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Comparative study on engineering properties of the selected turmeric varieties (Prathibha & Erode local)

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Abstract
Engineering properties of turmeric were determined *viz.*, axial dimensions (length, width and thickness), mean diameter, volume, surface area, bulk density, true density, and porosity for two varieties namely Prathibha and Erode local for both primary and secondary rhizomes. It is important to study the engineering properties to design variety of equipment for harvesting, processing, post-harvest handling, transportation, separation and packaging. Statistical analysis was performed to compare the differences between the two varieties of turmeric.

Keywords: Turmeric, engineering properties, curcuma, frictional properties, angle of repose, coefficient of friction

1. Introduction
Curcuma, the most important genus in the family *Zingiberaceae*, accounts for about 110 species, found in tropical Asia and the Asia–Pacific region. Amongst different species of *Curcuma longa* is the most recognized species, commercially known as turmeric. India is the largest producer, consumer and exporter of turmeric (Kanungo 2015) [15]. Turmeric is cultivated in almost all states in India; the main regions are Andhra Pradesh, Maharashtra, Orissa, Tamilnadu, Karnataka, and Kerala. Known as the Indian saffron, turmeric is rich in curcumin content and regarded as the best in the world both in terms of colour and curcumin content. The major antioxidative components found in turmeric are Curcumin, demethoxy curcumin and bis-demetoxy curcumin (Venkatesan *et al.*, 2000) [25]. Apart from antioxidant property, turmeric has been traditionally used for its anti-inflammatory (Lestari *et al.*, 2014) [17], antimutagenic, antimicrobial (Reddy *et al.*, 2005, Mahady *et al.*, 2002) [22, 18], and anticancer (Vera-Ramirez *et al.*, 2013, E-Wright *et al.*, 2013) [26, 9] properties. Hence, the demand for the good quality turmeric has increased in the recent years. The initial quality of the turmeric rhizomes and various post harvesting processes affects the end quality of turmeric products (Arora *et al.*, 2007) [2]. Physical properties of the turmeric rhizomes are important to design and fabricate processing equipment (Balasubramanian *et al.*, 2012) [5]. Studies with extensive literature review revealed the lack of information on the physical properties of turmeric rhizomes. Hence, an effort was made to study the physical properties of the turmeric rhizomes in terms of length, width, thickness, aspect ratio, arithmetic mean diameter, geometric mean diameter, square mean diameter, equivalent diameter, surface area, volume, sphericity, bulk density, true density, porosity, angle of repose and coefficient of friction.

2. Materials and Methods
Turmeric rhizome varieties - Prathibha and Erode Local were procured from Thalamalai, Erode district, Tamilnadu after three days of harvest. The dirt adhering to the rhizomes and the foreign materials were cleaned using clean water prior to experimentation. The rhizomes were stored at 6º C in a cold chamber using a plastic bag until all the experiments were conducted (Poornima *et al.*, 2019) [20].

2.1 Moisture content
Dean and Stark distillation method was used to determine the moisture content of the turmeric. The percentage moisture content was calculated by the following formula. (Ref: - A.O.A.C 17th edn 2000 Official Method 986.21, Moisture in Spices / I.S Specification No I.S 1797 – 1985 Methods of Test for Spices and Condiments).

$$Moisture\ content\ \%\ (w.b.) = \frac{V_w}{M}\ x\ 100$$

Where,
V_w = Volume of water collected, ml
M = Mass of turmeric, g

2.2 Physical properties
2.2.1 Size
The size of the primary, secondary and tertiary rhizomes was determined in terms of length (l), width (a) and thickness (b) using a Vernier caliper having a least count of 0.1 mm. Turmeric rhizomes were randomly collected in three batches weighing 1 kg. These batches were mixed and 25 rhizomes were selected randomly to determine the size. The dimensions of primary and secondary fingers were measured, and tertiary development in 5 % of rhizomes were ignored (Mohsenin 1986) [19].

