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Study of Physical Property of Kodo (*Paspalum scrobiculatum* L.) Millet

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A B S T R A C T

Kodo millet is one of the important millet crop grown mainly in Madhya Pradesh, India. Kodo is high in nutrition value with protein, fat and carbohydrate. The physical property of kodo was determine with three variety JNK-101, JNK-364 and Niwas-1 at three moisture content 7%, 11% and 12.6% (db). It was found that L,B,T in JNK-101ranging from 2.38 to 2.68mm, 1.43 to 2 mm, and 1.01 to 1.34 mm. Similarly in JNK-364 L,B,T range from 2.27 to 2.72 mm, 1.34 to 1.75 mm and 0.96 to 1.30 mm, in Niwas-1 L,B,T range from 2.44 to 2.95 mm, 1.78 to 2.32 mm and 1.32 to 1.70 mm. The size of kodoin all three variety ranges from 1.49 to 1.91 mm, 1.43 to 1.82 mm and 1.76 to 2.24 mm respectively. Sphericity increases in all three variety from 0.63 to 0.72 mm, 0.61 to 0.67 mm and 0.72 to 0.76 mm. The bulk density, true density and porosity in all three variety range from in JNK-10, was 676.67 to 681.0, 1202.67 kg/m2 to 1228.50 kg/m2 and 43.74 to 44.57%, JNK-364 674.33 to 684.33, kg/m2, 1201.33 to 1228.80 kg/m^2, 43.87 to 44.31% and Niwas -1 671.67 to 686.07 kg/m2, 1203 to 1227 kg/m2 and 44.17 to 44.13%. The angle of repose in JNK-101 25.28 to 26.07, JNK-364 25.26 to 26.04 and niwas-1 25.39 to 26.07 respectively. The physical property of kodo with all parameter increases with the increase in moisture content.

Introduction

The word “Millets” is used to represent many small-grained cereals. Millets crops comprise of pearl millets, sorghum, finger millet &small millets namely foxtail millets (Kagani), Kodo millets (Kodo), proso millets (Cheena), banyard millets (Sawan) and little millets (Kutki). Millets are one of the oldest cultivated food grains known to humans and have been a stable food in Northern Africa for thousand years and was a stable food in China and India prior to popularity of fine cereals like rice and wheat. These crops have a long history of cultivation of more than 5000 years and grown in many states. The area of small millets in India recorded 682.33 thousand ha, with production of 429.9 thousand and yield

630.00Kg/ha. Madhya Pradesh covers 33.4percent (227.7 thousand ha) of area and contributes 26.6 percent (114.5 thousand) of production with the average yield of only 503 Kg/ha small millets in the country (Directorate of Economics and Statistics (2015).

Kodo grains contain protein (8.35 %), fat (1.45%), carbohydrates (65.65%) and ash (2.95%). It may be considers as nutri-cereal little millet exhibit diversified use as food, feed and fodder. The grain compares well with other cereals. It is a fair source of protein (7070 to 16.50%), fat (2.45 to 9.04 %), carbohydrates (62.50 to 76.30%), an excellent source of dietary fibre(15.90 to 18.10%) with good amount of soluble (3.15 to 5.70%) and insoluble (10.20 to 14.95%) fractions (Kulkarni *et al.*, 1992, Hadimani and Malleshi, 1993 and Itagi, 2003).

Designing of machinery requires through understanding of essential engineering properties of agricultural material. Such basic information is of great importance for not only to engineers but also to food scientist and processor and other scientist who may exploit these properties and find new uses (Mohsenin, 1986). Knowledge of physical properties and their dependence on the moisture content are useful for the design and development of machine. These properties are used in analyzing and determining the efficiency of the machine and operation or process as well as determine quality or studying the behaviour of the product during testing of machine. Basic information on these engineering properties is of great importance and help engineers towards efficient process and machine development Kumar *et al.*, (2016) studied engineering properties of variety Indira Kode-1 in the moisture range from 8.19 to 12.71 percent (db) and observed that the length, width and thickness of Kodo increased with increase moisture content and also observed that with the increased moisture content the length breadth ratio of Kodo decreased. The size and sphericity of Kodo increased with the increase of moisture content, surface area and volume of Kodo grain increased with the increased in moisture content. The values of bulk density decreased but true density and porosity was increased with increase in moisture content. The angle of repose was increased with increase of moisture content.

