*Biological Forum – An International Journal* **14(4): 387-393(2022)**

**ISSN No. (Print): 0975-1130**
**ISSN No. (Online): 2249-3239**

# Studies on some Physical and Engineering properties of Finger Millet for Designing Thresher

***Kishan Kumar Patel[1*], R.K. Naik[2], Geeta Patel[1] and Shubham Pandey[1]***

*[1]Ph.D. Scholar, Department of FMPE, SVCAET and RS, IGKV, Raipur (Chhattisgarh) India.*
*[2]Professor, Department of FMPE, SVCAET and RS, IGKV, Raipur (Chhattisgarh) India.*

*(Corresponding author: Geeta Patel*)*

*(Received 16 August 2022, Accepted 07 October, 2022)*
*(Published by Research Trend, Website: www.researchtrend.net)*

**ABSTRACT: Finger millet also known as *Ragi* is an important staple food for the tribal region of Chhattisgarh. The knowledge of physical and engineering properties of the finger millet grains were important while designing of different agriculture machines. Present study was conducted to determine some of the physical and engineering properties of some finger millet grains varieties for designing of different components of finger millet thresher. The properties such as GMD, sphericity, volume, surface area, 1000 grain weight, bulk density, true density, porosity, coefficient of friction, angle of repose and terminal velocity were determined in the moisture range of 7 to 25 per cent db for three varieties of finger millet grain namely *Indira Ragi* 1, Chhattisgarh 2 and GPU 28. The result showed that GMD, sphericity, volume, surface area 1000 grain weight, coefficient of friction, angle of repose and terminal velocity increased with increase in moisture content for all the varieties. The values for these properties ranged between 1.33 to 1.52 mm, 0.92 to 0.94, 1.12 to 1.68 mm$^3$, 5.62 to 7.26 mm$^2$, 2.26 to 2.74 g, 0.39 to 0.43, 20.72 to 29.97 $^o$ and 4.15 to 5.93 m/s, respectively. The bulk density, true density and porosity of grains decreased with increase in moisture content for all three varieties. The values ranged between 755.67 to 676.45 kg/m$^{3,}$ 1510.96 to 1000.71 kg/m$^3$ and 49.99 to 32.40 per cent, respectively.**

**Keywords:** Engineering properties, moisture content, finger millet, physical properties, sphericity.

## INTRODUCTION

Finger millet (*Eleusine coracona* L.) is also known as *Ragi.* It has numerous nutrients and vitamins and can tolerate adverse environmental conditions like tolerance to moisture stress, resistance to water logging (Panda *et al*. 2021). It is grown on over 40 lakh ha worldwide with total production of 4.5 million tonnes. It is a primary food for millions in dry lands of East and Central Africa, and Southern India. In India, after pearl millet and sorghum, finger millet is the third most important millet in the country in terms of area (10.05 lakh hectares) and production (17.6 lakh tons) (Anonymous, 2019). Whereas in Chhattisgarh, finger millet is grown on area of 0.06 lakh hectares with the production of 0.02 lakh tons and the average productivity of finger millet crop in the state was 253 kg/ha in the year 2019-20 (Anonymous, 2019). The major finger millet growing districts are Baster, Nararayanpur, Bijapur, Sarguja, Rajnandgaon etc. Finger millets are a major food source for the tribal people of Chhattisgarh's Bastar area. After rice, the most significant minor grains among Bastar tribes are Kodo millet (*Paspalum scrobiculatum* L.) and finger millet *(Eleusine coracana*). The popularity of finger millet comes in part from its high nutritional and medicinal value, such as high fibre content (allowing for slow digestion), which is very popular in diabetic patients, calcium richness, which strengthens the bone, is good for treating anemia, and has anti-aging properties that help to reverse skin ageing (Pradhan *et al.,* 2010; Shobana *et al.,* 2011; Gull *et al.,* 2016; Ushakumari 2009). Earlier various researchers have determined the physical and engineering properties of different cultivars of the finger millet and other different crops like pearl millet (Panda *et al*. 2021, Pawase *et al.,* 2021), Indira Kodo millet (Kumar *et al.,* 2016), finger millet (Powar *et al.,* 2018; Swami and Swami, 2010; Ramashia *et al.,* 2017; Sial *et al.,* 2019) for finger millet grains, maize grains (Netam *et al*., 2021; Dange *et al*., 2021); Damian (2014) for mustard seeds. Patel *et al*., (2021) for linseed, foxtail millet (Sunil *et al*., 2016). The determination of physical and engineering properties of finger millet variety such as Indira Ragi 1, CG Ragi 2 and GPU-28 were not determined which are prominant varieties grown in the Chhattisgarh state. So, in this research paper an attempt has been made to study the physical and engineering properties of the finger millet cultivars in relation with different moisture content for the development of finger millet thresher.

