of machines and the analysis of the behavior of the product during agricultural process operations such as handling, planting, harvesting, threshing, cleaning, sorting and drying. The solutions to problems of these processes involve knowledge of the physical and engineering properties. Bulk density, true density, and porosity can be useful in sizing grain hoppers and storage facilities. Design of grain harvesting and handling system requires the determination of friction coefficient between grain and structural surface in contact with the grain (Aviara et al., 1999; Deshpande et al., 1993; Ogunjimi et al., 2002).There are many researchs about determination of physical properties of agriculture products, for example:

Cetin(2007), Tabatabaeefar and Rajabipour(2005), Oyelade(2005), Goyal(2007), Mwithiga and Sifunabarbunia(2006), Altuntas and Yildiz(2007), Yalcin(2007), determined physical properties of bean,

Accepted date: 2013-07-26 **Received date:** 2014-11-05

***Corresponding author: Ebrahimi.M.A,** Department of Agricultural Machinery Engineering, University College of Agriculture and Natural Resources, University of Tehran, Islamic Republic of Iran. Email: m.a.ebrahimi.65@ut.ac.ir.

apple, African star apple seeds, aonla fruits, sorghum, faba bean grains, pea seed, respectively.

The lack of published articles on moisture dependent physical properties of grass pea limits the mechanization of post-harvest processing of the seed. The aim of this research was to determine some physical properties of grass pea such as physical dimensions, mean diameters, size, 1000 seed mass, sphericity, surface area, volume, true density and bulk density over moisture content range from 10.65 to 19.92 % (d.b.). The effect of moisture content on some physical and engineering properties of Grass pea (*Lathyrussativus* L.,) wereinvestigatedtoo.

2 Material and methods

The dry seeds of grass pea cultivar, *Zanjan*variety, were used for all the experiments in this study. The seeds were cleaned manually to remove all foreign matter such as dust, dirt, stones, broken and immature grains. The initial moisture content of the seeds was determined by oven drying at 135 ± 2^{o}Cfor 72 h (Suthar and Das, 1996). The initial moisture content of the seeds was 10.65% d.b. The samples of the desired moisture contents were prepared by adding the amount of water as calculated from the following relation (Sacilik et al, 2003).

$$Q=Wi(Mf-Mi)/(100-Mf) \qquad (1)$$

Where Q = mass of added water in grams, Wi is initialmass of grain sample in grams, Mi and Mf are the initial and final moisture contents in percent (wet basis), respectively. The samples were kept at 4^{o}C in a refrigerator for ten days to enable the moistureto distribute uniformly throughout the sample. Before starting a test, the required quantity of the seed was taken out of the refrigerator and allowed to warm up to the room temperature.All the physical properties of the seeds were assessed at moisture levels of 10.65%, 13.04% and 19.92% d.b. with three replications at each moisture content.

2.1 Measuring procedure

2.1.1. Dimension

The longitudinal lengthwas defined as the largest lengthof the kernel while the transverse length was the longest dimension in an axis perpendicular to that of the major length. The thickness was then taken to be the smallestdimension along a third axis perpendicular to both the major and medium length. To determine these length, used from digital caliper (CT 15) to an accuracy of 0.005 mm (Figure 1) (Anonymous, 2009).The process was repeated until 100 measurements were recorded.

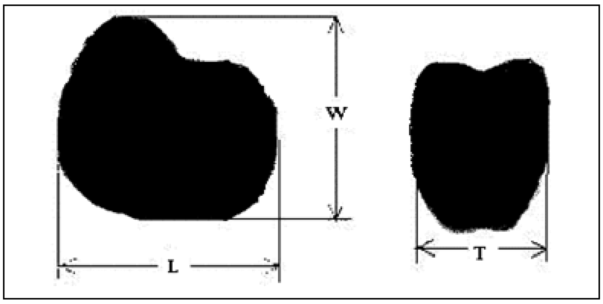

Figure 1 Three principle dimension of grass pea seed.
Note: Longitudinal length(L), transverse length(W), and thickness(T)

2.1.2. One thousand seed weight

To obtain the unit mass of the seed, thousand grains mass were measuredon a digital balance (GF3000, Japan) to an accuracy of 0.001 g. To evaluate thousand seedmass, 100 randomly selected grains from the bulk and 1000 seed mass was calculated as multiple of it.

