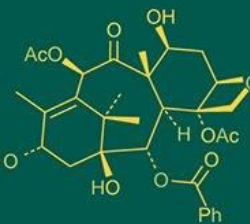
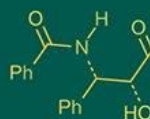
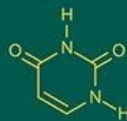
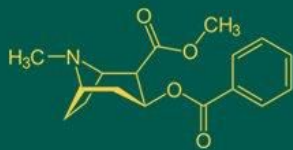


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Studies on some important physical properties of *Char* (*Buchanania lanzan*) seeds

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Abstract

Physical and mechanical properties of *Chironji* (*Buchanania lanzan*) seeds are necessary for the design of equipment for decortications of *chironji* seeds and to be handle, transport, and process and store the *chironji* kernels. The physical properties of *chironji* seeds and kernels have been evaluated as a function of *chironji* seeds moisture content varying from 8.97% to 13.09% (wb) seeds. In this range, seeds length, width, thickness and mass with geometrical mean diameter increases from 8.90 mm to 9.30 mm, 7.93 mm to 8.50 mm, 6.02 to 6.60mm, 0.19 to 0.22 g respectively; the seeds sphericity, aspect ratio and 1000 seeds mass increases from 84.40 to 87.50, 89.10 to 91.39 and 228g to 252g respectively; the seeds bulk density, true density, porosity and coefficient of friction increases from 562.5 to 527.5 kg/m³, 906.6 to 815.0 kg/m³, 35.58 to 37.75 and 0.643 to 0.717, 0.263 to 0.326, 0.673 to 0.821 and 0.347 to 0.400 for rubber, glass, stainless steel and sun-mika respectively; the seeds and angle of repose and specific heat increases from 19.29° to 24.70° and 0.05 to 0.10 kJ/g°C respectively.

Keywords: *Char*, physical property, *Chironji* seed, moisture content, angle of repose, coefficient of friction, bulk density, sphericity, true density

1. Introduction

Chironji (*Buchanania lanzan*) is common tree in dry deciduous forests. It is endemic to tropical dry deciduous forest of India. *Chironji* (*Buchanania lanzan*), belongs to family Anacardiaceae. It is a medium sized tree, with straight, cylindrical trunk, up to 10-15 m height and tomentose branches. This multipurpose tree provides food, fuel, fodder, timber and medicine to the local community [7]. Bark is rough, dark grey or black, fissured into prominent squares, 1.25-1.75 cm thick, and is reddish inside. Its leaves are thickly coriaceous, broadly oblong with a rounded base. Leaves have 10-20 pairs of straight, parallel veins. Fruits are drupe, ovoid or globose, black, 8-12 mm in diameter with hard stones. Unripe fruit are green in colour. The *chironji* seed is small sized slightly flattened and has an almond-like flavor and highly nutritious. There is a problem in the storage due to high oil content and an association of fungi with seeds.

2. Materials and Methods

The raw material *chironji* was collected from different region of the Chhattisgarh for the present investigation. The material was properly cleaned and drying after remove of outer skins or pulps from the *chironji* seeds to have a uniform sample. They were further cleaned manually to remove foreign matters and other impurities like stones.

Different properties of *chironji* such as moisture content, thousand grain mass, size and shape, specific gravity, bulk density, true density, porosity, and angle of repose were determined using standard techniques. In order to study the effect of moisture content on different physical and engineering properties of *chironji* seeds, the moisture content of the sample was varied. The moisture content of the *chironji* seeds was increased by adding the water on it. Calculated amount of water was added to the known weight of samples to obtain the samples of desired moisture content.

2.1. Moisture Content

To calculate the moisture to be added, the sample of weight W_2 at higher moisture M_2 was found out by the following expression:

$$W_2 = \frac{W_1(100 + M_2)}{(100 + M_1)} \times 100 \quad (1)$$

Where,

M_1 = Initial moisture content;

M_2 = Final moisture content;

W_1 = Initial weight of the sample; and

W_2 = Final weight of the sample.