## MATERIALS AND METHODS

The determination of physical and engineering property of finger millet grain as well as finger millet panicles is important for the designing of different components of the machine. The popular varieties of finger millet (*Indira Ragi*-1, Chhattishgarh-1 and GPU 28) were collected from SGCARS, Jagdalpur, Bastar and KVK, Kanker. These varieties are prominently cultivated by farmers of Chhattisgarh in recent years. The selected varieties were used to determine the physical properties.

**A. General properties of finger millet panicles.** The general properties of finger millet panicles were evaluated at the stage of maturity of crop. The general description of matured finger millet panicles is shown at Fig. 1 (Anonymous, 2010). The different general properties of randomly selected 20 matured finger millet panicles such as moisture content, finger length, earhead length, peduncle length, thumb finger, number of finger per earhead, weight, crop grain ratio, and grain straw ratio were measured.

**Moisture content of finger millet panicles.** The standard hot air oven method was used to assess the initial moisture content of finger millet ear head. Three samples weighing 50 g each were dried for 24 hours at 105± 1°C. The moisture content was calculated using Equation 1.

$$MC_{db} = \frac{W_i - W_f}{W_f} \qquad (1)$$

Where,

$MC_{db}$ = Moisture content (db), %; $W_i$= Initial weight of sample, g; and $W_f$ = Final weight of sample, g.

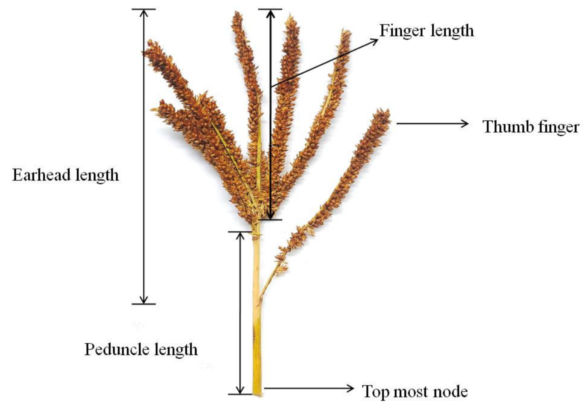


**Fig. 1.** General description of the matured finger millet panicle.

**Finger length** It is defined as the vertical distance between the base of the longest finger to its tip (Fig. 1). The earhead length was distance between longest finger to the base of thumb finger they were measured with the help of a thread and stainless scale.

**Peduncle length** was measured as base of the longest finger to top most node. The total numbers of fingers per earhead of finger millet crop is termed as the number of finger per earhead. It was determined by counting the total fingers per earhead.

**Crop grain ratio and Grain straw ratio.** The following formula was used to determine the crop grain ratio and Grain straw ratio

$$R_{CG} = \frac{W_C}{W_G} \qquad (2)$$

$$R_{GS} = \frac{W_G}{W_C - W_G} \qquad (3)$$

Where,

$R_{CG}$ = Crop grain ratio; $W_C$ = Total weight of the panicles, kg; and $W_G$ = Total weight of the grains, kg. $R_{CG}$ = Grain straw ratio;

**B. Physical properties of finger millet grain**

**Moisture content.** The initial moisture content of seed was determined by using the standard hot air oven method using following formula (AACC, 1995).

$$MC(\%) = \frac{W_2 - W_1}{W_3 - W_1} \times 100 \qquad (4)$$

Where,

MC= Moisture content on dry basis, %; $W_1$= Initial weight of the bowl, g; $W_2$ = sample weight before drying +bowl weight, g; and $W_3$ = sample weight after drying + bowl weight, g.

The desired moisture level of seed samples were obtained by adding or removing the distilled water from sample. The amount of water to be added or removed was calculated by using the following Equation. (Sacilink *et al.,* 2003)

$$Q = W_i \times \frac{M_f - M_i}{100 - M_f} \qquad (5)$$

Where,

Q = Weight of water to be added, g; $W_i$ = Initial weight of seed sample, g; $M_i$ = Initial moisture content of seed sample, % db; and $M_f$= Final moisture content of seed sample, % db.

It was conditioned in the refrigerator (5°C) for one week to disperse the added water evenly throughout the samples (Garnayak, *et al.,* 2008). Before beginning the test, the required number of samples were taken from the refrigerator and allowed to warm at room temperature for around 2 hours (Singh *et al.*, 2010).