2.1.3. Density and porosity

The bulk density is the ratio of the mass of a sample of a seed to its total volume. A volume of seedwas measured using a container by pouring the seedfrom a height of 15 cm (Bart-plange and Baryer, 2003; Sacilink et al., 2002) and its mass determined using digital balance to an accuracy of 0.001 g.For determine the true density used from the water displacement method as outlined by Mohsenin (1986).Density of grass pea was less than water density;therefore, industrial alcohol was used instead of water. True density was calculated as the ratio of mass of sample in air to mass of displaced industrial alcohol. The porosity was calculated from the measured values of bulk density and true density using the relationship given by Mohsenin (1986) and Sacilink et al. (2002). This relationship is as presented in form of Equation 2.

$$\varepsilon=(1-(\rho_b/\rho_t))\times 100 \qquad (2)$$

where (ε) is porosity (%),(ρ_b) is the bulk density in kg/m^3 and (ρ_b) is the true density in kg/m^3.

2.1.4. Repose Angle

For measurment of repose angle of grass pea, due to previous studies,A special box made of plywood and measuring 5×6×12 cm was usedfor discharge of the grass pea (Oje and Ugbor, 1991;Oyelade et al,2005).For the measurment repose angle of discharge,a gate was embedded in below of the box.The box was set on two prob and the removable gate was then gently slid up and the seeds allowed to assumed their natural angle. The height and surface of the seed insid and outside of the box was read and the angle of repose for discharge and full were calculated using the tangent rule.

$Ø=\tan^{-1}(H/M)$ (3)

where: Ø is the angle of repose; H is the height of the congeries of the sample in mm, and W is the width of the congeries of the sample in mm(Figure 2).

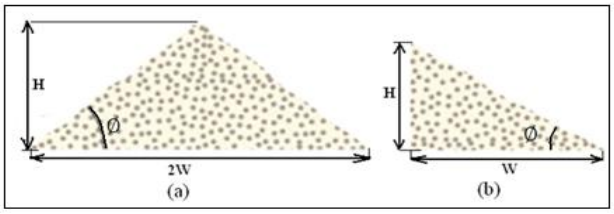

Figure 2Repose Angle in,full(a),discharge(b)

2.2.5 Sphericity

Sphericity of seeds was calculated by the following relationship (Mohsenin, 1970):

$$\psi=(LWT)^{1/3}/L \quad (4)$$

Where ψ is the Sphericity (beacause $(m^3)^{1/3}$=m then m/m is no dimension), L is the major length in (m),W is the medium length in (m),T is the minor length in (m)

2.1.6. Surface area

The following relationship was used to calculate the surface area of seeds (Mohsenin, 1970):

$$S=\pi D_g^2 \quad (5)$$

Where (S) is the surface area in(mm^2), D_g is the geometric mean diameter in mm.

2.1.7. Static coefficient of friction

The static coefficient of friction for grass pea against three different surfaces, namely ply wood, galvanized iron and glass was determined. For the work a gradient surface was used (Figure 1). A cubic box was placed on the surface and filled with the seed sample. The box was elevated until divide from the surface. Then, one side of the surface was elevated until the sample start to slide down, at this timethe angle of tilt,Θ_s , was read from a graduated scale.

Fig3 gradient surface

The coefficient of friction was calculated from the following relationship:

$$\mu=\text{Vertical/Horizental}=\tan\theta_s \quad (6)$$

Where μ is the coefficient of friction and θs is the angle of tilt in degrees.

2.1.8. Rupture force

To determine the mechanical properties of grass pea, a universal test unit was used (Figure 3). Load cell of the unit was 500 N to an accuracy of 0.5N.The seeds were placed between two aluminum jaws and pressed at the 0.5 mm/s speed until arrive to rupture point.Simultaneity force-deformation curves were recorded by a computer. The rupture force was determined in this method.

