International Journal of Agriculture, Environment and Bioresearch

Vol. 3, No. 01; 2018

ISSN: 2456-8643

ENGINEERING PROPERTIES OF KODO MILLET (*Paspalum scrobiculatum*): CO (3) VARIETY

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ABSTRACT

The engineering properties of kodo millet grains were measured at a moisture content of 9% (w.b.). The mean longitudinal diameter of grain was 2.983 ± 0.65 mm and lateral diameter was found to be 2.514 ± 0.43 mm. The weight of 1000 grains is 75.23 ± 2.07 g. The shape of grain and rice are spheroid. The bulk densities of kodo millet grains, rice and husk were 653, 835 and 287 kg/m3, respectively. The true density was to be 1176, 1021 and 1029 kg/m^3, respectively. The porosity was 40.0, 18.1 and 74.5 %, respectively. The tri-stimulus colour value (L* a* b*) for kodo millet grain (40.5, 4.0, 7.93); for kodo rice (46.8, 3.83, 12.33) and for husk (37.8, 3.86, 7.83). The angles of repose for kodo millet grain, rice and husk were found to be 18˚34, 24˚30 and 25˚12, respectively. The coefficient of friction values for kodo millet grain, rice and husk was 0.785, 0.859 and 1.702 on the glass sheet surface, 0.700, 0.819 and 1.060 on aluminium sheet surface and 0.708, 0.910, 1.150 on wooden sheet surface, respectively. The terminal velocity for grain, rice and husk were found to be 5.66, 6.38 and 2.20 m/s, respectively

Keywords: Kodo millet, Rice and husk, Aluminium sheet surface, Wooden sheet surface.

INTRODUCTION

Millets have been used in India and Africa as a staple food for thousands of years. It was reported that people were farming millet in India about 2500 BC. India has an area of 8.80 million hectares under minor millets with the production of 10.91 million tonnes annually. Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Tamil Nadu and Karnataka are the major states which contribute the production. India ranks 1st and 11th place in the top global production and per capita consumption of millets respectively (FAO, 2014). Small millets comprise the crops such as finger millet (*Eleusine coracana*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*setaria italic*), proso millet (*panicum milliaceum*) and barnyard millet (*Echinochloa frumentacea*), brown top millet (*Urochloa ramosa*). Among the major and minor millets, the minor millets in addition to nutritional benefits are rich in Phyto-chemicals, including phytic acid, which is believed to be lower the cholesterol level and phytate which is associated with reducing the chances of cancer (Anju and Sarita, 2010).

Kodo millet is an indigenous cereal crop of India. It is commonly known as 'kodo' in Hindi, varagu in Tamil and harka in Kannada. It is predominately grown in India and West African countries by tribal and poor people on unfertile land with no or low cash inputs. In India, this crop is grown in over 0.7 million hectares with largest area in the state of Madhya Pradesh followed by Chhattisgarh. However, it is also grown in Maharashtra, Uttar Pradesh, Gujarat, Karnataka and Tamilnadu. The kodo millet has crude protein content - 7 to 12%, fiber - 7 to 9%, fat - 1.1 to 5.0% and ash - 2.0 to 2.5%.

Knowledge of the engineering properties is important, useful and necessary in the design of processes, machines, structures and controls. These properties are used in analyzing and determining the efficiency of the machine and operation or process as well as determining quality or studying the behaviour of the product during agricultural processing unit operations. Basic information on these engineering properties is of great importance and help engineers towards efficient process and equipment development. The engineering properties like size, shape, colour, 1000 seed mass, true density, bulk density, porosity, angle of repose, coefficient of internal friction and terminal velocity for different millets at different moisture content have been studied and determined by many researchers (Balasubramanian and Vishwanathan, 2010; Ojediran et al. 2010; Swami and Swami, 2010; Singh et al., 2010, Sunil et al., 2016).

MATERIALS AND METHODS

The engineering properties of kodo millet (Nati Variety) with an initial moisture content of 9.00 ± 0.45 % (w.b.). It was purchased directly from the farmers of Tumkur District, Karnataka for evaluating the properties. The grains initial moisture content was determined by hot air oven method, at 105◦C for 24 hours (AOAC, 2012). The important engineering properties studied were: physical properties (Longitudinal and lateral diameter, shape, colour, true & bulk density, porosity and weight of 100 grains), frictional properties (Angle of repose and coefficient of friction) for millet, rice & husk.

