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*RESEARCH PAPER*

# Engineering properties of turmeric crop for development of a digger

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**Abstract :** Three variety of turmeric crop were selected for determination of physical and engineering properties for developing root crop digger. Fresh turmeric crop sample was selected for determination of linear dimensions *viz.*, length, width and thickness, geometric mean diameter, sphericity, surface area, bulk density and found as the average of 68.99, 35.76 and 24.72 mm, 37.55, 0.55, 4592.25 $mm^2$ and 476.50 $kg/mm^2$, respectively for Suparbha variety sample and 68.99, 35.76 and 24.72 mm, 38.59, 0.53, 4697.93 $mm^2$ and 479.42 $kg/mm^2$, respectively for Surma variety and 61.09, 32.12 and 23.25 mm, 34.30, 0.56, 3815.63 $mm^2$ and 468.32 $kg/mm^2$, respectively for Prathibha variety. The co-efficient of static friction for plywood, mild steel (MS), aluminium galvanized iron (GI) and stainless steel was found to be 0.34, 0.53, 0.43, 0.42 and 0.28, respectively in Supabha variety, 0.31, 0.52, 0.41, 0.0.39 and 0.26 in Surma variety and 0.37, 0.59, 0.51, 0.48 and 0.32 and Prathiba variety, respectively. The average peak load required for crushing and cutting of turmeric crop was found to be 438.49 N and 80.69N for Suparbha variety, 402.71N and 69.28N for Surma variety and 486.58N and 97.18N for Prathibha variety, respectively.

**Key Words :** Linear dimension, Geometric mean diameter, Sphericity, Surface area, Bulk density

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## INTRODUCTION

Indian spices are known for their flavor and colour in both domestic and foreign markets. They are widely usedin medical science because of their carminative, preservative and stimulative properties. For long, the country had produced almost allthe known spices in the world. India had been gifted with some spices due to the diverse agro climatic conditionsexisting in different parts of the country provide avast scopefor growing of different variety of spices.

India is the largest producer and exporter of spices in the world and so called, the 'spice bowl' of the world. According to Bureau of Indian Standards (BIS), about 63 spices are being grown in India. India has been the principal source of supply of the major spices in the global market. Despite stringent competition in global market, Indian spices maintain its robust demand in the international market with increased exports of spices and spice products from the country. Exports of Indian spices and spice products surged to Rs. 13,167.89 crore on a

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volume of 797,145 tonnes during April-December 2017 as against 663,247 tonnes valued at Rs. 12607.46 crore in the corresponding period of 2016, registering an increase of 20 per cent in volume and 4 per cent in rupee terms (The New Indian Express, 23rd April, 2018).

The production of spice crop in India was 6.9 million tonne with an area of 3.4 million hectare (Spice board, India, 2015-16). Among the different spices crop, India is the largest producer, consumer and exporter and global leader in value added products of turmeric in the world. In India the production of turmeric crop was found to be 0.943 million tonne with an area of 0.186 million hectare (NHRDF, 2015-16). Major turmeric growing states are Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, Assam and Maharashtra.

The main issue in growing the turmeric crop is the labour. A huge labour is required in weeding, harvesting and polishing. In the design of machine for digging and processing, the knowledge of different dimensions is important so as to minimize wastage or breakage while separating, grading, peeling and cleaning. The physical properties of Turmeric Rhizome can be important for design of equipment for processing, transportation, sorting, separating and also packing. But currently these properties are equally important for designing of the digging machine for turmeric crop. This results in an increase in work efficiency and decrease in product loss. Therefore, determination and consideration of these properties have an important role in designing of turmeric digging machine. There is not enough published work relating to physical properties of Turmeric Rhizome for a digging machine. Sphericity values of most agricultural produce have been reported to range between 0.32 and 1.00 and the more regular an object is, the lower the sphericity (Mohsenin, 1970). This is important information for hopper, separation and conveying equipment design.

**Objectives of the study :**

The objective of this study is to determine the selected engineering properties of Turmeric crop; (shape, size, volume, bulk density, Sphericity, surface area, moisture,compressive and cutting strength and these properties is used for designing a digger for turmeric crop.

## MATERIAL AND METHODS

**Dimensions of turmeric rhizome:**

Twenty samples of turmeric crop was randomly chosen for measuring dimensions *viz.*, length, width and thickness of each rhizome were measured using vernier caliper (least count 0.01 cm). The observations were made to get average values of length, width and thickness of the turmeric crop.

**Bulk density:**

Bulk density of turmeric crop was evaluated by dividing the weight of turmeric on its estimated volume. In this case, the volume was measured using a density iron box. It has the dimensions of 15.5*15.5*15.5 cm where a bulk turmeric crop was put in the box, and then the box was vibrated to the cop incorporation. 20 replications were taken to measure the bulk density.

**Moisture content :**

Moisture content was determined on the basis of weight basis (w.b) to determine the moisture content of sample, the turmeric crop was cut in thin slices of 3-4 mm and weighted on electronic balance, was oven dried to a constant weight at $60\pm2^0$ C (AOAC,1999).

