

## Some physical properties of arigo seeds

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Received June 28, 2009; accepted October 15, 2009

**A b s t r a c t.** The study was conducted to investigate the physical properties of arigo seeds, namely linear dimensions, mean diameters, sphericity, surface area, volume, true and bulk densities, porosity, angle of repose and static coefficient of friction at 10.3% (w.b.) moisture content. The results revealed that the mean length, width and thickness of arigo seeds were 19.0, 12.16, 10.1 mm, respectively. The arithmetic and geometric mean diameters were 13.7 and 13.2 mm, respectively. The sphericity, surface area and 1 000 grain mass of arigo seed were 0.8, 501.3 mm<sup>2</sup> and 1124.7 g, respectively. True and bulk densities were 1066.7 and 989.78. kg m<sup>-3</sup>, respectively. The static coefficient of friction on concrete and glass structural surfaces were observed to be the highest and lowest, respectively.

**K e y w o r d s:** arigo seeds, dimensions, sphericity, surface area, density

### INTRODUCTION

Arigo seed (*Dacryodes edulis*) is a cultivated plant grown for its aromatic spices and for industrial utilization. The nutritional values of arigo seed as aromatic spice are: protein 6.3%, crude fibre 10.7%, carbohydrate 47.6%, fat 33.5%, moisture content 7.0% and ash 3.3%.

The harvesting and processing of arigo seed operation is being done manually in Nigeria. The manual method is slow and labour intensive. The physical and mechanical properties are essential and practical for its processing, transportation, sorting, separating and cleaning.

Many researchers have reported on the physical and mechanical properties of seeds, nuts, kernels and fruits. The physical properties have been studied for various agricultural products by other researchers, such as soybean (Manuwa and Afuye, 2004), bambara groundnut (Adejumo *et al.*, 2005), caper fruit, Capparis spp (Sessiz *et al.*, 2005) cocoa bean (Bart-Plange and Baryeh, 2003), pigeon pea (Shepherd and Bhardwaj, 1986), locust bean seed (Ogunjimi *et al.*, 2002), wheat (Tabatabaeefar, 2003) and pistachio nut

and its kernel (Razavi *et al.*, 2007). Benson (2008) reported the physical properties of arigo seed and that study revealed that length, width, thickness, arithmetic and geometric mean diameter were 21.41, 10.55, 12.51, 15.21, 14.92 and 16.17 mm, respectively. The static coefficients of friction of arigo seed on galvanized steel and plywood structural surfaces were 0.263 and 0.675, respectively. The coefficient of sliding friction was the highest for galvanized steel, at 0.57, while for glass as a structural surface it had the lowest mean value of 0.27. These properties are essential in order to design equipment for the handling, transporting, sorting, processing, drying and storing of arigo seeds.

The aim of this paper was to determine some physical properties of arigo seeds.

### MATERIALS AND METHODS

The arigo seeds were selected and cleaned manually. It was ensured that the grains were free of dirt, broken ones and other foreign materials. The seeds were kept at room temperature for two days. The initial moisture content of the seeds was immediately measured (ASAE, 1998). Three samples, each weighing 15 kg, were placed in an oven set at 103°C for 72 h. The samples were cooled in a desiccator, reweighed, and the moisture content of the seeds was calculated.

The seed size was determined by measuring the dimensions of the three principal axes of 100 randomly selected seeds, using a micrometer screw gauge with a reading of 0.01 mm (Galedar *et al.*, 2008; Mohsenin, 1980). The sphericity was calculated using the relationship given by Koocheki *et al.* (2007) and Milani (2007). The surface area was calculated according to Mc Cabe *et al.* (1986). The aspect ratio,  $R_a$ , was calculated by applying the relationships given by

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Maduako and Faborode (1990). Bulk density was calculated according to Garnayak *et al.* (2008), while true density according to Li *et al.* (2008). The porosity of arigo seed in bulk was computed from the values of true density and bulk density of the grains (Mohsenin, 1980). The 1 000 grain mass was determined using precision electronic balance to an accuracy of 0.01 g. To evaluate the 1 000 grain mass, 50 randomly selected samples were weighed and multiplied by 20. The reported value was a mean of 20 replications (Dash *et al.*, 2008).

The static coefficient of friction for arigo seed was determined with respect to four test surfaces, namely: plywood, galvanized iron sheet, concrete and glass, and the angle of repose according to Galedar *et al.* (2008) and Mohsenin (1980).

## RESULTS AND DISCUSSION

Table 1 shows the axial dimensions, arithmetic and geometric mean diameter, sphericity, surface area and 1 000 grain mass of arigo seeds at moisture content level of 10.3% (w.b.). The results indicate that length, width and thickness of arigo seeds range from 11.2-22.2, 10.1-13.5, 9.1-11.4 mm, respectively. The corresponding axial dimensions of arigo seed as reported by Benson (2008) were 21.4, 12.5 and 10.6 mm, respectively. While the corresponding values of axial dimensions for jatropha seeds as reported by Garnayak *et al.* (2008) and Sirisombaron *et al.* (2007) were 18.7-21.0, 11.3-12.0 and 8.9-9.6 mm. Burubai *et al.* (2007) reported the axial dimensions for nutmeg as being 5.0-21.2, 9.1-14.1 and 8.0-14.2 mm. A critical view at the axial dimensions of arigo seed, nutmeg and jatropha seed revealed that there are significant differences at 0.05%. The axial dimensions play important roles in the design of equipment. It can be deduced from the above data that processing machines designed based on physical properties of arigo seeds may not be suitable for nutmeg as well as for jatropha (Dash *et al.*, 2008; Mohsenin, 1980).