2.2. Thousand Grains Mass

The 1000 grain mass was determined by selecting different lots of 1000 sound grains by counting from general lot, weighing them using electronic balance. The average value of 3 replications was taken.

2.3. Size and Shape

The geometric mean diameter (D_p) of the calculated by using the following relationship [11]

$$D_p = (LWT)^{1/3} \quad (2)$$

The degree of sphericity (ϕ) was calculated the following formula as described by [11]

$$\phi = \frac{(L \times B \times T)^{1/3}}{L} \quad (3)$$

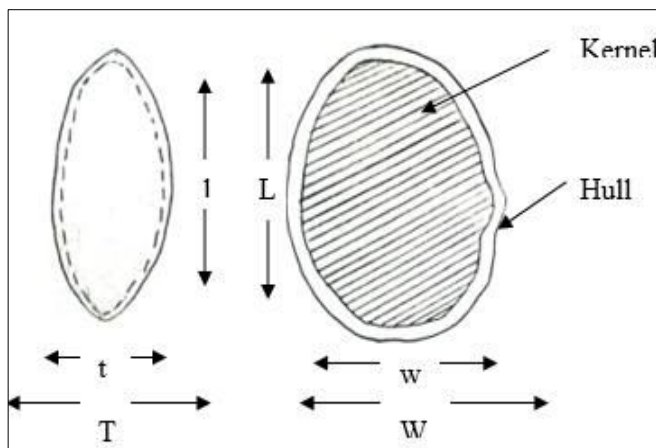


Fig. 1 Dimension of the *chironji* seed/ kernel

Where,

L = Length, (mm);

W = Width, (mm); and

T = Thickness, (mm).

2.4. Bulk Density

The true density of a nut or seed is defined as the ratio of the mass of a sample of a nut or seed to the solid volume occupied by the sample. The nuts and seeds volume and their true density were determined using the liquid displacement method. Toluene (C_7H_8) was used.

2.5. Porosity (ϵ)

2.5. Porosity (ϵ)

$$\epsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad (7)$$

Where,

ρ_t = True density; and

ρ_b = Bulk density.

2.6. Angle of Repose

$$\Phi = \tan^{-1} \left[\frac{2(H_a - H_b)}{D} \right] \quad (8)$$

Where,

Φ = Angle of repose ($^\circ$);

H_a = Height of the cone, (cm);

H_b = Height of the platform, (cm); and

D = Diameter of the platform, (cm).

2.7. Co-efficient of Internal Friction

$$\mu = \frac{F}{N} \quad (9)$$

Where,

μ = Co-efficient of internal friction;

N = Normal forces in the internal friction (N); and

F = Frictional forces in internal friction (N).

2.8. Specific Heat

$$\text{Specific heat} = \frac{(\text{amount of heat})}{(\text{mass of substance}) (\text{temperature changes})} \quad (10)$$

3. Results and Discussion

3.1. Angle of Repose

Table 1 shows the experimental values of the angle of repose for the *chironji* seeds at various moisture levels in the range of 8.97 to 13.09 (wb). A plot of the experimentally determined data on angle of repose corresponding to various moisture contents is represented in Fig. 2. It increased linearly from $19^\circ 29'$ to $24^\circ 70'$ with the increased in seed moisture. It may be due to the rough surface of *chironji* seed imposing resistance to the seeds from sliding on each other.

3.2. Linear Dimensions of Seeds

The variation of the length, width and thickness with mass of the seeds and kernels is displayed in Fig.2 and 3. All the dimensions increase linearly with seeds moisture content is increases.

3.3. Sphericity (Φ)

The effect of moisture content on sphericity of *chironji* seed is given in the consolidated Table 1 and its graphical representation is also provided in Fig 3. This is due to the fact that the seed swells initially from its breadth and thickness axes to some extent upon moisture absorption, but beyond a certain limit due to further soaking the seed tends to expand on its major diameter. Major diameter as denominator in the expression sphericity decreased. The relationship between moisture content and sphericity of *chironji* seeds was found to be non-linear.

