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Studies on physical properties of pearl millet grains

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Abstract
The perception on the physical properties was helpful in developing food processing machines and equipment for processing, packaging, and storage. Size, geometric mean diameter, sphericity, aspect ratio, bulk density, true density, porosity, thousand seed weight, angle of repose, coefficient of static friction are some engineering attributes that are vital in manufacturing of an equipment were investigated in the present study. The grain length varied from 3.39 to 4.79 mm, with a breadth of 2.22 to 2.79 mm and a thickness of 2.02 to mm. The 1000 grain weight ranges from 14.0 to 15.3 g, an angle of repose of 31.5 to 35.5°, The average coefficient of friction values was 0.38 & 0.36 in plastic, 0.40 & 0.40 in glass, 0.42 & 0.46 in mild steel sheet, 0.47 & 0.45 in fibre, and 0.51 & 0.53 in plywood and a bulk density of 577.63 to 565.16 kgm^{-3}, with a true density of 551 to 554 kgm^{-3} varieties were respectively.

Keywords: Bulk density, true density, porosity, thousand seed weight, angle of repose

Introduction
Pearl (*Pennisetum glaucum* L.) is one of the main staple foods in the world, and more than half the world's population will consume it. The most widely grown form of millet is Pearl millet (*Pennisetum glaucum* L.). It has been cultivated in Africa and the Indian subcontinent since prehistoric times. The centre of diversity and planned area of domestication for the crop is in the Sahel region of West Africa. The sixth most common cereal crop in the world and the primary source of food in the semi-arid regions of Asia and Africa. Pearl millet is grown globally on 30 million ha with the majority of crops in Africa (approximately 18 million ha) and Asia (>10 million ha) (Yadav and Rai, 2013). India is the world's largest producer of pearl millet and has a total millet production of 8.81 million MT (AICPMIP, 2014) followed by Nigeria (4.9 m MT) and Niger (2.7 m MT). Rajasthan, Gujarat, Maharashtra and Uttar Pradesh are the major pearl millets producing states in India.
Pearl millets are used largely to prepare traditional, thick or thin, fermented porridges in Africa. The second major use in Africa is malting for the brewing of traditional beers and wines. In West African countries, e.g., Senegal, millet is used for making couscous, pap, and fritters. In Cameroon, pearl millet based gruels and steamed cakes are prepared for feeding infants and preschool children. Malted peal millet in combination with legumes has been used to prepare malted weaning foods. Peal millet has also been used in composite flour with wheat for making bread. Up to 30% pearl millet was used successfully in making bread in Senegal.
Hence this study was conducted to investigate some properties of pearl millets, namely, size, shape, sphericity, cylindricity, 1000 seed mass, bulk density, true density, porosity, angle of repose, static coefficient of friction and hardness.

Methodology: The variety of pearl millet grains (ABV-04) was procured from the agriculture research station of ANGRAU, Rekulagunta, Andhra Pradesh, India. The seeds are cleaned by removing the foreign matter manually and evaluated in the department of processing and food engineering, DR.N.T.R CAE, ANGRAU, Bapatla, Andhra Pradesh, India. Fig: 1 shows the selected variety of pearl millet grains under study.

Fig 1: Pearl millet grains

Physical attributes measurements
The moisture content on a dry basis of the grain was determined by using the (ASAE, 2006) air oven-dry method (Sahay and Singh, 2005) at a temperature of 103 ±2 °c and a period of 24 h. The shape and size of the seed metering grooves were mostly influenced by the size and shape of the paddy. The axial dimensions are the length, width, and thickness of an object. Vernier calipers were used to measure all axial dimensions of the pearl millet grains (least count 0.01 cm) (Fig:2). 30 seeds were picked at random from 100 g samples to measure dimensions. The following equation is used to calculate the size of each seed in terms of mean geometric diameter (De) (Kenghe *et al*., 2015). The sphericity of grain is defined as the ratio of

the surface area of a sphere with the same volume as the grain on the grain's surface (Ravi *et al.*, 2015). Aspect ratio is used to define the shape of the pearl millet grains. It is the ratio of width to the length of the grain (Ravi *et al*., 2015).

$$Moistrue\ content\ (\%) = \frac{w_0 - w_1}{w_0} \times 100 \quad (1)$$

Where,
W_0 – Initial weight of the grains before drying, g
W_1 – Final weight of the grains after drying, g

$$D_e = (lbt)^{1/3} \quad (2)$$

Where,
D_e – Geometric mean diameter, mm
l - Length, mm
b - width, mm
t – Thickness, mm

$$\phi = \frac{(lbt)^{\frac{1}{3}}}{l} \quad (3)$$

Where
ϕ – Sphericity
l - Length, mm
b - width, mm
t – Thickness, mm

$$R_a = \frac{w}{l} \quad (4)$$

Where,
R_a - Aspect ratio
w - Width of paddy seed, mm
l - Length of paddy seed, mm.