**Geometric mean diameter, Surface area and Volume.** Linear dimensions (length, width, and thickness) were measured to determine the shape and size of finger millet grain. The linear dimensions of randomly selected seed of each variety were measured by using digital micrometer having least count of 0.01 mm and its average was recorded. The calculation of GMD, sphericity, surface area and volume were done by using following formula (Mohsenin, 1986).

$$GMD = (LWT)^{\frac{1}{3}} \quad (6)$$

$$\Phi = \frac{(LWT)^{\frac{1}{3}}}{L} \quad (7)$$

$$A_s = \pi(GMD)^2 \quad (8)$$

$$V = \frac{\pi B^2 L^2}{6(2L - B)} \quad (9)$$

Where,

L = Length of seed, mm; W = Width of seed, mm; and T = Thickness of seed, mm. $A_s$ = Surface area, $mm^2$; and GMD = Geometric mean diameter, mm. V = Volume, $mm^3$; B= $(WT)^{0.5}$;

**Thousand grain weight.** The procedure described in IS: 4333 (Part IV-1986) was adopted. Average of ten replications have been considered and reported as a 1000 grain weight of sample.

**Bulk density.** The bulk density of each variety of finger millet was measured by using standard test weight process. Bulk density was then calculated as the ratio between the grain weight and the volume of the cylinder using following formula (Akaaimo and Raji 2006; Mwithiga and Sifuna 2006,).

$$\rho_b = \frac{W_s}{V_s} \quad (10)$$

Where,

$\rho_b$ = Bulk density in $kg/m^3$;$W_s$=Weight of the sample in kg; and $V_s$ =Volume occupied by the sample, $m^3$.

**True density**

The true density was determined using the toluene ($C_7H_8$) displacement method. (Sacilik *et al.*, 2003; Garnayak *et al.*, 2008).

$$\rho_t = \frac{W_s}{V_t} \quad (11)$$

Where,

$\rho_t$ = True density, $kg/m^3$;$W_s$= Weight of seed, kg; and $V_t$= Volume of toluene displaced, $m^3$.

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad (12)$$

Where,

ε = Porosity; $\rho_t$ = True density, $kg/m^3$; and $\rho_b$ = Bulk density, $kg/m^3$.

**Coefficient of static friction.** Coefficient of static friction of finger millet grain was determined with respect to three surfaces: mild steel, stainless steel, and galvanized iron. The apparatus for measuring coefficient of static friction consists of a bottomless open container with a horizontal plane. The container was filled with known weight of finger millet grain and lifted gradually. When the container began to slide across the chosen surface the angle shown on the apparatus scale was recorded and the static coefficient of friction was computed using the Equation proposed by Sahay and Singh (1994).

$$\mu = \tan\alpha \quad (13)$$

Where,

μ = Coefficient of friction; and α = Tilt angle, degrees.

**Terminal velocity.** The terminal velocities of finger millet at different moisture contents were determined by an air column device A specimen was placed into an air stream from the top of the air column for each experiment. The airflow rate was then steadily increased until the seed became suspended in the air stream. A digital anemometer was used to measure the air velocity that kept the seed in suspension. (Gupta *et al.* 2007 and Sacilink *et al.* 2003).

**Angle of repose.** The angle of repose is the angle with horizontal at which the material will stand when piled. The angle of repose measuring equipment consisted of a funnel with a conical shape and a sliding and detachable opening on one end. It was determined using the formula below. The angle of repose of finger millet was used in the determination of the angle at which the reciprocating sieve of the thresher will be slanted so it has free flow of the seed at the outlet.

$$\Phi = \tan^{-1}\left(\frac{2H}{D}\right) \quad (14)$$

Where,

Φ = Angle of repose, degree; H = Height of the cone, cm; and D = Diameter of cone, cm.

## RESULT AND DISCUSSIONS

**Some general properties of finger millet crop panicles.** The properties relevant to design of the prototype, the finger millet variety *Indira Ragi*-1 panicles at moisture content of 16 % (db) were measured. The result showed that the finger length ranged between 72 to 110 mm. Similarly, the earhead length and peduncle length varied between 95-133 mm and 50-120 mm respectively. The numbers of fingers per earhead and weight of panicles was observed to be varied between 6-13 and 19-56 g, respectively.

The crop grain ratio, grain straw ratio and bulk density of the finger millet crop panicles were found that crop grain ratio varied between 1.39 to 1.61 grain straw ratios was found to be varied from 1.63 to 2.57 and. The bulk density of panicles was found to be ranged between 225 to 265 $kg/m^3$, respectively.