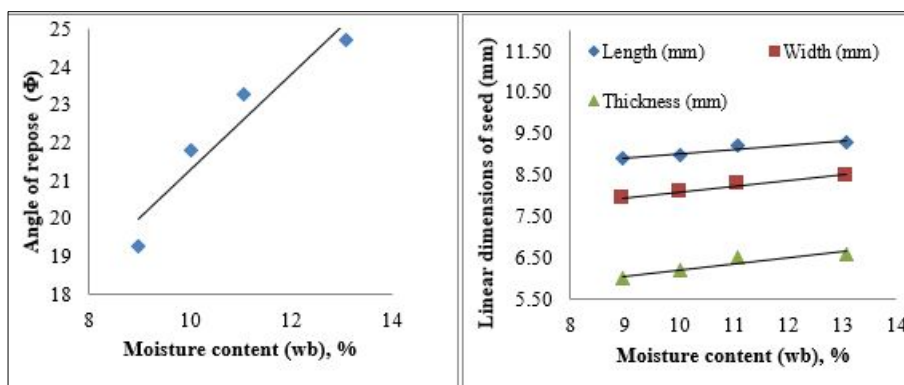


Fig 2: Effect of moisture content on angle of repose and linear dimension of *chironji* seed

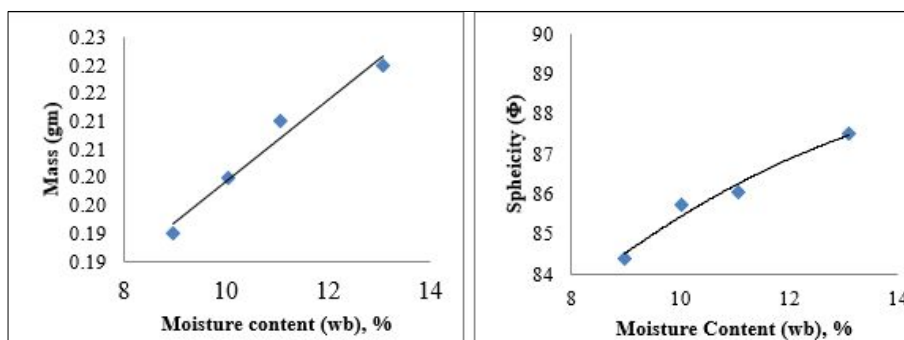


Fig 3: Effect of moisture content on mass and sphericity of *chironji* seeds

3.4. Thousand - Grain Mass

The thousand-grain mass for *chironji* seed was determined at different moisture contents ranging from 8.97 to 13.09 per cent (wb) increased linearly with increase in moisture content respectively. The increase in mass of the seeds ranged from 228 - 252 g. The graphical representation of effect of moisture content on thousand-grain mass is shown in Fig. 4.

3.5. Geometric Mean Diameter

Table 1 show that the equivalent diameter of the *chironji* seed increased with the increase in moisture content. The equivalent diameter varied from 7.79 to 8.05 mm. This was due to the fact that with the increase in moisture content the size of the seeds increased upon swelling which in turn increased the diameters (all the three). The change in equivalent diameter of the *chironji* seed with the increase in moisture contents is also shown in Fig.4.

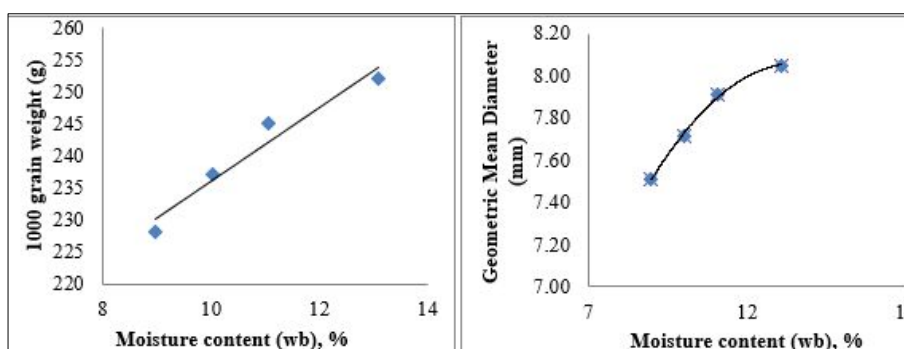


Fig 4: Effect of moisture content on thousand grain weight and GMD of *chironji* seeds.