With the measured l, a, and b values the geometric mean, arithmetic mean, square mean, and equivalent diameter were calculated by the following formulae.

$$\text{Geometric mean diameter (GMD)} = \sqrt[3]{lab}$$

$$\text{Arithmatic mean diameter (AMD)} = \frac{l+a+b}{3}$$

$$\text{Square mean diamter(SMD)} = \sqrt{la+ab+bl}$$

$$\text{Equivalent diamter(EQD)} = \frac{AMD+GMD+SMD}{3}$$

2.2.2 Surface Area and Volume
The surface area and volume of turmeric rhizomes were calculated by the relationship given below (Jain *et al.*, 1997) [12].

$$S = \frac{\pi B l^2}{2l - B}$$

Where,

$$B = \sqrt{ab}$$
$$V = 0.25\,[\left(\frac{\pi}{6}\right) l\,(a+b)^2]$$

2.2.3 Sphericity
The shape of a food material is expressed in terms of its sphericity. Sphericity (S) for turmeric 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. Sphericity was calculated by the formula given below (Mohsenin, 1986) [19].

$$S = \frac{\sqrt[3]{lab}}{l}$$

Where,
S - Sphericity, decimal
L, a and b - length, breadth and thickness, mm

2.2.4 Aspect ratio
Aspect ratio (R) of the turmeric rhizome was determined using the following relationship (Dhineshkumar *et al.*, 2016a) [7].

$$\text{Aspect ratio (R)} = \frac{W}{L} x100$$

Where,
W = intermediate diameter (mm),
L = major diameter with calyx (mm)

2.2.5 Bulk density
Bulk density was calculated from the ratio between mass and volume of the turmeric rhizome. It was measured by filling the turmeric rhizomes in a container of known volume and determining the weight of container. Bulk density was calculated using the formula given below (Baryeh 2001) [6].

$$Bulk\ density, (\rho_b) = \frac{mass}{volume} = \frac{m}{v}$$

Where,

$$\rho_b = Buk\ density\ \text{kg}/m^3$$

m= mass, kg
v= volume, m^3

2.2.6 True density
The true density of turmeric rhizomes was measured by platform scale method (Mohsenin, 1986) [19]. Turmeric samples were measured in the air on the electronic weighing balance of accuracy ± 0.01 g. The weighed samples were immersed in a container filled with water. From the mass of the displaced water, the true volume was determined using the following formula,

$$True\ volume, (m^3) = \frac{Mass\ of\ displaced\ water, (kg)}{Density\ of\ water, (kg\ m^{-3})}$$

From the true volume and the mass of the turmeric rhizomes on the air, true density was calculated using the following formula,

$$\rho_t = \frac{w_a}{v_t}$$

Where,
ρ_t- True density of turmeric rhizomes, kg/m^3
w_a- Mass of turmeric rhizomes in air, kg
v_t- True volume of turmeric rhizomes, m^3

2.2.7 Porosity
The porosity of turmeric rhizomes were calculated using bulk density and true density of rhizomes and the values were expressed in percentage (Kaleemullah *et al.*, 2003) [14].

$$\varepsilon = 1 - \left(\frac{\rho_b}{\rho_t}\right) x\ 100$$

Where,
ε – Porosity, %
ρ_b – Bulk density, kg /m^3
ρ_t– True density, kg /m^3

2.2.8 Coefficient of friction
Coefficient of friction is the ratio of force needed to start sliding the turmeric sample over a test surface by the weight of the sample. The apparatus used for determining the coefficient of friction is similar to the apparatus reported by Kaleemullah *et al.*, (2003) [14]. The experimental set up consist of a bottomless cylindrical container measuring 94 mm in

diameter and 98 mm in height, a frictionless pulley fitted on a frame, loading pan, and test surfaces of 4 types *viz*., plywood, stainless steel sheet, mild steel sheet, and rubber surface. A known quantity of turmeric sample was filled inside the bottomless cylindrical container and weights were added to the loading pan until the container started to move.

