2011 International Conference on Food Engineering and Biotechnology
IPCBEE vol.9 (2011) © (2011)IACSIT Press, Singapore

Some Physical Properties of *Parkia speciosa* seeds

M.H.R.O. Abdullah[1+], P.E. Ch'ng[2] and T.H. Lim[3]

[1]Department of Applied Sciences, Universiti Teknologi MARA (UiTM), 13500 Permatang Pauh, Pulau Pinang, Malaysia

[2]Department of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM), 13500 Permatang Pauh, Pulau Pinang, Malaysia

[3]Academy of Language Studies, Universiti Teknologi MARA (UiTM), 13500 Permatang Pauh, Pulau Pinang, Malaysia

Abstract. Some physical properties of Parkia speciosa seeds were examined in this study. The average moisture content (wet basis) of the seeds was found to be 74.15 (±3.45) % while the mean moisture content (wet basis) of the pods was 73.02 (±0.43) %. The mean of length, width and thickness of the seeds was 23.20 (±1.13), 17.27 (±0.99) and 9.87 (±0.82) mm respectively. The average value for geometric mean diameter, sphericity, aspect ratio, mass, surface area, volume, true density, bulk density and porosity was 15.80 (±0.85) mm, 68.15 (±2.52) %, 74.51 (±4.26) %, 1.868 (±0.316) g, 786.86 (±84.47) mm2, 2084.37 (±336.00) mm3, 1089.46 (±73.40) kgm-3, 419.88 (±15.27) kgm-3 and 61.29 (±3.18) % respectively. The coefficient of static friction on four types of structural surface was found to be varying from 1.056 (±0.063) for plywood to 1.378 (±0.110) for glass surface.

Keywords: Parkia speciosa, physical properties, seeds

1. Introduction

Parkia speciosa or popularly known as "petai" among the locals in Malaysia is a rainforest tree that can grow up to 40 m high and 100 cm in diameter. The tree is commonly found in Malaysia, Indonesia, Thailand and Philippines. It begins to bear fruit after about seven years of planting. The flowering and fruiting season of the tree peaks between August and October each year. The tree bears light-bulb shaped flowers that hang at the end of long stalks. Upon maturing, a cluster of long, twisted pods emerges at the end of each stalk. The *Parkia speciosa* seeds are encapsulated in these pods (Fig. 1). The seeds are very popular among the locals and are commonly used to prepare local traditional delicacy. They can be consumed raw or cooked with local spices such as garlic, chilli pepper and dried shrimp to enhance its aroma. The seeds are also used traditionally to treat diseases such as diabetes, kidney pain and cholera [1]. At present, the harvesting and processing of *Parkia speciosa* seeds in Malaysia are done manually. The operations are time consuming and labour intensive.

In designing machine for handling, processing and storing of these seeds, physical properties such as mass, length, width, thickness, geometric mean diameter, surface area, volume, true density, bulk density, porosity, sphericity, aspect ratio and static friction on different types of surfaces are of paramount importance. In recent years, many researchers have reported physical and mechanical properties of various types of seeds. These include locust bean seeds [2], quinoa seeds [3], amaranth seeds [4], caper seeds [5], sweet corn seeds [6], cucurbit seeds [7], jatropha seeds [8], roselle seeds [9], chia seeds [10], fennel seeds [11], arigo seeds [12] and nutmeg seeds [13]. The aim of this work was to determine some physical properties of *Parkia speciosa* seeds which could be useful in facilitating the design of machines to handle, process and store the seeds.

+ Corresponding author. Tel.: +6043823439; fax: +6043822768.
E-mail address: harisridzuan@gmail.com.

Fig.1. Pods and seeds of *Parkia speciosa*.

2. Materials and Methods

Fresh *Parkia speciosa* fruits were procured directly from a wet market in Bukit Mertajam town in the state of Penang, Malaysia. The fruits were processed manually to detach the seeds from their pods. Immature and broken seeds were removed from the sample. The physical properties of the seeds were determined at the temperature and relative humidity in the range of 21.2 – 25.1 ^{o}C and 70 – 90 % respectively for a period of not more than three days. During this period, the seeds were kept overnight in a refrigerator at 5 ^{o}C to maintain their freshness.

Moisture content of the seeds and pods was determined using AOAC standard method [14]. Five samples of seed and five samples of pod were dried in an air ventilated oven at 80 ^{o}C for three days. Moisture content (wet basis) was calculated as:

$$MC(\%) = \frac{M_i - M_f}{M_i} \times 100\% \quad (1)$$

where $MC(\%)$ is the moisture content, M_i is the initial mass and M_f is the final mass of the seed.