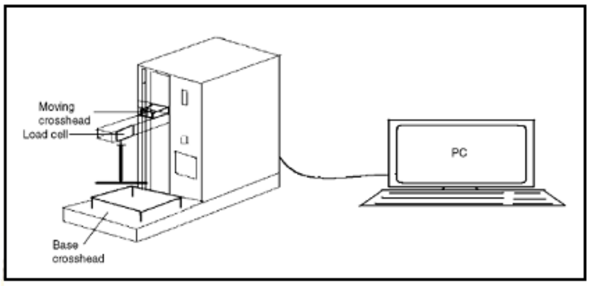

Figure 4 Universal test unit

3 Results and discussion:

3.1 Dimension

The dimension of grass pea was determined in three basic dimensions. All of this dimensions increased with increase in moisture content from 10.65 to 19.92 (d.b.).The longitudinal, transverse length and thickness was increased from 6.342 to 6.43 mm, 5.48 to 5.87 mm and 5.16 to 5.21 mm, respectively.

3.2 1000 seedmass

The mass of 1000 seeds for grass pea with increase in moisture content from 10.65% to 19.92% (d.b.), was found to increase from 115.27 to 123.75 g (Figure 5). This increase was linear. The linear equation for describe of this behavior was found in the following relation.

$$m_{1000}=1.047M_c+102.1 \quad (R^2= 0.999) \qquad (7)$$

Linear increase in the mass of 1000 seeds for pea, sorghum, faba bean and green wheat has bean noted byYalcin et al. (2006), Mwithiga & Sifuna (2005), Altuntas & Yildiz (2005),AL-Mahasneh andRababah (2006), respectively.

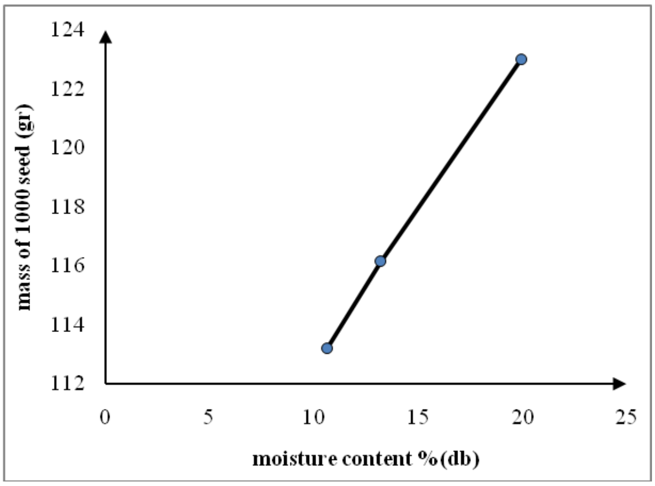

Figure5 Effect of moisture on mass of 1000 seed

3.3 Density and porosity

Whit increase in moisture content and permeate water in grass pea seeds, the bulk density , true density and the porosity was found to decrease. This increase was linear. Range of change with increase in moisture content from 10.65% to 19.92% (d.b.) for the bulk density, true density and the porosity was, 783.11 to 700.44 kg/m^3, 2486.6 to 1180.625 kg/m^3, and 68.50 to 40.67, respectively (Figure 6 and Figure 7). Linear relations between moisture content and mentioned parameters were found in the following equations.