Materials and Methods

The engineering properties of kodo millet with three variety of Kodo such as JNK-101, JNK-364 and Niwas-1. Different properties of Kodo such as moisture content, length, width, thickness, size, sphericity, angle of repose, bulk density, true density and porosity were determined by using standard techniques. In order to determine the effect of moisture content on different physical properties of kodo and kutki, the moisture content was determined.

Moisture content

It is ratio of weight of moisture to weight of dry product. It is expressed in percentage.

$$\text{Moisture content (db) \%} = \frac{weight\ of\ moisture}{weight\ of\ dry\ matter} \times 100 \quad 1$$

Length, width and thickness (LBT)

For the measurement of seed length (L), width (W) and thickness (T), randomly 100 grains from each variety were selected for determination of L, W and T by using vernier calliper with a least count of 0.01mm.

Size of the seeds was calculated with the following formula proposed by [2].

$$S_z = (L \times W \times T)^{1/3} \ldots (2)$$

Sphericity (φ)

Sphericity (φ) is defined as the ratio of size of grains to the length of the grain. The sphericity is expressed in percent. [3].

$$\emptyset = \frac{(LXBXT)^{1/3}}{L} \ldots (3)$$

Bulk density (B_d)

Bulk density (B_d) of kodo grains was determined by taking the weight of kodo in fixed volume [4].

$$B_d = \frac{W}{V} \ldots (4)$$

True density (Td)

The true density (Td) is defined as the ratio of mass of grain to the solid volume occupied. It is determined using liquid displacement technique [5].

$$T_d = \frac{M}{S} \ldots (5)$$

Porosity was calculated as ratio of the difference in the grain and bulk densities to grain density and expressed in percentage [6].

$$\text{Porosity } (\varepsilon)\ \% = 1 - \frac{B_d}{T_d} \ldots (6)$$

Angle of repose

A cylinder was filled up to top with sample and inverted on a plane (paper) surface. The paper was taken out gradually and cylinder was raised vertically, thus conical shape of the material was formed. Angle of repose was calculated by using the following expression [7].

$$\emptyset = \tan{-1}\ \frac{2(H_a - H_b)}{D_b} \ldots (7)$$

Results and Discussion

The result of physical property are shown in figure 1, 2, 3 and 4. The result of different physical properties of kodocrop with the three moisture content of 7%, 11% and 12.6%. On dry basis are presented in the following figure and tables.

Length, width and thickness

The result shows length, width and thickness of kodo in variety JNk-101, JNk364 and Niwas-1 increased with increase in moisture content from 7% to 12.6%. the length, width and thickness varied in JNK-101 from 2.38 to 2.68 mm, 1.43 to 2.00 mm and 1.01 to 1.34 mm, Similarly in JNK-364 LBT range from 2.27 to 2.72 mm, 1.34 to 1.75 mm and 0.96 to 1.30 mm with respect to moisture content similar trend observed in in Niwas-1 LBT range from 2.44 to 2.95 mm, 1.78 to 2.32 mm and 1.32 to 1.70 mm. This happened when the moisture increased grain length, width and thickness increased due to the fact that increased upon swelling which turn in increased in LBT. As shown in figure 1–3 and required regression equation is shown in table 1.

in moisture 7% to 12.6% the size of JNK-101 varied from 1.49 to 1.91 mm where in variety JNK-364 the size varied from 1.43 to 1.82 mm and similarly in Niwas-1 the size varied from 1.76 to 2.24 mm. The result shows that the moisture content increased with increase in size.

Sphericity

The sphericity of kodo increases with variety JNK-101 increase from 0.63 to 0.72(mm) as the moisture content increased from 7.10 to 12.6 % (db). Similarly in JNK-364 and Niwas-1 the sphericity increased from 0.61 to 0.67 and 0.72 to 0.76(mm). There is little variation at 11% moisture content in Niwas-1 due to the

effect of variety and moisture content. The relationship between spherecity and moisture in following equations (Fig. 4–6).