**Length of finger, ear head, peduncle, Number of finger per ear head, weight of panicles, crop grain ratio, grain straw ratio and bulk density of finger millet crop.**

| Particulars | Finger length, mm | Earhead length, mm | Peduncle length, mm | No. of fingers per earhead | Weight of panicles, g | Crop grain ratio | Grain straw ratio | Bulk Density, $kg/m^3$ |
|---|---|---|---|---|---|---|---|---|
| Range | 72-110 | 95-133 | 50-120 | 6-13 | 19-56 | 1.39-1.61 | 1.63-2.57 | 225-265 |
| Mean | 88.35 | 118.45 | 84.85 | 7.80 | 32.45 | 1.49 | 2.10 | 248.14 |
| SD | 8.55 | 11.34 | 19.67 | 1.54 | 9.28 | 0.10 | 0.40 | 17.81 |
| CV | 9.68 | 9.58 | 23.18 | 19.77 | 28.59 | 6.68 | 18.86 | 7.18 |

**2. Physical and engineering properties of finger millet grain.** The physical and engineering properties of the finger millet grain of three varieties namely *Indira Ragi* 1, Chhattisgarh 2 and GPU 28 were determined at five levels of moisture content (7, 10, 15, 20, and 25 %, db) with three replications. The study was conducted in post harvest laboratory, Department of Agricultural Processing and Food Engineering. The detail data were analysed statistically by CRD (Completely Randomised Design).

**Effect of variety and moisture on the geometric mean diameter, surface area, terminal velocity,**

**angle of repose, true density and bulk density of the finger millet grain.** The effect of different widely cultivated varieties *viz.* (*Indira Ragi* 1, Chhattisgarh 2 and GPU 28) and moisture contents (7, 10, 15, 20 and 25 per cent db) on the geometric mean diameter of the finger millet grain were recorded. It was observed that the varietal difference in geometric mean diameter of the finger millet grain was non significant whereas, there is significant difference in case of moisture content. However, the highest geometric mean diameter of 1.52 mm was observed at moisture level of 25 per cent while the lowest geometric mean diameter of 1.34 mm was observed at low moisture level of 7 per cent. It was observed that the GMD of the finger millet grain increased with increase in moisture content in polynomial trend Fig. 2. It may be due to moisture absorption of seeds and increase in length, width and thickness due to increase of moisture. The results are in agreements with the findings of Swami and Swami (2010); Ramashia *et al.* (2017) for finger millet grains

However, the highest surface area of 7.26 $mm^2$ was observed at moisture level of 25 per cent while the lowest surface area of 5.623 $mm^2$ was observed at low moisture level of 7 per cent. The interactive effect of variety and moisture content on the surface area of the finger millet grain was found to be non significant. The graphical representation of effect of different varieties and different moisture levels on surface area is depicted in the Fig. 3**.** It was found that the surface area of the finger millet grain increased with increase in moisture content in polynomial trend. The increase in the surface area may be due to direct relation with the linear dimensions of the seed. The results are also reported by Powar *et al.* (2018) for finger millet grains.

The pictorial representation of effect of different varieties and different moisture levels on bulk density is depicted in the Fig. 4. It was found that the bulk density of the finger millet grain decreased with increase in moisture content in polynomial trend. The decrease in the bulk density with increase in moisture content may be due to more increase of volume of grain relative to weight of grains. The results are in agreements with the findings of Powar *et al.* (2018) for finger millet grains, Omprakash *et al.* (2019) for pearl millet grains, Singh *et al.* (2021) for *Deenanath* seeds, Damian (2014) for mustard seeds, Swami and Swami (2010) for finger millet grains and Ramashia *et al.* (2017) for finger millet grains.

The effect of different varieties and different moisture levels on true density is depicted in the Fig 5. It was found that the true density of the finger millet grain decreased with increase in moisture content in polynomial trend. The reason for decrease in the true density may be due to more increase in volume as compared to mass of grains. The results are in agreements with the Damian (2014) for mustard seeds.

The graphical representation of effect of different varieties and different moisture levels on terminal velocity is depicted in the Fig. 6. It was found that the terminal velocity of the finger millet grain increased with increase in moisture content in polynomial trend.

The graphical representation of effect of different varieties and different moisture levels on angle of repose is depicted in the Fig. 7. It was found that the angle of repose of the finger millet grain increased with increase in moisture content in polynomial trend. The increase in the angle of repose may be due to moisture absorption of seeds in their intercellular space. The results are in agreements with the findings of Ramashia *et al.* (2017) for finger millet grains and Patel *et al.* (2021) for linseed.

