

Determination of Physical Characteristics of *Jatropha*

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Abstract

Jatropha curcas, a member of the Euphorbiaceae is a multipurpose tree of significant economic importance because of its several industrial and medicinal uses. The *jatropha* could be grown in all wastelands, except waterlogged areas. The single kernel weight, length, width, thickness and hardness of *jatropha* grains varied in the range of 0.129—0.966 g, 12.5—19.9 mm, 5.5—11.2 mm and 3.5—11.0 kgf, respectively. The mean value of weight, length, width, thickness and hardness were calculated as 0.041 g, 6.01 mm, 4.34 mm, 2.21 mm and 5.69 mm, respectively. The values of standard deviation for weight, length, width, thickness and hardness were 0.152, 0.91, 0.77, 0.69 and 1.02 respectively. The geometric mean diameter, sphericity were computed in the range of 9.56—14.05 mm, 0.54—0.85, with mean, 11.80 mm, 0.643, respectively. The standard deviation values of geometric mean diameter and sphericity were 0.56 and 0.029, respectively.

Key words : *Jatropha curcas* L. (ratanjot), Physical characterization.

Jatropha curcas L. (ratanjot) considered as a wild oilseed plant of the tropics is being credited as a most promising bio-fuel crop ideally suited for growing in the wastelands of the country. It is a plant of Latin American origin, which is now widespread throughout arid and semiarid tropical regions of the world. *Jatropha curcas*, a potential anti-feedant candidate, belongs to the family, Euphorbiaceae. The seed which is black and oval in shape is rich in fixed oil (1). The plant is a native of North America but now thrives well in Africa and Asia. It is easy to establish as it grows relatively quickly with high yields (2). Recently there was renewed interest on the utilization of the seed oils in view of the relatively high oil content (3). There are some chemical elements in the seed, which are poisonous and render the oil not appropriate for human consumption. The latex of *Jatropha curcas* (ratanjot) contains an alkaloid known as "Jatrophine" which is believed to have anticancerous properties. It is also used as an external application for skin diseases and rheumatism and for sores on domestic livestock. In addition, the tender twigs of the plant are used for cleaning teeth, while the juice of the leaf is used as an external application of piles. Finally, the roots are reported to be used as an antidote for snake-

bites. The *jatropha* oil is odorless and colorless when fresh but become yellow on standing. The seeds and oil are toxic due to the presence of curcive and curcative.

Methods

Seeds of *jatropha* were collected from university farm of G. B. Pant University of Agriculture and Technology, Pantnagar. Physical properties were determined at Process and Food Engineering Lab, Department of Post Harvest Process and Food Engineering, College of technology.

Experimental Design and Sample Preparation

Sample of *jatropha* were first cleaned and dried to remove moisture up to 8—9% and stored in polyethylene bags. A sample of thousand seeds was randomly taken for measuring thousand seeds weight, thousand seeds volume, bulk density, true density, porosity, coefficient of friction and angle of repose while 25 seeds were randomly taken for measuring the grain dimension, sphericity and porosity. All the

Table 1. Size characteristic of *Jatropha* at 8% (db) moisture content. Mean values are the average values of triplicates \pm SD.

| Range | Length (mm) | | Width (mm) | | Thickness (mm) | | L/W ratio | W/T ratio |
|-----------|-----------------|----------|------------------|-------|-----------------|----------|-----------|-----------|
| | Mean | Range | Mean | Range | Mean | Range | | |
| 12.5–19.9 | 16.2 \pm 0.91 | 7.2–16.9 | 12.5 \pm 0.77 | | 8.35 \pm 0.69 | 5.5–11.2 | 1.29 | 1.49 |
| 11.3–20.0 | 15.6 \pm 0.91 | 7.8–15.7 | 11.75 \pm 0.77 | | 8.9 \pm 0.69 | 5.8–12.0 | 1.32 | 1.32 |

properties were determined at the moisture content 8–9%.