The co-efficient of static friction (μ) was calculated as the ratio of frictional force (F) to the normal force (Nf) as,

$$\mu = \frac{F}{N_f}$$

2.2.9 Angle of repose

Angle of repose indicates the cohesion amongst the individual units of the materials. The angle of repose is determined by the angle made by turmeric with the horizontal surface when piled from a known height. One bag of about 25 kg of turmeric rhizomes was piled over a horizontal surface to makeup a heap in form of an inverted cone. The radius of the pile was calculated from the circumference and slant height of pile (Sreenarayanan *et al.*, 1985) [23].

$$\theta = tan^{-1}(\frac{2H}{D})$$

Where,
θ = Angle of repose (º degree),
H= Height of the heap, mm
D = Diameter of the pile, mm

3. Results and Discussion

3.1 Geometric properties

Geometric properties such as length, width, thickness, aspect ratio, arithmetic mean diameter, geometric mean diameter, square mean diameter, equivalent diameter, surface area and volume, of turmeric rhizome variety Prathibha at a moisture content of 83% (w.b.) and Erode Local at a moisture content of 74% (w.b.) were given in Table.1

Among the two varieties, the geometric properties of Variety 1 Prathibha were higher compared to Variety 2 Erode local by 19.15 % in length, 27.78 % in width, and 36.33 % in thickness. The average length of turmeric values reported in previous studies was 25 to 75 mm (Ravindran *et al.*, 2007) [21]. Higher the length, width and thickness of the primary and secondary rhizome, higher the arithmetic mean diameter, geometric mean diameter, square mean diameter, equivalent diameter, surface area, and volume (Balasubramanian *et al.*, 2012) [5]. However, there was no similar trend observed in geometric properties of the two varieties. Similar observation was made by Dhineshkumar *et al.*, (2016b) [8]. The aspect ratio and sphericity of turmeric rhizomes showed an alternative trend compared with other geometric properties i.e. when length increases aspect ratio and sphericity decreases. This trend is the result of irregular shapes of the turmeric rhizomes. A linear relationship between volume and surface area with varietal size was observed with reference to Balasubramanian *et al.*, (2012) [5].

3.2 Gravimetric properties

Gravimetric properties such as bulk density, true density and porosity of turmeric rhizome was given in Table.2. The moisture content of the turmeric rhizome variety Prathibha and Erode Local were 83 % (w.b.) and 74 % (w.b.) Subramanian *et al.* (2007) [24] reported a decreasing behavior in bulk density of minor millets with higher moisture content. Due to varietal difference between the two turmeric varieties, there is no such trend in moisture content to bulk density was observed. Volume of the rhizome samples was found to be higher when moisture content was higher. The similar trend was observed by Konak *et al.* (2002) [16] for chickpea seeds, Irtwange *et al.*, (2002) [10] for African yam bean and Ajav *et al.* (2014) [1] for ginger rhizomes. True density was found to be lower for the turmeric variety, which is high in moisture content. Poornima *et al.* (2019) [20] reported that moisture content and true density has an inverse proportionality. Same trend was observed by Kaleemullah *et al.* (2002) [13] for arecanut kernels, Isik (2007) [11] for round red lentil grains. Porosity of the turmeric samples was increased with increased moisture content (Balakrishnan *et al.*, 2020) [4]. True density is inversely proportional to porosity. However, maximum porosity of 60.15 % was recorded in Erode local variety with true density of 1035.6 kg/ m^3. This variation is due to the dimensional differences in geometric properties of the two turmeric varieties.

3.3 Frictional properties

Frictional properties such as angle of repose (º) and coefficient of friction were given in Table 3. Both varieties of turmeric rhizomes exhibited similar angle of repose 39.71 º for Prathibha and 39.14 º for Erode local. From the table it was clear that, stainless steel recorded minimum coefficient of friction and mild steel recorded maximum coefficient of friction in both the varieties. The coefficient of friction recorded with mild steel surface were 0.72 for the variety Prathibha and 0.75 for the variety Erode local.