Three principal dimensions namely, length (*L*), width (*W*) and thickness (*T*) of 100 seeds were measured using a digital vernier calliper (Model CD-6BS-Mitutoyo Corporation, Japan) with a resolution of 0.01 mm. The measurements for each dimension were replicated 100 times.

In order to calculate the geometric mean diameter (*D*) for each seed, the three principal dimensions were used. The geometric mean diameter was calculated based on the following equation [15]:

$$D = (LWT)^{\frac{1}{3}} \quad (2)$$

Sphericity (*S*) is defined as the ratio of the surface area of a sphere having the same volume as the seed to the surface area of the seed. The sphericity was determined using the following expression [15]:

$$S = \frac{(LWT)^{\frac{1}{3}}}{L} \quad (3)$$

In order to gather more information about the shape of the seed, aspect ratio (*R*) of the seed was determined from the following relationship [16]:

$$R = \frac{W}{L} \times 100\% \quad (4)$$

The mass of 100 individual seeds was measured using an electronic balance (Model PS200/2000/C/2-RADWAG, Poland) with an accuracy of 0.001 g. The measurements were replicated 100 times.

Surface area (*A*) of the seed was calculated based on the geometric mean diameter using the following formula [17]:

$$A = \pi D^2 \quad (5)$$

Volume (V) for 10 individual seeds was determined using water displacement method as described by Dutta *et al.* [18]. The seeds were weighed and coated with table glue and allowed to dry in order to prevent water absorption. Each seed was lowered into a measuring cylinder containing water such that the seed did not float during immersion in water. The weight of water displaced by the seed was recorded. The ratio of mass to volume of the seed was treated as true density (ρ_T):

$$\rho_T = \frac{m}{V} \tag{6}$$

where m = mass of individual seed (kg) and V = volume of individual seed (m^3).

The bulk density is defined as the ratio of the mass of the sample of the seeds to its total volume. The bulk density was determined according to the method described by Fraser *et al.* [19] by filling an empty 250 ml cylindrical container with *Parkia speciosa* seeds. The seeds were poured from a constant height, striking off the top level and weighted. Bulk density (ρ_B) was calculated as

$$\rho_B = \frac{m_B}{V_B} \tag{7}$$

where m_B = mass of the sample of seeds (kg) and V_B = volume of container (m^3).

Porosity (*P*) is described as the fraction of the space in the bulk grain that is not occupied by the grain. To calculate the porosity of the bulk seed, the following relationship [20] was used.

$$P = \frac{\rho_T - p_B}{\rho_T} \times 100\% \tag{8}$$

The coefficient of static friction was determined on four different structural surfaces, namely plywood, galvanized steel sheet, rubber and glass. Each seed was placed on the surface and raised gradually by screw until the seed begin to slide. The angle that the inclined surface makes with the horizontal when sliding begins was measured. The coefficient of static friction (μ_s) was calculated using the following expression:

$$\mu_s = \tan\theta \tag{9}$$

where θ = angle that the incline makes with the horizontal when sliding begins.

3. Results and Discussion

The results of some physical properties of *Parkia speciosa* seeds determined in this study were shown in Table 1. The moisture content (wet basis) of the seeds was found to be in the range of 68.59 – 77.70 % while the moisture content (wet basis) of the pods was in the range of 72.54 – 73.72 %. The moisture content is the most vital factor that influences the storability of the seed. The higher the moisture content, the shorter the storage life of the seed would be due to the rapid growth of mould on the seed. Table 1 shows that the *Parkia speciosa* seed has mean moisture content of 74.15%. This would suggest that the seed has poor storage potential due to its high moisture content. The mean value of length, width and thickness of the seeds was 23.20 (±1.13), 17.27 (±0.99) and 9.87 (±0.82) mm respectively. The dimensions of *Parkia speciosa* seeds were higher than those for cucurbit seeds [7] and jatropha seeds [8] but lower than fennel seeds [11]. Dimensions of the seed are of paramount importance in determining the aperture size of the machine to process the seed. Apart from that, the dimensions could be useful in determining the shape of the seed. Since the three semi-axes of the seed are unequal, the shape of *Parkia speciosa* seed is considered as scalene ellipsoid. The calculated geometric mean diameter ranges from 13.19 to 18.10 mm with a mean value of 15.80 (±0.85) mm. The geometric mean diameter obtained can be used to determine the volume and sphericity of the seed theoretically.