**Geometric mean diameter (GMD):**

The geometric mean diameter for the 20 samples was determined using the measured geometric dimensions of length (L), width (W) and thickness (T) (Mohsenin, 1986 and Bahnasawy *et al*., 2004). The equation is given below:

$$\text{Geometric mean diameter (GMD)} = (LWT)^{1/3} \quad (1)$$

Sphericity (S) is defined as the ratio of the surface area of a sphere having the same volume as the Rhizome to the surface area of the Rhizome. The shape of a food material is usually expressed in terms of its sphericity. It is an important property used in fluid flow and heat and mass transfer calculations. Sphericity was determined using the measured geometric dimensions (Eq. 2).

$$\text{Sphericity} = \frac{GMD}{L} \quad (2)$$

**Surface area:**

By using the geometric mean diameter (GMD), the surface area of turmeric crop were calculated as given in the following eq. 3.

$$\text{Surface area} = \pi GMD^2 \quad (3)$$

**Co-efficient of static friction :**

The co-efficient of static friction ($\mu_s$) of onion bulbs were determined by inclined plane method. The samples

were filled in a container of dimension 15×15×15 cm and placed on the different test surface. The test surfaces used for this study are plywood, mild steel, galvanized iron sheet, stainless steel sheet and aluminum sheet. The horizontal surface was tilted up until the samples begin to slide downward on the surface. The angle of inclination of test surface with the ground surface was measured by a protractor and consider it as an angle of internal friction. The tangent of angle was taken as co-efficient of friction between surface and sample (Ghaffari *et al*., 2013).

$$\mu_s = \tan \theta \quad (4)$$

where,

$\mu_s$ = Co-efficient of static friction; and

$\theta$ = Angle of inclination of material surface, degrees.

**Crushing and cutting resistance of turmeric:**

Crushing and cutting resistance of turmeric was considered as an important mechanical property during the digging of turmeric crop. The crushing and cutting resistance of the turmeric crop was measured by using texture analyzer (Food Corporation Technology ILC-S with a 1000 load cell. The texture analyzer is used in determining different physical properties of fruits and vegetable crops.

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

**Physical properties of turmeric crop:**

Table 1 shows the physical properties of turmeric crop of 3 varieties of which samples were used in the laboratory and evaluated for development of a digger.

**Suparbha variety sample:**

The linear dimension *viz.*, length, width and thickness range was found to be 51.00-88.20, 15.70-77.80 mm and 17.10-41.80 with the average of 68.99, 35.76 and 24.72 mm, respectively. The linear dimensions were measured at the average moisture content (w.b.) of 84%. The SD and co-efficient of variance of length, width and thickness were calculated to be 10.24, 11.49 and 5.99 and 10.84, 32.12 and 24.21 %, respectively. Similarly geometric mean diameter, sphericity, surface area and bulk density varied from 26.79-63.20 mm, 0.39-0.72, 2253.08-12540.39 $mm^2$ and 437.05-510.62 $kg/mm^2$, with the average of 37.55, 0.55, 4592.25 $mm^2$ and 476.50$kg/mm^2$, respectively. The SD and cv were found to be 7.38, 0.07, 2080.76 and 476.50 and 19.66, 13.50, 45.31 and 3.72, respectively. By using the linear dimension of turmeric crop, the spacing between the rods of the oscillating unit was determined.

**Surrma variety sample:**

The linear dimension *viz.*, length, width and thickness range was found to be 56.90-96.30, 23.90-45.00 and 17.60-34.10 mm with the average of 68.99, 35.76 and 24.72 mm, respectively. The linear dimensions were measured at the average moisture content (w.b.) of 87.59 %. The SD and co-efficient of variance of length, width and thickness were calculated to be 9.81, 5.23 and 5.03 and 13.28, 14.57 and 20.13 %, respectively. Similarly geometric mean diameter, sphericity, surface area and bulk density varied from 32.48-43.26 mm, 0.41-0.70,

**Table 1 : Physical properties of turmeric crop samples**

| Particulars | | Length, mm | Width, mm | Thickness, mm | Geometric mean diameter, mm | Sphericity | Surface area, $mm^2$ | Bulk density, $kg/m^2$ |
|---|---|---|---|---|---|---|---|---|
| Suparbha | Range | 51.00-88.20 | 15.70-77.80 | 17.10-41.80 | 26.79-63.20 | 0.39-0.72 | 2253.08-12540.39 | 437.05-510.62 |
| | Mean | 68.99 | 35.76 | 24.72 | 37.55 | 0.55 | 4592.25 | 476.50 |
| | SD | 10.24 | 11.49 | 5.99 | 7.38 | 0.07 | 2080.76 | 17.72 |
| | CV (%) | 14.84 | 32.12 | 24.21 | 19.66 | 13.50 | 45.31 | 3.72 |
| Surma | Range | 56.90-96.30 | 23.90-45.00 | 17.60-34.10 | 32.48-43.26 | 0.41-0.70 | 3312.60-5876.45 | 449.13-513.04 |
| | Mean | 73.88 | 35.91 | 24.97 | 38.59 | 0.53 | 4697.93 | 479.42 |
| | SD | 9.81 | 5.23 | 5.03 | 2.69 | 0.08 | 647.94 | 18.59 |
| | CV (%) | 13.28 | 14.57 | 20.13 | 6.96 | 15.74 | 13.79 | 3.88 |
| Prathibha | Range | 41.60-74.90 | 18.90-44.20 | 14.20-34.20 | 23.44-43.58 | 0.43-0.69 | 1725.34-5964.73 | 439.19-497.20 |
| | Mean | 61.09 | 32.12 | 23.25 | 34.30 | 0.56 | 3815.63 | 468.32 |
| | SD | 9.30 | 7.68 | 5.53 | 6.35 | 0.06 | 1340.72 | 13.66 |
| | CV (%) | 15.23 | 23.92 | 23.78 | 18.53 | 10.75 | 35.14 | 2.92 |