Shape and size: Shape and size are inseparable in a physical object and both are generally necessary if the object is to be satisfactorily described. The shape and size of the product is an important parameter that affects conveying characteristics of solid materials by air. The size of the kodo millet grain was determined by measuring the longitudinal and lateral diameters using the digital vernier caliper having the least count of 0.01 mm. The average size of the kodo millet grains was calculated from randomly selected 10 grain samples. The magnified image (shape) of kodo millet is compared with the standard shapes described in the chart given by Mohsenin (1986) and accordingly reported.

Weight of 1000 seeds: Thousand kodo millet seeds, unbroken and sound grains, from ten randomly drawn samples were weighed and recorded. The mean value is reported.

True density: True density is used in design of storage bins and in separation of desirable materials from impurities (Tavakoli, 2002). The apparatus used for measuring true density of grains consisted of a 100 ml measuring jar and a weighing balance. Fifty ml of toluene was taken in a measuring jar and a known weight of grain sample was poured into the measuring jar. The rise in the toluene level was recorded as the true volume of the grains without void space. The true density of the grain was calculated by using the following formula (Mohsenin, 1986).

$$\text{True density } (kg/m^3) = \frac{\text{Weight of chilli (kg)}}{\text{True volume of chilli excluding void space } (m^3)}$$

Bulk density:-The bulk density was determined by using wooden box of volume 1000 ml. The kodo millet grains were filled into the box and the top was levelled off. The grains were then weighed using a precision electronic balance. The bulk density was calculated using the formula:

$$\text{Bulk density } (kg/m^3) = \frac{\text{Weight of chilli (kg)}}{\text{Volume of grains including pore space } (m^3)}$$

Porosity:- Porosity of grains was calculated by using the bulk density and true density values (that were found earlier) by using the following formula:

$$\text{Porosity, \%} = (1 - \frac{\text{Bulk density}}{\text{True density}} \times 100)$$

Colour: - The colour measurement of kodo millet was made using Minolta chromameter (Make: Minolta Instrument Co., Japan; Model-CRB 200). It is a light weight, compact tristimulus colour analyser for measuring reflected-light colour of a sample. It combines advanced electronics and optical technology to provide high accuracy and complete portability of data. Using an 8 mm diameter (measuring area) diffused illumination and a 0° viewing angle, the chromameter takes accurate colour measurements instantaneously and the readings are displayed. A Pulsed Xenon Arc (PXA) lamp in a mixing chamber provides diffused lighting over the surface of sample. Six high sensitivity silicon photocells, filtered to match the CIE (Commission International IEclairage) Standard Observer Response, were used by meter‟s double-feedback system to measure both incident and reflected lights. The chromameter detects any slight variation in the spectral power distribution of the PXA lamp and compensates automatically. Chromaticity may be measured in either Yxy (CIE, 1931) or L*a*b* (CIE, 1976) coordinates and the colour difference could be in terms of Δ (Yxy), Δ (L*a*b*), or Δ (E*ab). Data generated can be converted between co-ordinate systems between chromaticity and colour difference measuring modes by the meter. The instrument also offers a choice of either CIE illuminate C or D65 lighting conditions and in the present experiment, the CIE illuminate C was used. After initial calibration of the meter with a white colour standard, the sample was placed on the measuring head of the meter and the samples colour was measured in terms of Yxy, L*a*b* and ΔE.

Frictional properties: - The frictional properties such as coefficient of friction and angle of repose are important in designing of storage bins, hoppers, chutes, pneumatic conveying systems, screw conveyors, forage harvesters, etc.

Angle of repose:- The angle of repose determines the maximum angle of pile of grain in horizontal plane. Flow ability of grains is usually measured using the angle of repose value (a measure of the internal friction between grains) that is useful in design of hoppers (Mahmud et al., 2009). The angle of repose is the angle between base and slope of the cone formed on a free vertical fall of grains on to a horizontal plane. It was determined by following the procedure described by Sahay and Singh (1994). From the height and diameter of grains heaped in natural piles, the angle of repose was calculated by using the following formula:

$$\theta = \mathrm{Tan}^{-1}\frac{2H}{D}$$

Where,
θ = Angle of repose, degrees
H = Height of the heap, m
D = Diameter of the heap, m

Coefficient of friction: - The coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute (Ghasemi et al., 2007). The coefficient of friction of grains was determined against two material surfaces namely, card board and mild steel by “inclined surface” method (Mohsenin, 1986).The static angle of friction was determined by measuring the angle of inclination at which the grain placed on it just began to slide of inclined test surface was measured.
Coefficient of static friction = Tan θ

Where,
θ = Angle of friction, degrees

Aerodynamic properties: - Aerodynamic properties of agricultural products are important and required for design of air conveying systems and the separation equipment (Sahay and Singh, 1994).