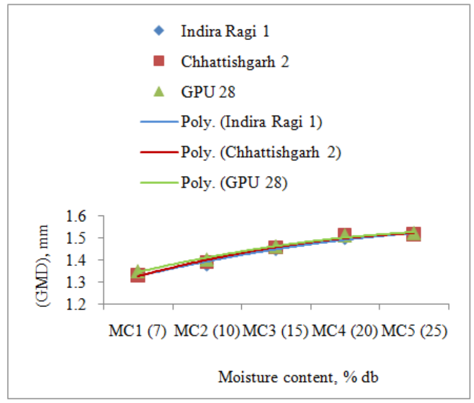


**Fig. 2.** Effect of variety and moisture content on the geometric mean diameter of the finger millet grain.

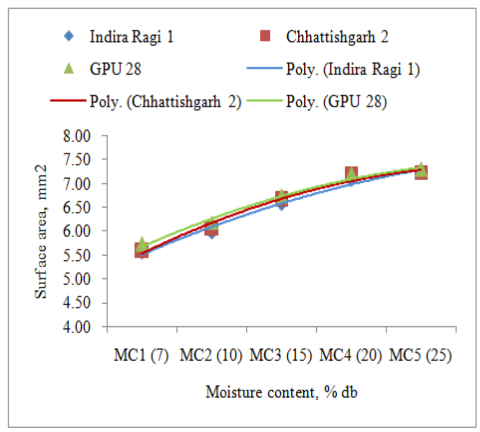


**Fig. 3.** Effect of variety and moisture content on the surface area of the finger millet grain.

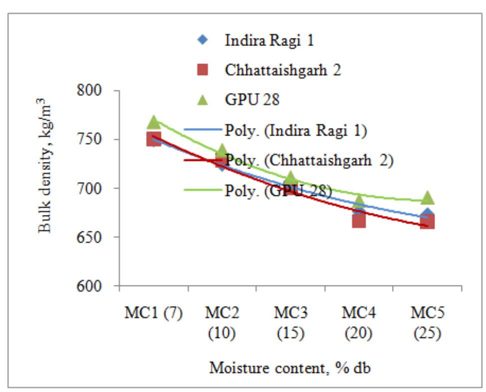


**Fig. 4.** Effect of variety and moisture content on the bulk density of the finger millet grain.

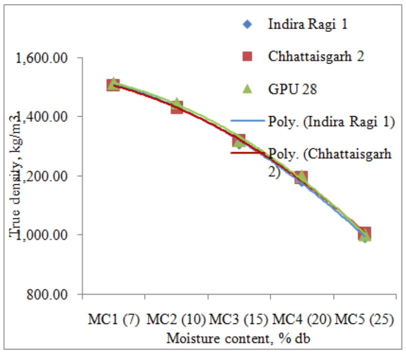


**Fig. 5.** Effect of variety and moisture content on the true density of the finger millet grain.

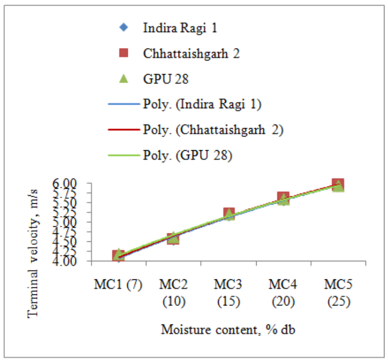


**Fig. 6.** Effect of variety and moisture content on the terminal velocity of the finger millet grain

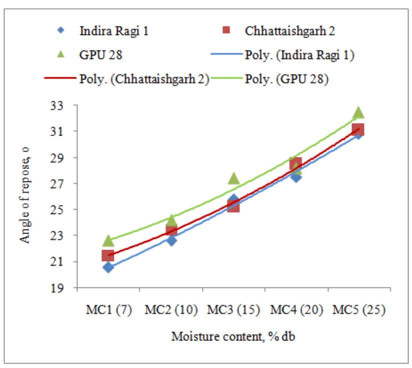


**Fig. 7.** Effect of variety and moisture content on the angle of repose of the finger millet grain.

**Effect of variety and moisture content on the sphericity, 1000 grain weight, coefficient of static friction and volume of the finger millet grain.** The effect of varieties (*Indira Ragi* 1, Chhattisgarh 2 and GPU 28) and moisture contents (7, 10, 15, 20 and 25 %, db) on sphericity, 1000 grain weight, coefficient of static friction and volume of the finger millet grain was recorded. The detailed data were analyzed statistically using CRD (Completely Randomised Design) and represented in the Table 3 and 4. It was observed that there is no significant difference between the sphericity in case of moisture content and variety at 5 per cent level of significance. However, the highest sphericity of 0.937 was observed at moisture level of 25 per cent while the lowest sphericity of 0.916 was observed at low moisture level of 7 per cent.