$$\rho_b=18.592M_c+869.7(R^2= 0.979) \qquad (8)$$

$$\rho_t=-131.5M_c+3749(R^2= 0.931) \qquad (9)$$

$$\varepsilon=-2.941M_c+98.92 \quad (R^2= 0.993) \qquad (10)$$

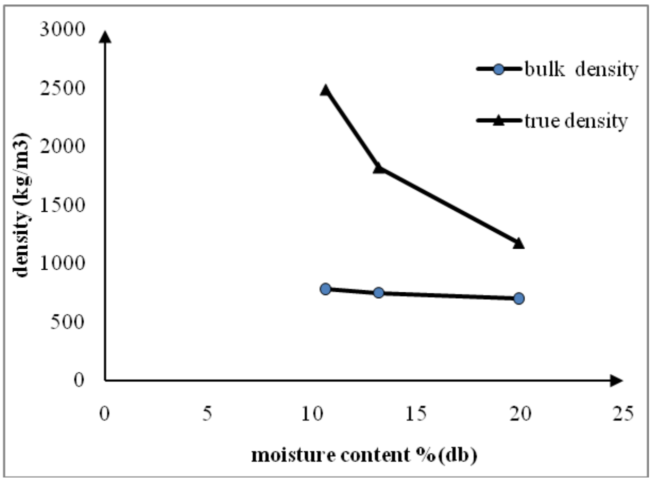

Figure6 Effect of moisture content on bulk and true density

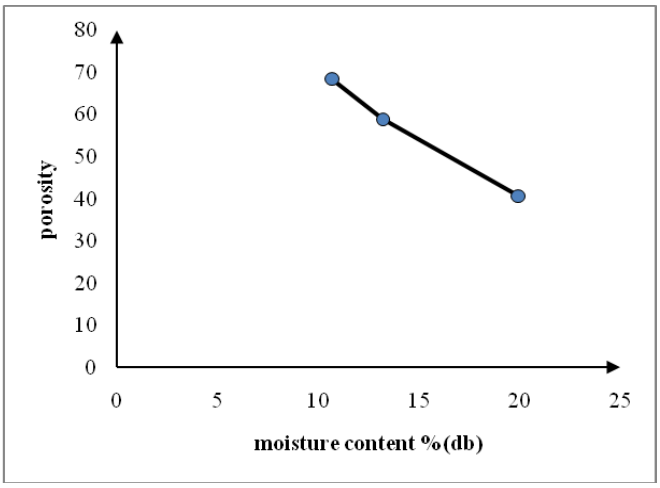

Figure 7 Effect of moisture content on porosity.

3.4 Repose angle

This parameter was calculated by Equation 3 and its results were showed in Figure 8. At the all levels of moisture content, the repose angle for full position was more than discharg. However, increasing of moisture content was founf to increased the repose angle of discharg and was found to decrease the repose angle of full, But this effect was not significent.

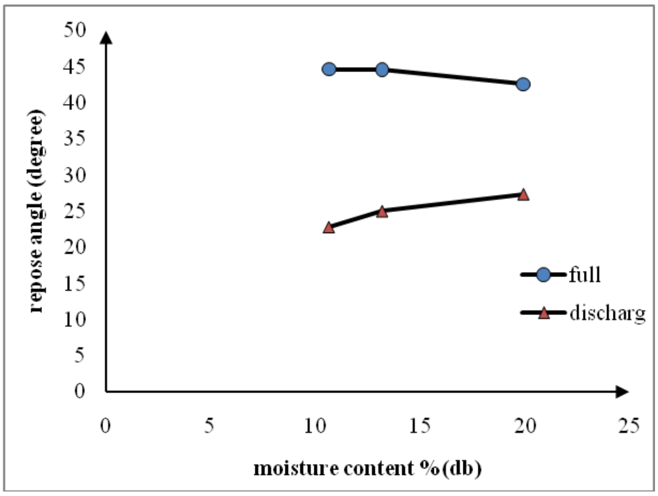

Figure 8 Effect of moisture content on repose angle

3.5 Sphericity

The sphericity of grass pea was found to increase from 88.9% to 90.43% with increase in moisture content from 10.65% to 19.92% (d.b.) (Figure 9). Similar this increase was linear, too.This increase can be described by the following relation.

$$\psi=0.001M_c+o.870 \quad (R^2=0.987) \qquad (11)$$

This behavior have bean reported by Ozarslan (2002) for cotton, Altuntas and Yildiz (2005) for faba bean.

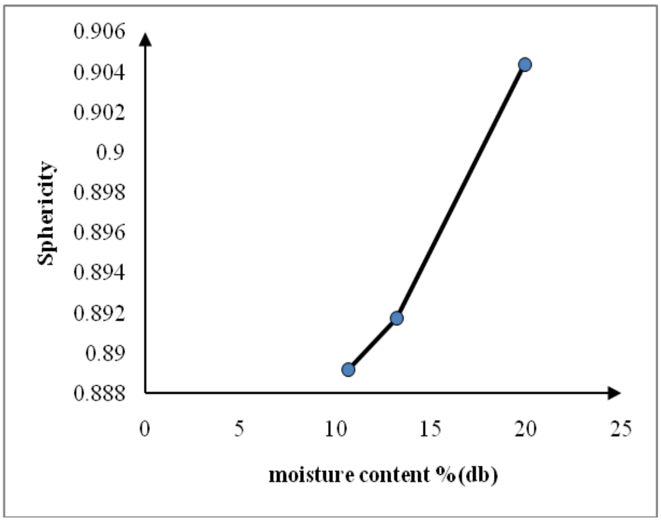

Figure 9 Effect of moisture on sphericity

3.6 Surface area

With increase in moisture content from 10.65% to 19.92% (d.b.), pursuant increase in volume of grass pea seeds a linear increase was found in surface area.this increase was found from 99.90 to 106.23mm^2 (Figure 10)can show this increase by following linear relationship.

$$S=0.710M_c+91.92 \quad (R^2=0.978) \qquad (12)$$

Similar this increase in surface area have bean reported by Ozarslan (2002) for cotton, Altuntas & Yildiz (2005) for faba bean and AL-Mahasneh & Rababah (2006) for green wheat.