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5. Conclusion

Physical properties of turmeric rhizomes such as axial dimensions (length, width and thickness), mean diameter, sphericity, volume, surface area, bulk density, true density and porosity for the two varieties namely Prathibha and Erode local were determined. These data will facilitate designing of equipment's for post-harvest processing and handling. The physical properties of any food materials and its derived products are very essential for designing and development of process machineries such as feed hoppers, storage structure, material handling and packaging equipment.

Table 1: Geometric properties of turmeric rhizomes

Dimension	Variety I Prathibha		Variety II Erode Local	
	Primary finger	Secondary finger	Primary finger	Secondary finger
Length (mm)	98.40 ± 16.59	54.80 ± 11.42	79.56 ± 3.10	39.32 ± 2.10
Width (mm)	26.38 ± 3.00	19.47 ± 2.75	19.05± 3.05	10.94 ± 2.10
Thickness (mm)	25.65 ± 3.50	18.53 ± 2.41	16.33 ± 2.35	8.76 ± 1.28
Aspect ratio	0.27 ± 0.06	0.36 ± 0.06	2.31 ± 0.03	0.29 ± 0.07
Arithmetic mean diameter (mm)	50.14 ± 5.51	30.94 ± 5.042	38.32 ±1.8	20.3 ±0.75
Geometric mean diameter (mm)	40.26 ± 3.31	26.96 ± 3.82	25.37 ± 2.7	16.35 ±1.35
Square mean diameter (mm)	75.79 ± 6.59	49.33 ± 7.32	52.45 ±4.18	29.66 ±1.9
Equivalent diameter (mm)	55.40 ± 4.98	35.74 ± 5.38	38.25 ± 3.4	22.73 ±1.34
Surface area (mm^2)	4619.21 ± 792.69	1150.70 ± 503.25	2272.25 ±369.82	645.543 ± 87.25
Volume (mm^3)	35014.14± 8753.23	10893.20± 4827.98	11579.7± 2986.17	1942.910± 468.82
Sphericity	0.41 ± 0.06	0.50 ± 0.05	0.35 ± 0.37	0.45 ± 0.03

Values indicate after ± indicates standard deviation

Table 2: Gravimetric properties of turmeric rhizome

Properties	Variety I Prathibha	Variety II Erode Local
Bulk density (kg/m^3)	456.02 ± 12.23	411.85 ±15.449
True density (kg/m^3)	1010.21 ± 52.70	1035.6 ± 48.71
Porosity (%)	54.72 ± 3.05	60.15 ±2.31

Values indicate after ± indicates standard deviation

Table 3: Frictional property of turmeric rhizome

Properties	Variety I Prathibha	Variety II Erode Local
Angle of Repose (°)	39.71 ± 1.25	39.14 ±1.16
Coefficient of friction		
Stainless steel	0.53 ± 0.01	0.53± 0.01
Aluminium	0.57 ± 0.01	0.66 ±0.02
Galvanized iron	0.58 ± 0.01	0.73 ±0.02
Mild Steel	0.72 ± 0.01	0.75 ±0.02