Similarly the significantly highest thousand grain weight of 2.736 g was observed at moisture level of 25 per cent while the lowest of 2.259 g mm was observed at low moisture level of 7 per cent. But in case of static coefficient of friction and volume of the finger millet grain it was found that the varietal difference was non significant whereas, there is significant difference in case of moisture content. However, the highest coefficient of static friction of 0.432 was observed at moisture level of 25 per cent while the lowest coefficient of static friction of 0.393 was observed at low moisture level of 7 per cent. The interactive effect of variety and moisture content on coefficient of static friction of the finger millet grain was found to be non significant. However, the highest volume of 1.683 $mm^3$ was observed at moisture level of 25 per cent while the lowest volume of 1.119 $mm^3$ was observed at low moisture level of 7 per cent. The interactive effect of variety and moisture content on the volume of the finger millet grain was found to be non significant. Similar results have been also reported by Swami and Swami (2010) and Ramashia *et al.,* (2017) for finger millet grains.

The significance of different physical and engineering properties of finger millet for designing different component of thresher was presented in Table 5.

**Table 3: Effect of variety and moisture content on sphericity and 1000 grain weight of finger millet grain.**

| Variety | Sphericity | | | | | | 1000 grain weight | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 | Mean | M1 | M2 | M3 | M4 | M5 | Mean |
| *Indira Ragi* 1 | 0.917 | 0.920 | 0.933 | 0.943 | 0.943 | 0.931 | 2.297 | 2.401 | 2.506 | 2.687 | 2.919 | 2.562 |
| Chhattisgarh 2 | 0.913 | 0.923 | 0.923 | 0.940 | 0.940 | 0.928 | 2.130 | 2.241 | 2.332 | 2.551 | 2.562 | 2.423 |
| GPU 28 | 0.917 | 0.917 | 0.927 | 0.927 | 0.927 | 0.923 | 2.349 | 2.462 | 2.628 | 2.689 | 2.727 | 2.571 |
| Mean | 0.916 | 0.920 | 0.928 | 0.937 | 0.937 | | 2.259 | 2.368 | 2.489 | 2.642 | 2.736* | |
| CD<br>Factor (Variety) | NS | | | | | | 0.05 | | | | | |
| Factor (MC) | NS | | | | | | 0.065 | | | | | |
| Factor (V×MC) | NS | | | | | | 0.112 | | | | | |

Note: MC1 to MC5: Moisture content, % db

**Table 4: Effect of variety and moisture content on coefficient of static friction and volume of finger millet grain.**

| Variety | Coefficient of static friction | | | | | | Volume | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 | Mean | M1 | M2 | M3 | M4 | M5 | Mean |
| *Indira Ragi* 1 | 0.392 | 0.401 | 0.423 | 0.429 | 0.438 | 0.417 | 1.103 | 1.233 | 1.450 | 1.640 | 1.690 | 1.423 |
| Chhattisgarh 2 | 0.384 | 0.396 | 0.414 | 0.426 | 0.428 | 0.409 | 1.103 | 1.263 | 1.457 | 1.660 | 1.680 | 1.433 |
| GPU 28 | 0.403 | 0.414 | 0.421 | 0.426 | 0.429 | 0.418 | 1.150 | 1.293 | 1.483 | 1.647 | 1.680 | 1.451 |
| Mean | $0.393_{b}$ | $0.403_{b}$ | $0.419_{ab}$ | $0.427_{ab}$ | $0.432_{a}$ | | $1.119_{d}$ | $1.263_{c}$ | $1.463_{b}$ | $1.649_{a}$ | $1.683_{a}$ | |
| CD Factor (Variety) | NS | | | | | | NS | | | | | |
| Factor (MC) | 0.026 | | | | | | 0.0093 | | | | | |
| Factor (V×MC) | NS | | | | | | NS | | | | | |