The mean of sphericity and aspect ratio of the seeds were 68.15 (±2.52) % and 74.51 (±4.26) % respectively while the mean mass of the seeds was 1.868 (±0.316) g. The sphericity was higher compared to fennel seeds [11] but lower than amaranth [4] and caper seeds [5]. The low sphericity and aspect ratio of the seeds indicate that the Parkia *speciosa* seed is likely to slide on their flat surfaces rather than roll. This parameter is of utmost importance in designing of hopper to handle the seeds. The average surface area was found to be 786.86 (±84.47) mm^2 while the mean volume determined for 10 seeds was 2084.37 (±336.00) mm^3. True density and bulk density of the seeds were 1089.46 (±73.40) and 419.88 (±15.27) kgm^{-3} respectively. The reported value of true density for quinoa [3] and arigo [12] seeds are very similar to *Parkia* *speciosa* seed. However, their bulk density was higher compared to *Parkia speciosa* seed. The bigger size of *Parkia speciosa* seeds may have contributed to the lower value of bulk density. This parameter is important in determining the storage capacity. The average porosity of the *Parkia speciosa* seeds was 61.29 (±3.18) %. This value was found to be in the same order as sweet corn [6] and fennel seeds [11] but higher than locust bean [2] and chia seeds [10]. The porosity of seed is important because it shows the resistance of the seeds to airflow during drying process.

The coefficient of static friction of *Parkia speciosa* seeds against four types of structural surface was determined. The results were indicated in Table 2. The coefficient of static friction for *Parkia speciosa* seeds were greater than the values reported for cucurbit seeds [7] and nutmeg seeds [13]. The large value of coefficient of static friction may be attributed to the high moisture content in the seed as well as the stickiness of the surface of the seed. It was found that the seed had the highest coefficient of static friction on glass followed by galvanized steel sheet, rubber and plywood. This property is of paramount importance in determining the steepness of the storage container, hopper or any other loading and unloading device [12].

Table 1. Some physical properties of *Parkia speciosa* seeds.

Physical properties	Unit of measurement	No. of observation	Mean value	Minimum value	Maximum value	Standard deviation
Moisture content of seed (w.b.)	%	5	74.15	68.59	77.70	3.45
Moisture content of pod (w.b.)	%	5	73.02	72.54	73.72	0.43
Length	mm	100	23.20	18.52	25.64	1.13
Width	mm	100	17.27	14.15	20.23	0.99
Thickness	mm	100	9.87	8.08	12.38	0.82
Geometric mean diameter (GMD)	mm	100	15.80	13.19	18.10	0.85
Sphericity	%	100	68.15	63.27	75.61	2.52
Aspect ratio	%	100	74.51	65.05	84.72	4.26
Mass	g	100	1.868	1.139	2.906	0.316
Surface area	mm^2	100	786.86	546.44	1028.71	84.47
Volume	mm^3	10	2084.37	1201.14	3102.51	336.00
True density	$kg\ m^{-3}$	10	1089.46	929.23	1212.00	73.40
Bulk density	$kg\ m^{-3}$	10	419.88	403.20	457.28	15.27
Porosity	%	10	61.29	54.67	66.11	3.18

Table 2. Coefficient of static friction of *Parkia speciosa* seeds on four types of structural surface.

Coefficient of static friction on	No. of observation	Mean value	Minimum value	Maximum value	Standard deviation
Plywood	25	1.056	0.933	1.150	0.063
Galvanized steel sheet	25	1.270	1.036	1.483	0.114
Rubber	25	1.183	0.966	1.376	0.100
Glass	25	1.378	1.192	1.540	0.110

4. Conclusion

The average moisture content (wet basis) of the *Parkia speciosa* seeds determined in this study was 74.15 (±3.45) % while the mean moisture content (wet basis) of the pods was 73.02 (±0.43) %. The mean of length, width and thickness of the seeds was 23.20 (±1.13), 17.27 (±0.99) and 9.87 (±0.82) mm respectively. The average value for geometric mean diameter, sphericity, aspect ratio, mass, surface area, volume, true density, bulk density and porosity was 15.80 (±0.85) mm, 68.15 (±2.52) %, 74.51 (±4.26) %, 1.868 (±0.316) g, 786.86 (±84.47) mm^2, 2084.37 (±336.00) mm^3, 1089.46 (±73.40) kgm^{-3}, 419.88 (±15.27) kgm^{-3} and 61.29 (±3.18) % respectively. The coefficient of static friction on four types of structural surface was found to be vary from 1.056 (±0.063) for plywood to 1.378 (±0.110) for glass surface. The technical data obtained in this study may be useful in the design of machine for handling and processing of the *Parkia speciosa* seeds.