Experimental Procedure

The moisture content of the sample was determined using a standard method (4). Three samples, each weight about 20 g, were placed in an oven maintained at 103 C for 72 h. The samples were then cooled in desiccators, weighed and the moisture content of seeds was calculated. Three dimensions viz. length, width and thickness of randomly selected seeds were measured by using vernier caliper with least count of 0.01 mm. Thousand-kernel weight was measured following Indian standards (4). The grains were sorted out, counted and weighed. The weight of 1,000 grains was determined using the equations :

$$W = \frac{a \times 1000}{b} \quad \dots (1)$$

Where, W = weight of 1,000 grains, g ; a = weight of whole grains in the sample, g ; and b = number of grains in the sample.

The 1,000 - kernel volume was measured by toluene displacement method (5). For this, relative density (RD) bottle was filled with toluene and weighed, after which 10 g sample was poured into the bottle and weight recorded again. The displaced volume of toluene gives the volume of sample. Number of grains in the 10 g sample was counted. The total volume for 10 g sample was multiplied by 1,000 and divided by the number of grains to get the 1,000- kernel volume. For true density of seeds, the method of relative density (RD) bottle and toluene (5) was used. Subsequently, 25 g of grain sample was placed in the RD bottle with sufficient toluene to cover the sample. The RD bottle was the placed inside a vacuum desiccators and the air was gradually removed by a

vacuum pump, which promoted the escape of the entrapped air. When air bubbles ceased to come off, the vacuum was released. The bottle was filled with toluene and weighed. The true density of the grain sample was calculated using the relationship :

$$\text{True density } (\rho_t) = \frac{\text{Specific gravity of toluene} \times \text{weight of the grain sample}}{\text{Weight of the toluene displaced by grain}} \quad \dots (2)$$

Bulk density of the grain was determined by standard method (4). This involved filling the measuring cylinder of 500 ml with grain from a height of 15 cm and then weighing the contents was obtained by subtracting the weight of empty cylinder from the weight of cylinder when filled with grain. The ratio of weight of contents to the volume gave the bulk density of the grains. The angle of repose was determined by following Indian standards (6). Then the angle of repose was given by

Table 2. Statistical parameters of grain dimensions.

| Statistical parameters | Length of grain | Width of grain | Thickness | Geometric mean diameter | Sphericity |
|------------------------|-----------------|----------------|-----------|-------------------------|------------|
| 1 Maximum (mm) | 19.9 | 16.9 | 11.2 | 14.05 | 0.85 |
| 2 Minimum (mm) | 12.5 | 7.2 | 5.5 | 9.56 | 0.54 |
| 3 Standard deviation | 0.91 | 0.77 | 0.69 | 0.56 | 0.029 |
| 4 Variance | 0.614 | 0.287 | 0.450 | 0.23 | 0.0007 |
| 5 Mean (mm) | 16.20 | 12.05 | 8.35 | 11.80 | 0.643 |
| 6 Mode (mm) | 19.0 | 11.0 | 9.0 | 12.17 | 0.67 |
| 7 Median (mm) | 18.3 | 11.0 | 8.80 | 12.02 | 0.65 |
| 8 Skewness | -1.64 | -0.45 | -0.19 | -0.40 | 1.02 |

Table 3. Values of constant, correlation coefficient and standard error of estimation for various physical characteristics estimated by Gaussian model.

| Property | Constants | | | R ² | SE |
|----------------------|-----------|------|-------|----------------|------|
| | a | b | c | | |
| Length | 26.3 | 5.9 | 0.28 | 0.94 | 3.59 |
| Width | 15.1 | 4.3 | 0.30 | 0.88 | 3.02 |
| Thickness | 20.5 | 2.2 | 0.08 | 0.94 | 2.50 |
| Single kernel weight | 15.5 | 0.04 | 0.005 | 0.90 | 2.74 |

$$\phi = \tan^{-1} \frac{\text{Height of pile}}{\text{Radius of cylinder}} \quad \dots (3)$$

The angle of friction was determined by as per Indian standards (7). The grain was kept in a rectangular frame placed in such a way that only the grain and the surface of the tilting table was in contact. The angle of the table which first induced sticking was measured. Sphericity expresses the shape character of the grain relative to that of a sphere of the same volume (5) and was defined as :

$$\text{Sphericity} = \frac{d_c}{d_e} \quad \dots (4)$$

Where, d_c = diameter of a sphere of the same volume as that of grain and d_e = diameter of the smallest circumscribing sphere or the longest diameter of the grain.