Size

The size of kodo with three variety JNK-101, JNk-364 and Niwas-1 increased with increase

For Kodo JNK-101, y = 0.045x + 0.59, R^2 = 0.964

For Kodo JNK-364, y = 0.03x + 0.583, R^2 = 0.964

For Kodo Niwas-1, y = 0.03x + 0.583, R^2 = 0.964

Table.1 Correlation between length, width and thickness

Parameters	Kodo JNK-101	Kodo JNK-364	Kodoniwas -1
Length	0.15x + 2.266 R^2 = 0.848	0.175x + 2.23 R^2 = 0.892	0.255x + 2.19 R^2 = 0.998
Width	0.285x + 1.186 R^2 = 0.939	0.205x + 1.176 R^2 = 0.889	0.27x + 1.366 R^2 = 0.541
Thickness	0.165x + 0.876 R^2 = 0.900	0.17x + 0.813 R^2 = 0.946	0.19x + 1.086 R^2 = 0.865

Table.2 physical property of kodo millet

Moisture content	variety	Bulk density	True density	Porosity	Angle of repose
7.2%	Kodo JNK 101	676.67	1202.67	43.74	25.28
	Kodo JNK 364	674.33	1201.33	43.87	25.26
	Kodo NIwas-1	671.67	1203.00	44.17	25.39
11%	Kodo JNK 101	677.00	1228.00	44.87	25.90
	Kodo JNK 364	678.50	1220.50	44.41	25.83
	Kodo NIwas-1	681.50	1224.50	44.34	25.89
12.6%	Kodo JNK 101	681.00	1228.50	44.57	26.07
	Kodo JNK 364	684.33	1228.80	44.31	26.04
	Kodo NIwas-1	686.07	1227.90	44.13	26.07

Table.3 correlation between Bulk density, True density and porosity

Parameters	Kodo JNK-101	Kodo JNK-364	Kodoniwas -1
Bulk density	2.165x + 673.8 R^2 = 0.806	3.335x + 671.2 R^2 = 0.979	y = 7.2x + 665.3 R^2 = 0.957
True density	12.91x + 1193. R^2 = 0.764	13.73x + 1189. R^2 = 0.950	12.45x + 1193. R^2 = 0.850
Porosity	0.415x + 43.56 R^2 = 0.502	0.22x + 43.75 R^2 = 0.586	0.02x + 44.25 R^2 = 0.032