Note: MC1 to MC5: Moisture content, % db

**Table 5: Use of physical and engineering properties of finger millet.**

| Sr. No. | Name of property | Value range | Used for design of components |
|---|---|---|---|
| 1. | Crop grain ratio* | 1.39 – 1.61 | Hopper, cylinder, sieve etc. |
| 2. | Grain straw ratio* | 1.63 – 2.57 | Feed rate determination, hopper, outlets etc. |
| 3. | Bulk density*, kg/m$^3$ | 225 – 265 | Feeding hopper, storage etc. |
| 4. | Geometric mean diameter, mm | 1.33 – 1.52 | Sieve size, concave clearance, concave openings etc. |
| 5. | Sphericity | 0.91 – 0.94 | Sieve slope, sieve opening shape, outlets etc. |
| 6. | Volume, mm$^3$ | 1.10 – 1.68 | Threshing drum, hopper, storage etc. |
| 7. | Surface area, mm$^2$ | 5.56 – 7.26 | Sieve area, concave arc area, etc |
| 8. | 1000 grain weight, g | 2.26 – 2.74 | Output capacity, feed rate etc. |
| 9. | Bulk density, kg/m$^3$ | 676.45 – 755.67 | Reciprocating sieve dimensions, threshing cylinder etc. |
| 10. | True density, kg/m$^3$ | 1000.71 – 1510.96 | Reciprocating sieve dimensions, threshing cylinder etc. |
| 11. | Porosity, % | 32.40 – 49.99 | Storage, outlets etc. |
| 12. | Coefficient of static friction (MS sheet) | 0.393-0.432 | Sieve material selection, outlet design etc. |
| 13. | Terminal velocity, m/s | 4.15 – 5.93 | Aspirator design, fan size etc |
| 14. | Angle of repose, $^o$ | 21.55 – 31.47 | Hopper, sieve slope, outlet slopes etc. |

* Properties of finger millet crop panicle

## CONCLUSIONS

The present study provides the basic information about moisture dependent engineering properties of finger millet plant and its grain. In this study the effect of moisture content and variety of finger millet at different physical properties like, GMD,1000 grain weight, bulk density, true density, coefficient of friction, terminal velocity, angle of repose, were determined. Physical properties of finger millet grains were significantly varies with different moisture content and result shows that the properties are not significantly differ from variety to variety. These properties are very useful for designing different component of finger millet thresher such as feeding chute, aspirator design, blower fan size, output size and slope, cylinder dimensions etc.

## FUTURE SCOPE

This study can be used for designing of different components of finger millet thresher like feeding chute, threshing cylinder, sieve size, fan size, reciprocating sieve etc.

**Acknowledgement**. The authors Acknowledged AICRP on FIM and Department of Farm Machinery and Power Engineering, SV College of Agricultural Engineering and Technology and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur, 492012, India for providing necessary funds and facilities for the research work.
**Conflict of Interest.** None.

## REFERENCES

AACC (1995). Approved methods, American Association of Cereal Chemists.10$^{th}$ edition, moisture determination, 44-15A, Minnasota, St Paul.

Akaaimo, D. I. and Raji, A. O. (2006). Some physical and engineering properties of prosopis africana seed. *Boisystems Engineering*, *95*(2): 197-205.

Anonymous. (2010). Guidelines for the conduct of test for distinctiveness, uniformity and stability on finger millet, Protection of Plant Varieties and Farmers' Rights Authority (PPV and FRA) http://millets.res.in/dus/fingermillet.pdf)

Anonymous. (2019). Area, production and yield statistics millets, millet stats, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, Government of India, https://milletstats.com/apy-stats/.

Anonymous (2002). IS 4333-4: Bureau of Indian Standards (BIS). Indian Standard Test Code for Method of Analysis for Food grains, Part 4: Determination of the Mass of 1000 Grains, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002.

Damian, C. (2014). Physical properties of mustard seeds. *Lucrari Stiintifice – seria Zootehnie, 61*: 39-44.

Dange, A.R., Naik, R.K., Dave, A.K. and Patel, G. (2021). Studies on Engineering Properties of Maize for Development of Maize Dehusker Cum Sheller. *Biological Forum – An International Journal, 13*(3a): 598-604.

Garnayak, D. K., Pradhan, R. C., Naik, S. N. and Bhatnagar, N. (2008). Moisture- dependent physical properties of jatropha seed (*Jatropha curcas* L.). *Industrial Crops and Products, 27*: 123-129.

Gull, A., Ahmad, G., Prasad, K. and Kumar, P. (2016). Technological, processing and nutritional approach of finger millet (*Eleusine coracana* L.)-A mini review. *Journal of Food Processing and Technology*, *7*: 6.

Gupta, R. K., Arora , G. and Sharma, R. (2007). Aerodynamic properties of sunflower seed (*Helianthus annuus L.*). *Journal of Food Engineering*, *79*: 899-904.

Kumar, D., Patel, S., Naik, R. K. and Mishra, N. K. (2016). Study on Physical Properties of Indira Kodo-I (*Paspalum Scrobiculatum* L.) Millet. *International Journal of Engineering Research and Technology*, *5*(01): 39-45.