When the grain is considered to be a triaxial ellipsoid with length, width and thickness as intercepts a, b and c, respectively, the sphericity can be expressed as (5).

$$\text{Sphericity} = \frac{(abc)^{1/3}}{a} \quad \dots (5)$$

In the present study, above equation was employed to compute the sphericity. Porosity is the ratio of volume of the pores to the total volume. The porosity of the grain sample was computed from the bulk density and true density values using the following expression :

$$\text{Porosity} (\varepsilon) = \frac{P_t - P_b}{P_t} \times 100 \quad \dots (6)$$

Where ε = Porosity, % ; p_t = true density, kg / m³ ; p_b = bulk density, kg/m³.

Results and Discussion

Grain Dimensions

The grain dimension i.e. length (L), width (W), thickness (T) and the ratios of L to W and W to T of jatropha grain was measured at constant moisture (Table 1). For attempted mathematical models, the statistical parameters : correlation (r) standard errors (SE) were computed. The range, mean value and standard deviation for the grain dimensions, mean value for the L/W and W/T ratio geometric mean diameter and the sphericity for jatropha at constant moisture are shown in Table 2. The mean values of length, width and thickness were 16.2 mm, 12.5 mm and 8.35 mm, 15.6 mm, 11.75 mm and 8.9 mm at constant moisture (8%, db). The values of standard deviation of length, width and thickness were 0.91, 0.77 and 0.69 respectively. The value of (L/W) and (W/T) ratio were 1.29, 1.32 and 1.49, 1.32 at constant moisture. These values were well within the range.

Sphericity

The over all range of sphericity of jatropha grains considered in the study were from 0.850 to 0.545. The values of other statistical parameters such as mean, mode, median and standard deviation were found to be 0.643 mm, 0.67 mm, 0.65 mm and 0.029. The general shape of frequency distribution resembles normal distribution (Gaussian model) curve and was tested for its ability in predicting the frequency distribution of length, width and thickness. The Gaussian model is given by the following equation :

$$Y = ae - \frac{(x - b)^2}{2C^2} \quad \dots (7)$$

Where, Y = grain dimensions, mm, X = moisture content, % (db), a, b and c = constant.

The values of constants of Gaussian model, correlation coefficient (r), and standard error (SE) in respect to single kernel length, width and thickness are reported in Table 3.

Thousand Kernel Weight and Volume

The values of thousand kernels weight and volume found to be 608.40 g and 800 ml, respectively of *Jatropha* seed. The values of thousand kernel weight and volume for grain are 37.2 g and 26.03 ml respectively. The values of thousand kernel weight and volume are higher for *Jatropha* grain compare to horse grain. Bulk density and true density were found to be 0.37 and 0.868 g/ml respectively.

True Density

The true density of jatropha grain was found to be 0.868 g/ml. The true density decreased linearly with increase at moisture, this observation was in agreement with the Chung and Converse (8) who reported that the true density decreased linearly with increase in moisture content over a range of 8 to 25% (db) for wheat and corn. But the present observation in contrary to Bhattacharya et al. (9) who found that true density increased with increase in moisture content for paddy and rice grain respectively. The true density of grain of *Jatropha* was significantly positively correlated with width, thickness, length and geometric mean diameter.

Bulk Density

The bulk density for jatropha grain at constant moisture (8% db) was found to be 0.37 g/ml. The bulk density was positively correlated with the length, width, thickness and thousand kernel weight of the grain.

Angle of Friction

Angle of friction for *Jatropha* grains on wood was found to be 28.75°. The angle of repose was found to be 48.18° angle of friction for horse gram on wood are found to be 24.5° and angle of repose was found to be 27.10°.

Hardness

In the present investigation grain hardness (grain compression property) has been defined as the maximum force, in kg force (kgf), required to break the grain or to produce a deformation equivalent to 60% of grain thickness i.e. 60% strain in the grain under compression. The values of ranges of hardness for *Jatropha* grain were found to be 3.5 kgf to 11.0 kgf. The hardness decreased with increase in moisture content. The hardness for *Jatropha* grain was considerably positively correlated with thousand kernel volume, true density and porosity of the grain.

Conclusion

It is concluded that the physical properties of jatropha can be useful in design, and operation of various equipments, safe storage and drying and other post harvest processing operations.

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