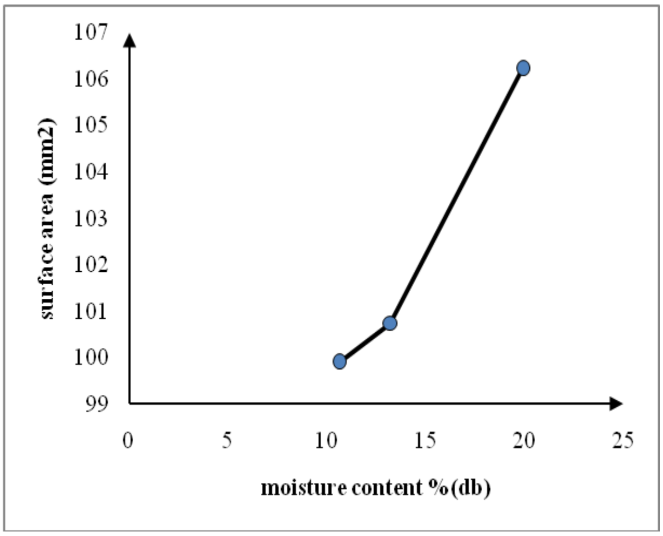

Figure 10 Effect of moisture on surface area.

3.7 Static coefficient of friction

Static coefficient of friction between grass pea and three surfaces, namely ply wood, galvanized iron and glass was determined, in entire of this surface a linear increase was found in Static coefficient of friction. With increase in moisture content from 10.65% to 19.92% (d.b.), this increase for ply wood, glass and galvanized iron steel was found from 0.274 to 0.502, 0.302 to 0.431 and 0.334 to 0.414, respectively (Figure 11).The linear equation for describe of this behavior for ply wood, glass and galvanized iron steel was found in the relations (12,13,14) respectively:

$$\mu = 0.023M_c + 0.040 \quad (R^2= 0.968) \qquad (13)$$

$$\mu = 0.012 M_c + 0.202 \quad (R^2= 0.729) \qquad (14)$$

$$\mu = 0.008 M_c + 0.252 \quad (R^2= 0.915) \qquad (15)$$

This behavior for pea, sorghum, faba bean and green wheat has bean reported by Yalcin et al (2006), Mwithiga

& Sifuna (2005), Altuntas & Yıldız (2005), Al-Mahasneh & Rababah (2006), respectively.

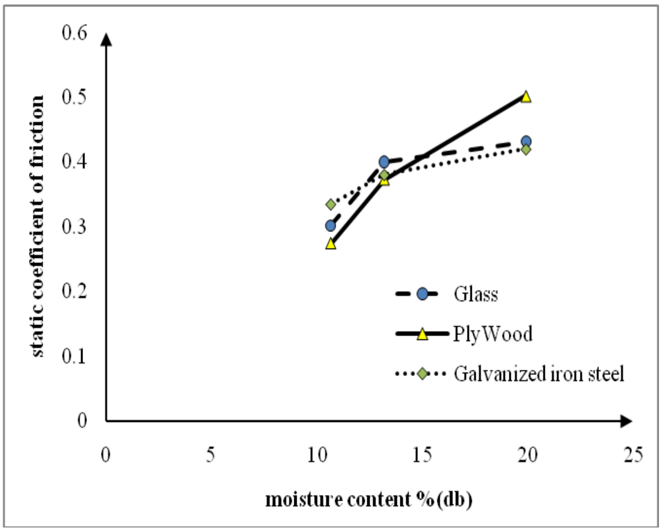

Figure 11 Effect of moisture on static coefficient of friction

3.8 Rupture force

The rupture force of grass pea in moisture content from 10.65% to 19.92% (d.b.) was scrutinied.This parameter in moisture content more than 11% was not clear. But it was clear in 10.65%(d.b) and was 171±35N in 0.8±0.37 mm of deformation.