Fig.1 Effect of moisture content on Length, width and thickness of Kodo JNk-101

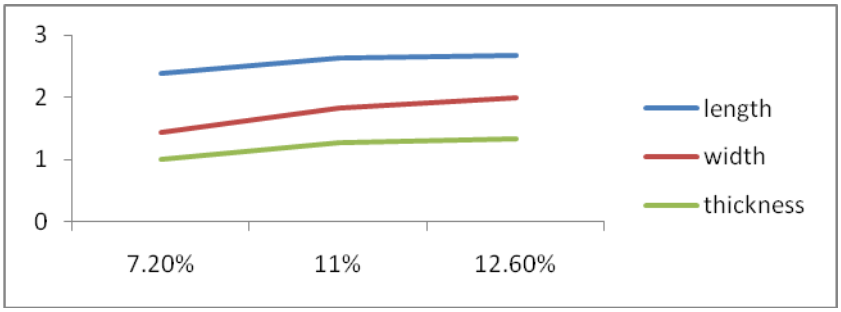


Fig.2 Effect of moisture content on Length, width and thickness of Kodo JNk-364

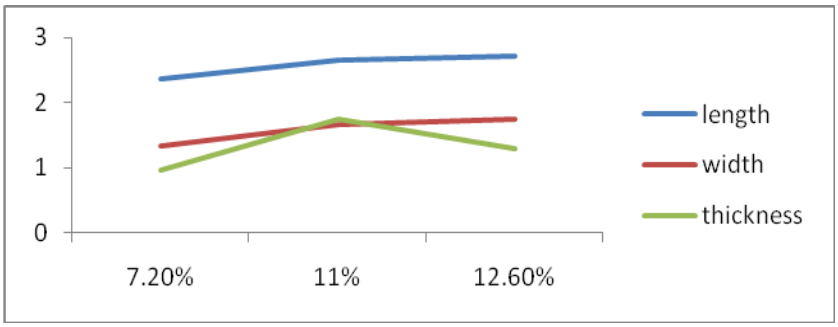


Fig.3 Effect of moisture content on Length, width and thickness of Kodo Niwas-1

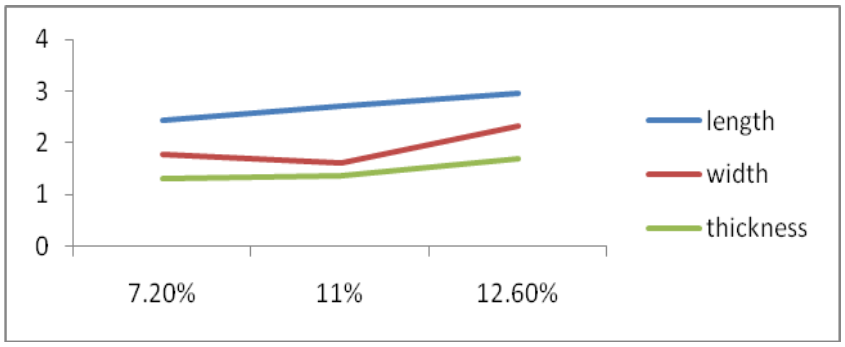


Fig.4 Effect of moisture content on sphericity of Kodo JNk-101

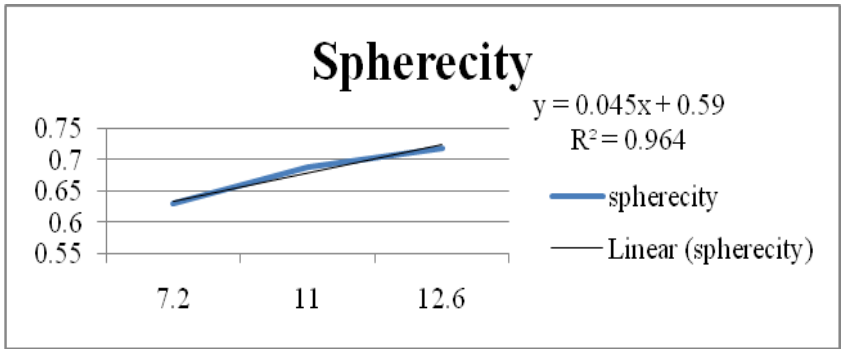


Fig.5 Effect of moisture content on sphericity of Kodo JNk-364

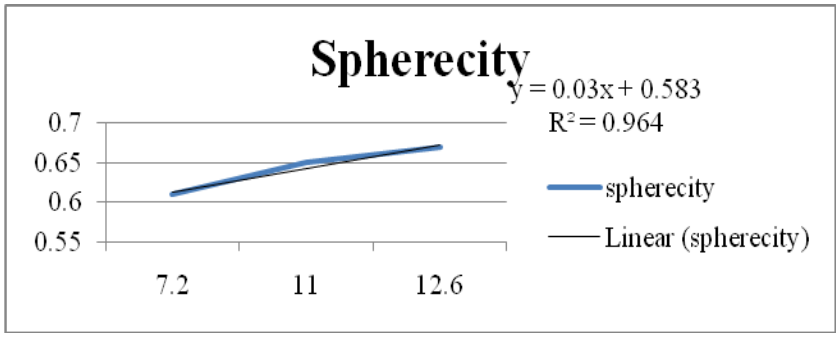


Fig.6 Effect of moisture content on sphericity of Kodo Niwas-1

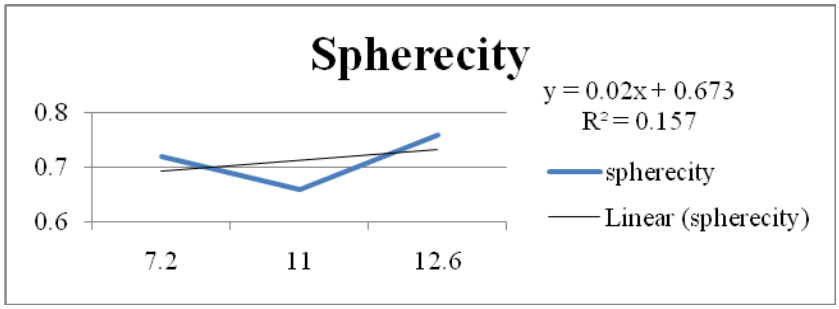


Fig.7 Effect of moisture content on angle of repose of Kodo JNk-101

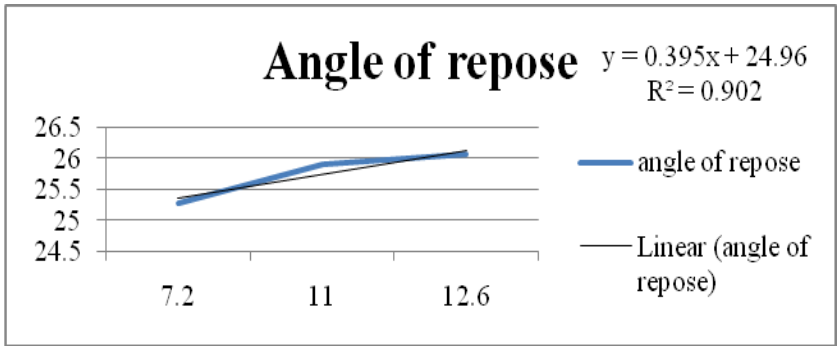


Fig.8 Effect of moisture content on angle of repose of Kodo JNK-364

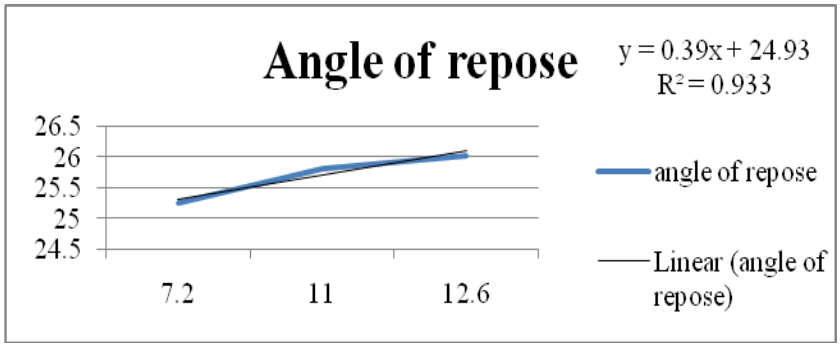
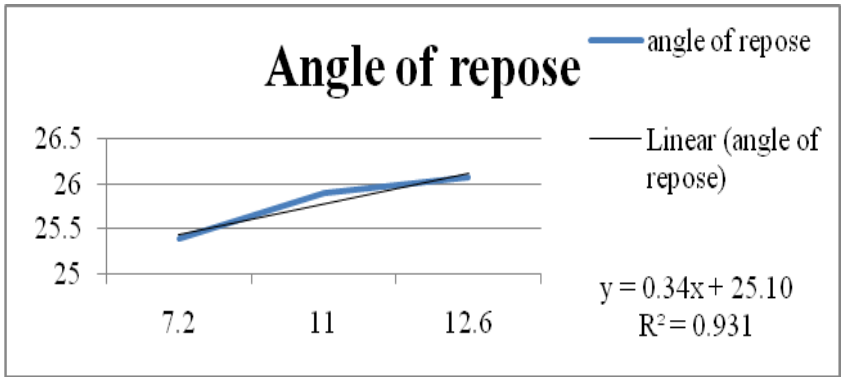


Fig.9 Effect of moisture content on angle of repose of Kodo Niwas-1



Bulk density, True density and Porosity

The bulk density, true density and porosity for kodo millet obtained at three different moisture content ranging from 7% to 12.6% (db). The bulk density, true density and porosity increased in JNK-101from 676.67 to 681 kg/m2, 1201.67 to 1228.50 kg/m2 and 43.74 to 44.57%. Similarly in variety JNK-364 the bulk density, true density and porosity increased with respect to moisture content from 674.33 to 684.33 kg/m2, 1201.33 to 1228.80 kg/cm2 and 43.87 to 44.31%. this trend also followed in Niwas-1 the bulk density, true density and porosity varied from 671.67 to 686.07 kg/cm2, 1203 to 1227.90 kg/cm2 and 44.17 to 44.13 % respectively. The equation is shown as following.

Angle of repose

The angle of repose at different moisture content range from 7 to 12.6% (db) increased with increase in moisture content shown in table 2 and figure 7. The angle of repose increased in JNK-101 ranged from 25.28 to 26.07 where in variety JNK-364 the angle of repose 25.26 to 26.04 and in Niwas-1angle of repose varied from 25.39 to 26.07. The relationship between angle of repose and moisture content as shown in figure 7–9.

It was observed that the length, width and thickness of kodowith all three variety JNK-101, JNK-364 and Niwas -1 increased with increasing moisture content. Also observed that the size, sphericity increased as the moisture content increases. The value of bulk density, true density and porosity was also increased as the moisture content increases. The angle of repose with all three variety increases with increase in moisture content.

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