3.6. Bulk Density

The bulk density of *chironji* seeds decreased from 562.5 kg/m³ to 527.5 kg/m³ Table 2 and. Statistical analysis showed that the values of bulk density at all moisture levels are showing significant difference with each other. The grand mean was observed as 544.92 kg/m³ and the standard deviation among the values was 15.49 per cent.

3.7. True Density

The true density of *chironji* seeds determined at different

moisture contents ranging from 8.97 to 13.09 per cent (wb) decreased with the increase in moisture content Table 2. True density of *chironji* seeds was observed in the range of 906.6 kg/m³ to 815 kg/m³. Statistical analysis showed that the values of true density at all moisture levels are showing significant difference among each other. The grand mean was 865.4 g/ml and the standard deviation was observed as 39.74 per cent.

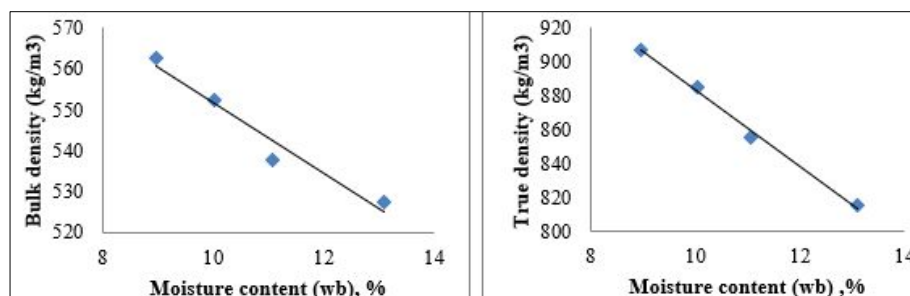


Fig 5: Effect of moisture content on bulk density and true density of *chironji* seed.

3.8. Porosity (ϵ)

The estimated porosity of *chironji* seeds was found to decrease with the increase in moisture content Table 2. The porosity value for *chironji* seeds was calculated to be 37.74 to 35.58 per cent for the moisture range of 8.97 to 13.09 per cent (wb) Fig.6. The reason for this decrease is that as the *chironji* seeds gain moisture, its volume increases, thus the number of seeds and in a fixed volume decreases. Since the number of seeds per unit volume decreases, the porosity, i.e. the per cent pore spaces between the particles also decrease. Further, porosity depends on the bulk density as well as true densities of the material and the magnitude of variation also depends on the values of densities. Statistical analysis showed that the standard deviation was 1.05 per cent. The grand mean of porosity of the seeds and kernels was

observed as 36.79 per cent.

From Table 2 it can be noticed that all the values of porosity are showing non-significant difference with each other.

3.9. Coefficient of External Friction (μ)

The static coefficient of friction for external surfaces for *chironji* seeds determined with respect to four different structural surface is shown in Table 2. It is observed that the static coefficient of friction for *chironji* seeds increased with increase in moisture content on all surfaces. The static coefficient of friction was greatest on mild steel surface (0.673 to 0.821) than rubber (0.643 to 0.717) and plywood (0.347 to 0.400) followed by the least for glass (0.243 to 0.326) respectively.

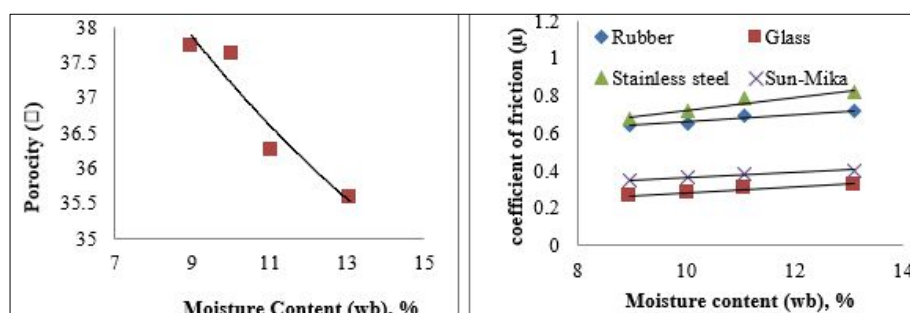


Fig 6: Effect of moisture content on porosity and Coefficient of External Friction of *chironji* seed and kernel