Mohsenin, N.N. (1986). Physical Properties of Plant and Animal Materials. *Gordon and Breach Science Publishers*, New York.

Mwithiga, G. and Sifuna, M. M. (2006). Effect of moisture content on the physical properties of three varieties of sorghum seeds. *Journal of Food Engineering*, *75*: 480–486.

Netam, A., Patel, K. K. and Naik R. K. (2021). Moisture dependent physical properties of maize cobs and kernels. *The Pharma Innovation Journal*, *10*(12): 332-337

Omprakash , Jha, S. K., Kar, A., Sinha, J. P., Satyavathi, C. T. and Iquebal, M. A. (2019). Physical properties of pearl millet grain. *Pantnagar Journal of Research*, *17* (2):129-137.

Panda, S., Swain, S. K., Behera, D., Mohanty, D. K., Mohapatra, A. K., Rayaguru, K. and Dash, A. K. (2021). Moisture Dependent Physical and Engineering Properties of Pearl Millet Grains. *Biological Forum – An International Journal*, *13*(2): 345-351.

Patel, G., Naik, R. K. and Patel, K. K. (2021). Studies on some physical and engineering properties of linseed. *Biological Forum -An International Journal*, *13*(3): 303-308.

Pawase, P. A., Chavan, U. D. and Kotecha, P. M. (2021). Effect of Blanching on Nutritional Quality of Different Pearl Millet Cultivars. *Biological Forum – An International Journal*, *13*(1): 651-661.

Powar, R., Aware, V. V., Shahare, P. U., Sonawane, S. P., Dhande, K. G. and Vidyapeeth (2018). Moisture-dependent physical properties of finger millet grain and kernel (*Eleusine coracana Gaertn* L.). *Journal of Indian Society of Coastal Agriculture and Research, 36*(1): 48-56.

Pradhan, A., Nag, S. K. and Patil, S. K. (2010). Traditional methods of harvesting and processing for small millet in tribal region of Bastar. *Indian Journal of Traditional Knowledge*, *9*(4):681-663.

Ramashia, S., Gwata, E. T., Taylor M., Stephen, Anyasi, T., and Jideani, A. (2017). Some physical and functional properties of finger millet (*Eleusine coracana* L.) obtained in sub-Saharan Africa. *Food Research International*, *104*, 110-118.

Sacilik, K., Öztürk, R., & Keskin, R. (2003). Some physical properties of hemp seed. *Biosystems engineering*, *86*(2), 191-198.

Sahay, K. M. and Singh, K. K. (1994). Unit Operations of Agricultural Processing. 1st Edn., Vikas Publishing House Pvt. Ltd., New Delhi, India.

Shobana, S., Krishnaswamy, K., Sudha, V., Malleshi, N. G., Anjana, R. M., Palaniappan, L. and Mohan, V. (2011). Finger millet (*Eleusine coracana* L.): A review of its nutritional properties, processing and plausible health benefits. Chapter 2, www.ncbi.nih.gov/pubmed/23522794

Sial, S.K., Swain, D. Behera, P. M. Mohapatra, A. K. Mohapatra and Dash, A. K. (2019). Moisture related engineering properties of different OUAT released varieties of ragi, *Green Farming*, *10*(3): 341-345.

Singh, K.P. (2010). Development of a dehuller for barnyard millet (*Echinochloa frumentacea*) and formulation of millet-wheat composite flour. Ph. D. Theses, Indian Institute of Technology, Kharagpur.

Singh, S.K., Kautkar, S., Gurjar, B., Pathak, P. K. and Swami, S. (2021). Engineering properties of spikelets and true seeds of Deenanath (*Pennisetum pedicellatum Trin.*) grass. *Range Mgmt. and Agroforestry*, *41*(2): 328-335.

Sunil, C. K., Venkatachalapathy, N., Shanmugasundaram, S., Pare, A., and Manickam, L. (2016). Engineering properties of foxtail millet (*Setaria* L.): Variety- HMT 1001. *International Journal of Science, Environment and Technology*, *5*: 632-637.

Swami, S. S. and Swami, S. B. (2010). Physical properties of finger millet (*Eleusine coracana*). *International Journal of Agricultural Engineering, 3*(1): 156-160.

Ushakumari, S. R. (2009). Technological and physicchemical characteristics of hydrothermally treated millet. Thesis, Ph.D. Central Food Technological Research Institute, Mysore.

**How to cite this article:** Patel, K. K., Naik, R. K., Patel, G. and Pandey S. (2022). Studies on some Physical and Engineering properties of Finger Millet for Designing Thresher. *Biological Forum – An International Journal, 14*(4): 387-393.