**Table 2 : Co-efficient of static friction at different surfaces**

| Variety | Co-efficient of static friction | | | | |
|---|---|---|---|---|---|
| | Plywood | MS Sheet | Aluminium | GI Sheet | Stainless steel |
| Suparbha | 0.34 | 0.53 | 0.43 | 0.42 | 0.28 |
| Surma | 0.31 | 0.52 | 0.41 | 0.39 | 0.26 |
| Prathibha | 0.37 | 0.59 | 0.51 | 0.48 | 0.32 |

3312.60-5876.45 $mm^2$ and 449.13-513.04 $kg/mm^2$, with the average of 38.59, 0.53, 4697.93 $mm^2$ and 479.42 $kg/mm^2$, respectively. The SD and cv of geometric mean diameter, sphericity, surface area and bulk density were found to be 2.69, 0.08, 647.94 and 18.59 and 6.96, 15.74, 13.79 and 3.88, respectively.

**Prathibha variety samples:**

The linear dimension *viz.*, length, width and thickness range was found to be 41.60-74.90, 18.90-44.20 and 14.20-34.20 mm with the average of 61.09, 32.12 and 23.25 mm, respectively. The linear dimensions were measured at the average moisture content (w.b.) of 82 %. The SD and co-efficient of variance of length, width and thickness were calculated to be 9.30, 7.68 and 5.53 and 15.23, 23.92 and 23.78 %, respectively. Similarly geometric mean diameter, sphericity, surface area and bulk density varied from 23.44-43.58, 0.43-0.69, 1725.34-5964.73 mm and 439.19-497.20$kg/mm^2$, with the average of 34.30, 0.56, 3815.63 $mm^2$ and 468.32 $kg/mm^2$, respectively. The SD and cv of geometric mean diameter, sphericity, surface area and bulk density were found to be 6.35, 0.06, 1340.72 and 13.66 and 18.53, 10.75, 35.14 and 2.92, respectively.

**Co-efficient of static friction** :

Among the frictional properties, the co-efficient of friction varied for different surfaces. Table 2 shows the coefficient of static friction of different surfaces. The coefficient of static friction for plywood, mild steel (MS), aluminium galvanized iron (GI) and stainless steel was found to be 0.34, 0.53, 0.43, 0.42 and 0.28, respectively in Supabha variety. Similarly The co-efficient of static friction for plywood, mild steel (MS), aluminium galvanized iron (GI) and stainless steel was found to be 0.31, 0.52, 0.41, 0.0.39 and 0.26 and 0.37, 0.59, 0.51, 0.48 and 0.32 in Surma and Prathiba variety, respectively.

**Crushing and cutting resistance:**

The average peak load required for crushing and cutting of turmeric crop was found to be 438.49 N and 80.69N for Suparbha variety, 402.71N and 69.28N for Surma variety and 486.58N and 97.18N for Prathibha variety, respectively.

## REFERENCES

AOAC (1999). Official Methods of Analysis of the Association of Official Analytical Chemists Washington D.C. pp. 211.

**Bahnasawy, A.H., EI-Haddad, Z.A., EI-Ansary, M.Y. and Sorour, H.M. (2004).** Physical and mechanical properties of some Egyptian onion cultivars. *J. Food Engg.*, **62**: 255-261.

**Ghaffari, H., Marghoub, N., Sheikhdarabadi, M.S., Hakimi, A. and Abbasi, F. (2013).** Physical properties of three Iranian onion varieties. *Internat. Res. J. Appl. Basic Sci.*, **7**(9): 587-593.

**Krishandas, M.** Indian Spice Economy -An Analytical Approach to the Production and Export Performance LAP Lambert Academic Publishing, 112.

**Mohsenin, N.N. (1970).** Physical properties and Animal Materials. Gordon and Breach Science Publishers. New York.

**Mohsenin, N.N. (1986).** Physical properties of plant and animal materials. Second revised. Gordon and Breach Sci. Publ., New York.

**Olaoye, J.O. (2000).** Some physical properties of castor nut relevant to the design of processing equipment. *J. Agric. Engg. Res.*, **77**(1) : 113-118.