3.10. Specific Heat (C_p)

The variation in specific heat with moisture content and temperature of *chironji* seeds is presented in Table 1 and Fig

6. The specific heat of *chironji* seed varied from 0.05 to 1.0 kJ/g°C for the experimental range of variables studied.

Table 1: Effect of moisture content on physical properties of *chironji* seeds

Sample number	Moisture content (wb) %	Moisture content (db) %	Angle of repose (Φ)	Length (mm)	Width (mm)	Thickness (mm)	Mass (g)	Sphericity (ϕ)	1000 grain weight (g)	Specific Heat (kJ/g°C)	GMD (mm)	Aspect Ratio (%)
1	8.97	9.85	19.29	8.90	7.93	6.02	0.19	84.40	228	0.05	7.51	89.10
2	10.03	11.15	21.80	9.00	8.10	6.20	0.20	85.72	237	0.06	7.71	90.00
3	11.07	12.45	23.26	9.20	8.30	6.50	0.21	86.06	245	0.07	7.91	90.21
4	13.09	15.06	24.70	9.30	8.50	6.6	0.22	87.50	252	0.10	8.05	91.39
SD (σ)	01.75	02.22	2.30	0.18	0.24	0.26	0.01	1.27	10.34	0.02	0.23	0.94
Avg.	10.79	12.12	22.26	9.00	8.20	6.33	0.20	85.92	240.5	0.07	7.79	90.17

Table 2: Effect of moisture content on Coefficient of friction of *chironji* seeds

Sample Number	Moisture content (wb) %	Moisture Content (db) %	Bulk density kg/m³	True density kg/m³	Porosity (ϵ)	Coefficient of friction (μ)			
						Rubber	Glass	Stainless steel	Sun-Mika
1	8.97	9.85	562.5	906.6	35.58	0.643	0.263	0.673	0.347
2	10.03	11.15	552.2	885.2	36.25	0.652	0.282	0.717	0.369
3	11.07	12.45	537.5	855.0	37.62	0.695	0.304	0.782	0.382
4	13.09	15.06	527.5	815.0	37.74	0.717	0.326	0.821	0.400
SD (σ)	1.75	2.22	15.49	39.73	1.05	0.035	0.027	0.066	0.022
Avg.	10.79	12.12	544.9	865.4	36.79	0.676	0.293	0.748	0.374

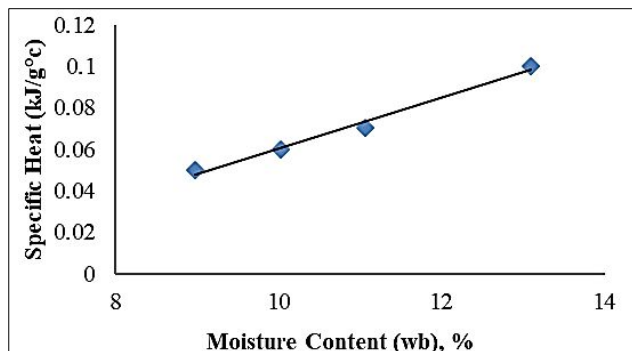


Fig 7: Effect of moisture content on specific heat of *chironji* seeds.

4. Conclusion

Angle of repose was increased linearly with the increase in seeds moisture. The variation of the length, width, thickness and mass of the seeds is increase linearly with moisture content. The value of sphericity decreased if moisture content of seeds increased. The thousand-grain mass for *chironji* seeds moisture contents increases linearly with increase in moisture content. The equivalent diameter of the *chironji* seeds increased with the increase in moisture content. The bulk density of *chironji* seeds decreased with increases moisture content. The true density of *chironji* seeds was decreased with the increase in moisture content. The porosity value for *chironji* seeds was increases for increasing of moisture content. It is observed that the static coefficient of friction for *chironji* seeds increased with increase in moisture content on all surfaces. The variation in specific heat with moisture content and temperature of *chironji* seeds.

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