4 Conclusion

The following conclusions are drawn from the investigation on physical properties of grass pea for moisture content range of 10.65% to 19.92% d.b.

1) Increasing of moisture content was found to increase mass of 1000 seeds kernel surface area, kernel volume, and static friction coefficient, while decreasing bulk density, true density, and porosity.

2)Static friction coefficients were found to increase as moisture content increases.

3) The rupture force of grass pea in moisture content more than 11% was not clear. But it was clear in 10.65%(d.b).

Reference

Al-Mahasneh, M.A., and T. M. Rababah. 2007. Effect of moisture content on some physical properties of green wheat. J*ournal of Food Engineering*, 79: 1467–1473.

Altuntas, E., and M. Yildiz. 2007. Effect of moisture content on some physical and mechanical properties of faba bean (Viciafaba L.) grains, *Journal of Food Engineering,* 78: 174–183.

Anonymous. 2009. Project on "Minor Fruit Tree Species Conservation" - RESGEN29. DESCRIPTOR LIST FOR POMEGRANATE (Punica granatum L.). http://www. unifi.it /project/ueresgen29/netdbase/s2/dls2.htm,

Aviara, N. A., M. I. Gwandzang, and M. A. Haque. 1999. Physical properties of guna seeds. *Journal of Agricultural Engineering Research*, 73(2): 105–111.

Bart-plange, A., and E. A. Baryer. 2003. Physical properties of category B cocoa beans. *Journal of Food Engineering,* 60(3): 219–227.

Cetin. M. 2007.Physical properties of barbunia bean(Phaseolus vulgaris L. cv. 'Barbunia') seed.*Journal of Food Engineering*, 80: 353–358.

Deshpande, S. D., S. Bal, and T. P. Ojha. 1993. Physical properties of soya bean. *Journal of Agricultural Engineering Research*, 56: 89–98.

Goyal, R.K., A. R. P. Kingsly, P. Kumar, and H. Walia. 2007, Physical and mechanical properties of aonla fruits, *Journal of Food Engineering* 82: 595–599.

Mohsenin, N. N. 1970. Physical properties of plant and animal materials. New York: Gordon and Breach Science Publishers.

Mohsenin, N. N. 1986. Physical properties of plant and animal materials. New York: Gordon and Breach Science Publishers.

Mwithiga, G., and M.M. Sifuna. 2006. Effect of moisture content on the physical propertiesof three varieties of sorghum seeds. *Journal of Food Engineering*, 75: 480–486.

Ogunjimi, L. O., N. A. Aviara, and O. A. Aregbesola. 2002. Some engineering properties of locust bean seed. *Journal of Food Engineering*, 55(2): 95–99.

Oje, K., and E. C. Ugbor. 1991. Some physical properties of oil bean seed. *Journal of Oil Bean Seed*, 50: 305–313.

Oyelade, O.J., P.O. Odugbenro, A.O. Abioye, and N.L.Raji. 2005. Some physical properties of African star apple (Chrysophyllumalibidum) seeds.*Journal of Food Engineering*, 67: 435–440.

Ozarslan, C. 2001. Physical properties of cotton seed. *Biosystems Engineering*, 83(2): 169–174.

Sacilink, K., R. Ozturk, and R. Kesikin. 2002. Some physical properties of hemp seeds. *Biosystems Engineering*, 86(2): 191–198.

Smartt, J. 1990. Pulses of the classical world. In: Summerfield, R.J., Ellis, E.H. (Eds.), Grain Legumes: Evaluation and Genetic Resources. Cambridge Univ. Press, Cambridge, pp: 190–200.

Suthar, S. H., and S. K. Das. (1996). Some physical properties of karingda [Citrus lanatus (thumb) mansf] grains. *Journal of Agricultural Engineering Research*, 65(1): 15–22.

Tabatabaeefar, A., and A. Rajabipour. 2005. Modeling the mass of apples by geometrical attributes, *Scientia Horticulturae*, 105: 373–382.

Yalcýn, I., C. O. zarslan, and T. Akbas. 2007.Physical properties of pea (Pisumsativum) seed.*Journal of Food Engineering*, 79: 731–735.