Fig 2: Determining of Physical attributes

Gravimetric properties
Bulk density is defined as the ratio of the mass of the pearl millets to its total (bulk) volume. It was determined by filling a circular container of known volume with pearl millets without compaction. The true density (ρ_t) is the ratio of the mass of the pearl millets to its true volume. It was determined using the Toluene displacement method. Toluene (C_7H_8) was used in place of water because grains absorbed toluene to a lesser extent. (Ravi *et al.* 2015). Porosity is defined as a measure of voids or space of the volume within the substance that occupied the total volume. It is calculated by using the relationship between bulk density and true density (Muralidhar *et al.* 2012).

Thousand-grain weight was determined by using the electronic balance of accuracy 0.001g (Fig: 3). A thousand seeds kernels are determined by counting the 1000 seeds and weight them. The same procedure was repeated five times and an average weight of the sample was reported (Zareiforoush *et al.* 2009).

$$\rho_b = \frac{m}{v} \quad (5)$$

Where,
ρ_d – Bulk density, kg m^{-3}
m – Mass of paddy seeds, kg
v – Volume of paddy seeds, m^3

$$\emptyset = (1 - \frac{\rho_b}{\rho_t}) \quad (6)$$

Where,
ø – Porosity, (%)
P_b – Bulk density, kg m^{-3}
P_t – True density, kg m^{-3}

Fig 3: Determination of gravimetric properties

Frictional properties
The angle of repose (θ) is considered as the angle in degrees with the horizontal at which the material will stand forming a heap. The angle of repose was calculated from the measurement of the height of the heap at the center and the base diameter of the heap (Chidanand *et al.* 2015). The coefficient of static friction simply indicates the frictional forces acting between two bodies under stationary conditions (Muralidhar *et al*. 2012). Mild steel sheets, plywood, glass, fiber, and plastic are the materials utilized. With the help of a screw attached to the instrument, the structural surface with the cylinder resting on it was gradually inclined until the cylinder just began to slide down. The procedure was repeated five times, and the data was recorded. The coefficient of static friction between the test surface and the pearl millet grains has been calculated by using tangents at the above angle (Fig: 4).

$$\theta = tan^{-1}(\frac{2h}{d}) \quad (7)$$

Where
Θ - Angle of repose, ^{0}
h – height of the pile, cm
d – diameter of the pile, cm

$$\mu = tan\theta \quad (8)$$

Where
µ - Coefficient of static friction
θ – Angle measured between the horizontal surface and inclined surface, ^{0}

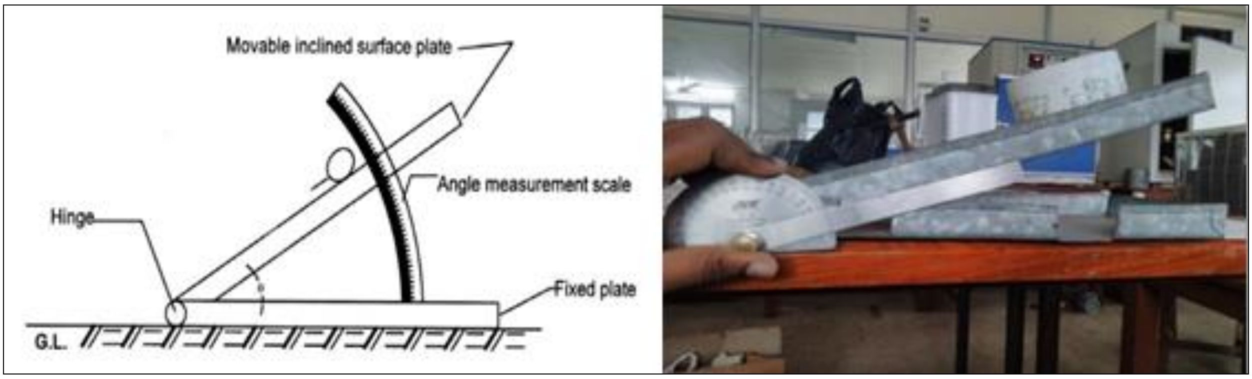

Fig 4: Determination of frictional properties

Results and Discussions

Physical properties of the grains *viz*. size, shape, bulk and true density, porosity, angle of repose, coefficient of static friction, and moisture content were determined. The size and shape of the grains were considered to be relevant to the design of equipment. The slope of the hopper was selected based on the angle of repose of the seed. The mechanical properties of grains help to study the hardness of seeds and strength required to damage the grains by mechanical components.

Physical attributes

The average moisture content of the ABV04 was 12.6% (w.b), respectively. The size of the selected seeds was determined in terms of length, width, and thickness by taking a sample of 30 seeds of different seeds and geometric mean diameter was calculated for ABV04 variety. The average values of length, width, and thickness were found 2.67, 1.15, and 1.35 mm for ABV04, respectively. The geometric mean diameter of ABV04 was observed to be 3.00 and 3.05 mm respectively. The completer data was mentioned in table: 1 and table.