Values indicate after ± indicates standard deviation

5. References

1. Ajav E, Ogunlade C. Physical properties of ginger *(Zingiber officinale)*: Global Journal of Science Frontier Research: D. Agriculture and Veterinary 2014;14(8).
2. Arora M, Sehgal V, Sharma S. Quality evaluation of mechanically washed and polished turmeric rhizomes. Journal of Agricultural Engineering 2007;44(2):39-43.
3. Athmaselvi K, Varadharaju N. Physical and thermal properties of turmeric rhizomes. Madras Agricultural Journal 2002;89(10/12):666-671.
4. Balakrishnan M, Jeevarathinam G, Aiswariya S. Physical, frictional and thermal properties of turmeric rhizomes. International Journal of Chemical Studies 2020;8(4):2268-2271. Doi: 10.22271/chemi.2020.v8.i4y.9968.
5. Balasubramanian S, Mohite A, Zachariah KSTJ, Anand T. Physical properties of turmeric (*Curcuma longa* L.). Journal of Spices and Aromatic Crops 2012;21(2):178-181.
6. Baryeh EA. Physical properties of bambara groundnuts. Journal of Food Engineering 2001;47(4):321-326.
7. Dhineshkumar V, Anandakumar S. Physical and engineering properties of turmeric rhizome. South Asian Journal of Food Technology and Environment 2016a;2(1):304-308.
8. Dhineshkumar V, Anandakumar S. Physical and engineering properties of turmeric rhizome. Journal of Food Research and Technology 2016b;4(1):30-34.
9. Wright EL, Frye JB, Gorti B, Timmermann BN, Funk JL. Bioactivity of turmeric-derived curcuminoids and related metabolites in breast cancer. Current pharmaceutical design 2013;19(34):6218-6225.
10. Irtwange S, Igbeka J. Some physical properties of two African yam bean (Sphenostylis stenocarpa) accessions and their interrelations with moisture content. Applied Engineering in Agriculture 2002;18(5):567.
11. Isik E. Some physical and mechanical properties of round red lentil grains. Applied Engineering in Agriculture 2007;23(4):503-509.
12. Jain R, Bal S. Properties of pearl millet. Journal of agricultural engineering research 1997;66(2):85-91.
13. Kaleemullah S, Gunasekar JJ. PH-Postharvest Technology: Moisture-dependent Physical Properties of Arecanut Kernels. Biosystems Engineering. 2002;82(3):331-338.
14. Kaleemullah S, Kailappan R. Geometric and morphometric properties of chillies. International Journal of Food Properties 2003;6(3):481-498.
15. Kanungo S. Influence of Market Arrival on Price Formation of Turmeric in Kandhamal District of Odisha. IOSR Journal of Business and Management 2015;17(1):01-05.
16. Konak M, Carman K, Aydin C. PH-Postharvest Technology: Physical properties of chick pea seeds. Biosystems Engineering. 2002;82(1):73-78.
17. Lestari M, Indrayanto G. Curcuim. Profiles Drug Subst. Excip. Relat. Methodol 2014;39:113-204. Doi: 10.1016. B978-0-12-800173-8.00003-9.
18. Mahady G, Pendland S, Yun G, Lu Z. Turmeric (*Curcuma longa*) and curcumin inhibit the growth of Helicobacter pylori, a group 1 carcinogen. Anticancer research 2002;22(6C):4179-4181.
19. Mohsenin NN. Physical properties of plant and animal materials 1986.
20. Poornima D, Ganapathy S, Surendrakumar A. Comparision of physical properties of turmeric rhizomes at fresh, boiled and dried conditions. Journal of Pharmacognosy and Phytochemistry 2019;8(6):44-48.
21. Ravindran P, Babu KN, Sivaraman K. Turmeric: the genus Curcuma: CRC press 2007.
22. Reddy RC, Vatsala PG, Keshamouni VG, Padmanaban G, Rangarajan PN. Curcumin for malaria therapy. Biochemical and biophysical research communications 2005;326(2):472-474.
23. Sreenarayanan V, Subramanian V, Visvanathan R. Physical and thermal properties of soybean. Proceedings of Indian Society of Agricultural Engineers 1985;3(2):161-169.
24. Subramanian S, Viswanathan R. Bulk density and friction coefficients of selected minor millet grains and flours. Journal of Food Engineering 2007;81(1):118-126.
25. Venkatesan P, Rao M. Structure-activity relationships for the inhibition of lipid peroxidation and the scavenging of free radicals by synthetic symmetrical curcumin analogues. Journal of Pharmacy and Pharmacology 2000;52(9):1123-1128.
26. Vera-Ramirez L, Pérez-Lopez P, Varela-Lopez A, Ramirez-Tortosa M, Battino M, Quiles JL. Curcumin and liver disease. *Biofactors* 2013;39(1):88-100.