5. References

[1] C. Orwa, A. Mutua, R. Kindt, R. Jamnadass and A. Simons. *Agroforestree Database: a tree reference and selection guide version 4.0.* 2009. (http://www.worldagroforestry.org/af/treedb/) (accessed 23.12.2010)

[2] L.A.O. Ogunjimi, N.A. Aviara and O.A. Aregbesola. Some physical engineering properties of locust bean seed. *J. Food Eng.* 2002, **55**: 95-99.

[3] C. Vilche, M. Gely, and E. Santalla. Physical properties of quinoa seeds. *Biosyst. Eng.* 2003, **86:** 59–65.

[4] R. Abalone, A. Cassinera, A. Gast´on, and M.A. Lara. Some physical properties of Amaranth seeds. *Biosyst. Eng.* 2004, **89**: 109–117.

[5] E. Dursun and I. Dursun. Some physical properties of caper seed. *Biosyst. Eng.* 2005, **92**: 237-245.

[6] M. Bulent Coskun, I. Yalcin and C. Ozarslan. Physical properties of sweet corn seed (Zea mays saccharata Sturt.). *Journal of Food Engineering*. 2006, **74** (4): 523–528.

[7] E. Milani, S.M.A. Razavi, A. Koocheki, V. Nikzadeh, N. Vahedi, M. MoeinFord and A. GholamhosseinPour. Moisture dependent physical properties of cucurbit seeds. *Int. Agrophysics*. 2007, **21**: 157-168.

[8] D.K. Garnayak, R.C. Pradhan, S.N. Nalk and N. Bhatnagar. Moisture-dependent physical properties of jatropha seed. *Industrial Crops Products*. 2008, **27**: 127-129.

[9] J. Sánchez-Mendoza, A. Domínguez, S. Navarro-Galindo and J.A. Lüpez-Sandova. Some physical properties of roselle (*Hibiscus Sabdariffa* L.) seeds as a function of moisture content. *J. Food Eng.* 2008, **87**: 391-397.

[10] V.Y. Ixtaina, S.M. Nolasco and M.C. Tomas. Physical properties of chia (*Salvia hispanica* L.) seeds. *Industrial Crops Products*. 2008, **28**: 286-293.

[11] H. Ahmadi and K. Mollazade. Some physical and mechanical properties of fennel seed (*Foeniculum vulgare*). *J. Agric. Sci.* 2009, **1**(1): 66-75.

[12] R.M. Davies. Some physical properties of Arigo seeds. *Int. Agrophys.* 2010, **24**: 89-92.

[13] M.H.R.O. Abdullah, P.E. Ch'ng and T.H. Lim. Determination of Some Physical Properties of Nutmeg (*Myristica fragrans*) Seeds. *Research Journal of Applied Sciences, Engineering and Technology*. 2010, **2**(7): 669-672.

[14] AOAC. *Official Methods of Analysis*. Association of Official Analytical Chemists, Washington, DC., 1984.

[15] N.N. Mohsenin. *Physical Properties of Plant and Animal Materials*. Gordon and Breach Science Publishers, New York, USA., 1970.

[16] J.N. Maduako and M.O. Faborode, Some physical properties of cocoa pods in relation to primary processing. *Ife J. Technol.* 1990, **2**: 1-7.

[17] W.L. McCabe, J.C. Smith and P. Harriot. *Unit Operations of Chemical Engineering*. McGraw-Hill Press, New York, USA., 1986.

[18] S.K. Dutta, V.K. Nema and R.K. Bhardway. Physical properties of gram. *Journal of Agricultural Engineering Research*. 1988, **39**: 259–268.

[19] B.M. Fraser, S.S. Verma and W.E. Muir. Some physical properties of fanabeans. *Journal of Agricultural Engineering Research*. 1978, **22**: 53–57.

[20] R. Thompson and W. Isaac. Porosity determination of grains and seeds with air comparison pycnometer. *Transactions of the ASAE*. 1967, **10**(5): 693-696.