Table 1: Axial dimension of pearl millet variety ABV 04

S. No	Descriptive statistics	Length (mm)	Width (mm)	Thickness (mm)
1.	Average	2.67	1.15	1.25
2.	Maximum	3.16	2.1	1.31
3.	Minimum	3.62	1.62	1.32
4.	Standard deviation	0.23	0.105	0.062

Based on observed dimensions *viz*. length, breadth, and thickness of different seeds. The sphericity of the pearl millets ABV 04 was obtained as 32.01 and 34.88 respectively. The lowest sphericity is observed in ABV 04 due to its axial dimensions. The aspect ratio (R_a) is used for the classification of Pearl millet shape and is observed as 27.95 for ABV04 variety respectively.

Gravitational attributes

The bulk density of seeds is a significant consideration while designing box capacity and optimizing the crop's seed rate. The bulk density of pearl millet ABV04 was 583.20 kg m^{-3}, respectively. By eliminating the voids in a cylinder, the apparent volume of seeds is achieved. The average density of ABV 04 5204 pearl millets was 1069.50 kg m^{-3} and 1077.64 kg m^{-3}, respectively. The pearl millet had an average porosity of 45.5% ABV04, respectively. Due to the moisture content of the grains, the porosity of the grains is affected by their volume. The complete data was mentioned in the table 3 and 4.

Table 3: Gravimetric properties of pearl millet grain of variety ABV 04

S. No	Descriptive statistics	Bulk density (Kg m^{-3})	True density (Kg m^{-3})	Porosity
1.	Average	596.13	1057.64	43.64
2.	Maximum	565.15	1043.15	45.06
3.	Minimum	585.03	1045.9	40.68
4.	Standard deviation	7.92	32.57	36.70

A thousand grains of ABV04 was determined by manually counting 1000 seeds and weighing them on an electric balance. A thousand grains of weighed 14 and respectively, and observing the obtained results show that the weight of ABV04 was recorded.

Frictional Properties: The peak angle of a pile of grain in the horizontal plane is defined as the angle of repose. The slope of the seed hopper must be determined to allow seeds to keep flowing. ABV 04 angle of repose of 28.10 and 27.40 degrees, respectively coefficient of friction were examined in different materials, including plywood, mild steel sheet, fiber, plastic, and glass. The average coefficient of friction values was 0.38 & 0.36 in plastic, 0.40 & 0.40 in glass, 0.42 & 0.46 in mild steel sheet, 0.47 & 0.45 in fibre, and 0.51 & 0.53 in plywood, respectively. As a result, plywood had the highest coefficient of friction while plastic had the lowest. Fig: 5 gives the variation of the coefficient of static friction on different materials used.

Fig 5: Variation of coefficient of friction on different materials

Conclusion

The observed values can be used to construct seed metering cells with cell sizes ranging from 7 to 10 mm for selected varieties. The seed metering discs thickness and cell radii were calculated based on breadth and length. Thus, average values of angle of repose and coefficient of friction can be used to design the hopper. To ensure the free flow of seed, the maximum angle of repose found in ABV 04 can be used to design a seed hopper slope of 30^0. Plastic had a lower coefficient of friction than glass, mild steel, fiber, and wood surfaces in all of the tested kinds. As part of agricultural equipment, a mild steel sheet was selected as a material for seed hopper fabrication for the free flow of seeds by analysing several recommendations. It was concluded that a minimum angle of 30^0 can be used to design a hopper by selecting the low friction mild steel sheet.

References

1. Adebowale AA, Fetuga GO, Apata CB, Sanni LO. Effect of variety and initial moisture content on physical properties of improved millet grains. Nigerian Food Journal. 2012;30(1):5-10.
2. Balasubramanian S, Viswanathan R. Influence of moisture content on physical properties of minor millets. Journal of food science and technology. 2010;47(3):279-284.
3. Baryeh EA. Physical properties of millet. Journal of Food Engineering. 2002;51(1):39-46.
4. Jain RK, Bal S. Properties of pearl millet. Journal of agricultural engineering research. 1997;66(2):85-91.
5. Obadina AO, Arogbokun CA, Soares AO, de Carvalho CWP, Barboza HT. Changes in nutritional and physico-chemical properties of pearl millet (Pennisetum glaucum) Ex-Borno variety flour as a result of malting. Journal of food science and technology. 2017;54(13):4442-4451.
6. Pawase PA, Shingote A, Chavan UD. Studies on Evaluation and Determination of Physical and Functional Properties of millets. (Ragi and pearl millet). Asian Journal of Dairy and Food Research. 2019;38(3):203-212.
7. Siroha AK, Sandhu KS. Effect of heat processing on the antioxidant properties of pearl millet (*Pennisetum glaucum* L.) cultivars. Journal of Food Measurement and Characterization. 2017;11(2):872-878.
8. Siroha AK, Sandhu KS, Kaur M. Physicochemical, functional and antioxidant properties of flour from pearl millet varieties grown in India. Journal of Food Measurement and Characterization. 2016;10(2):311-318.