The calculated geometric mean diameters for arigo seeds, nutmeg and simarouba were 13.2 ( $\pm 0.1$ ), 12.4 ( $\pm 0.7$ ) and 14.8 mm ( $\pm 0.8$ ), respectively. The analysis of variance results revealed that the differences were statistically insignificant at the level of 0.05% for those seeds. The 1000 grain mass of arigo seeds, simarouba fruit and kernel, maize, red gram and cotton were 1124.7 ( $\pm 111.3$ ), 1120.0 ( $\pm 52.34$ ) and 330.3 ( $\pm 29.4$ ), 268.30 ( $\pm 0.1$ ), 102 ( $\pm 0.1$ ) and 81.4 ( $\pm 0.2$ ), respectively. The results revealed that arigo seed values were close to the corresponding values for simarouba fruit, but significantly different from simarouba kernel, maize, red gram and cotton at 0.05 statistical level. The mean sphericity of arigo seed was 0.80 ( $\pm 0.09$ ). The corresponding values for nutmeg, simarouba fruit and kernel and jatropha seed and kernel as reported by Dash *et al.* (2008) and Burubai *et al.* (2007) were 0.74, 0.69, 0.65, 0.64 and 0.68, respectively. It can be observed from the above results that the value of arigo sphericity was higher than those for nutmeg, simarouba and jatropha, while the sphericity values obtained in simarouba and jatropha were almost similar. Furthermore, the values of sphericity as reported by Jayan and Kuman (2004) for maize, red gram and cotton were 0.621 ( $\pm 0.065$ ), 0.750 ( $\pm 0.016$ ) and 0.677 ( $\pm 0.016$ ). The average true and bulk density were 1066.7 and 989.78 kg m<sup>-3</sup>. The corresponding true and bulk density of nutmeg and simarouba fruit and kernel were 836.5, 488.8, 622.3 and 727.3 kg m<sup>-3</sup>. These values showed that the differences in true and bulk density of the arigo seeds, nutmeg and simarouba were significant at 0.05 level. The average porosity of arigo seeds was 31.1%. The corresponding values of simarouba fruit and kernel were 33.2 ( $\pm 2.03$ ) and 28.6% ( $\pm 2.9$ ). Burubai *et al.* (2007) reported porosity of 41% ( $\pm 4.2$ ) for nutmeg. The porosity of arigo seeds, nutmeg and simarouba were statistically different. The angle of repose of arigo seeds was 24.5° ( $\pm 1.01$ ). The corresponding angle of repose of simarouba fruit and kernel were higher than that of arigo seeds. The corresponding values of angle of repose for maize, red gram and cotton were 22.1, 28.5, and 21.5°, respectively.

**Table 1.** Some physical properties of arigo seeds at 10.3% (w.b.)

Properties	No. sample	Minimum	Maximum	Mean	SD
Length (mm)	100	11.2	22.2	19.0	1.1
Width (mm)	100	10.1	13.5	12.2	0.8
Thickness (mm)	100	9.1	11.4	10.1	0.8
1000 grain mass (g)	50	1 096.1	1 189.5	1 124.7	71.8
Arithmetic mean diameter (mm)	100	11.2	14.8	13.7	1.0
Geometric mean diameter (mm)	100	11.2	15.0	13.2	1.4
Sphericity	100	0.7	0.9	0.8	0.1
Surface area (mm <sup>3</sup> )	50	384.5	680.2	501.4	35.6
Volume (mm <sup>3</sup> )	100	350.2	501.1	422.2	31.7
Aspect ratio (%)	100	47.6	56	52.8	3.3

**Table 2.** Chosen properties of arigo seed at 10.3% (w.b.)

Properties	Values	SD
True density (kg m <sup>-3</sup> )	1066.7	55.8
Bulk density (kg m <sup>-3</sup> )	989.8	28.7
Porosity (%)	31.07	2.05
Angle of repose (°)	24.5	0.9
Static coefficient of friction:		
Glass	0.20	0.004
Plywood	0.21	0.007
Metal	0.25	0.009
Concrete	0.27	0.010

The static coefficient of friction of arigo seeds against four different structural surface were measured. The results indicated that the concrete structural surface had the highest value of static coefficient of friction followed by metal and the angle of repose was 24.5°(0.9°). While the glass had the least static coefficient of friction (Table 2). The result obtained by Benson (2008) was in agreement with the corresponding values of coefficient of static friction of arigo seed. Tunde-Akintunde and Akintunde (2007) reported that the static friction coefficient for benniseed on selected surfaces was almost equal to that of the gram. This property is important in the determination of steepness of storage container, hopper or any other loading and unloading device.

#### CONCLUSIONS

1. The average length, width, thickness, arithmetic and geometric mean diameter, sphericity, surface area and 1000 grain mass were: 19.0, 12.2, 10.2, 13.7, 13.2 mm, 0.8, 601.3 mm<sup>2</sup> and 1124.7 g, respectively, at moisture content of 10.3% (w.b.).

2. The porosity, volume, aspect ratio, true density and bulk density of arigo seeds were: 31.1%, 422.2 mm<sup>3</sup>, 52.8%, 1066.7 and 989.78 kg m<sup>-3</sup>, respectively.

3. The static coefficient of friction for different surfaces (glass, concrete, plywood and steel) were experimentally determined. The highest static coefficient of friction was observed with concrete surface, while the least was noticed with glass.

4. The angle of static friction of arigo seed was 24.5°(±0.9°).

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