Terminal velocity: - Terminal velocity is required to decide the velocity of winnowing air blown to separate a lighter material (Sahay and Singh, 1994). Terminal velocity is equal to air velocity at which the particle remains in suspended state in a vertical pipe. In this study, only terminal velocity of kodo millet was measured using an air column. For each test, a sample was dropped into the air stream from the top of the air column and air was blown up the column to suspend the material in the air stream. The air velocity near the location of the sample suspension was measured by digital anemometer having a least count of 0.1 m/s (Gharibzahedi et al., 2010a).

RESULTS AND DISCUSSION

The engineering properties of kodo millet grains measured at a moisture content of 9% (w.b.). The size was determined from the measurement of longitudinal and lateral diameters of 10 randomly selected grains of kodo millet and the mean values are recorded in Table 4.1. The mean longitudinal diameter of for kodo millet grain was found to be 2.983 ± 0.65 mm and the lateral diameter of kodo millet grain was found to be 2.514 ± 0.43 mm. The weight of 1000 kodo millet grains was found to be 75.23 ± 2.07 g. The shape of kodo millet grain and rice was found to be spheroid. The bulk densities of kodo millet grains, rice and husk were found to be 653, 835 and 287 kg/m3, respectively. The true densities for kodo millet grains, rice and husk were found to be 1176, 1021 and 1029 kg/m3, respectively. The porosity for kodo millet grains, rice and husk were found to be 40.0, 18.1 and 74.5% respectively. This study indicated that the values of bulk density, true density, porosity of kodo millet are close to the findings of Rajesh (2004) for little millet. The angles of repose for kodo millet grain, rice, and husk were found to be 18 34 , 24 30 and 25 12 , respectively. The coefficient of friction for kodo millet grain, rice, husk were 0.785, 0.859 and 1.702 on the glass sheet surface and 0.700, 0.819 and 1.060 on aluminium sheet surface and 0.708, 0.910, 1.150 on wooden sheet surfaces, respectively, which are comparable to the findings of Balasubramanian and Viswanathan (2010) for kodo millet. The terminal velocities of kodo millet were found to be 5.66, 6.38 and 2.20 m/s were comparable to the findings of Razavi (2008) for dehulled grains.

CONCLUSION

The mean longitudinal, lateral diameters and weight of 1000 seeds of raw kodo millet grain were 2.983mm, 2.514mm, 1.585mm and 75.29 g, respectively. The shape of grain resembled spheroid. for kodo millet grain, rice and husk, the mean values were: bulk density - (653, 835 and 287 kg/m3), true density - (1176, 1021 and 1029 kg/m3), porosity- (40, 18.1 and 74.5%) and colour - (L*a*b*) ((40.5, 7.93 and12.33), (46.8, 3.83 and 12.33) and (37.8, 3.86 and 7.83)), respectively. For kodo millet grain, rice and husk, the mean angle of repose values were 18˚34, 24˚30 and 25˚12 the values of coefficient of friction were (0.785, 0.859 and 1.702) on the glass surface, (0.700, 0.819 and 1.060) on aluminum surface and (0.708, 0.910, 1.150) on wooden surface, respectively. The mean terminal velocity for kodo millet grain, rice, and husk were found to be 5.66, 6.38 and 2.20 m/s, respectively. These properties can be used for design of equipment for handling and processing of the kodo millet.

REFERENCE

[ANJU, T. and SARITA, S., 2010, Suitability of foxtail millet (Setaria italica) and barnyard millet (Echinochloa frumentacea) for development of low glycemic index biscuits. Mal. J. Nut., 16(3): 361-368.

ISSN: 2456-8643

AOAC,2012, Official Methods of Analysis. Association of Official Analytical Chemists, Washington D.C.

BALASUBRAMANIAN, S. and VISHWANATHAN, R., 2010, Influence of moisture content on physical properties of minor millet. J. Food Sci. Tech., 47(3): 279-284.

[GARIBOLDI, F., 1972, Rice Chemistry and Technology. Edit; D.F. Houston, D.F, American Association of Ceral Chemistry. Inc., St. Paul., Minnesota, 8: 358-362

[MOHSENIN, N.N. 1986. Physical Properties of Plant and Animal Materials, 2nd edition. Gordon and Breach Science Publishers, New York.

MAHMUD, T.K., ZHU, K., ISSOUFOU, A., FATMATA, T. and ZHOU, H., 2009, Functionality, in vitro digestibility and physicochemical properties of two varieties of defatted foxtail millet protein concentrates. Int. J. Mol. Sci., 10: 5224-5238.

OJEDIRAN, J.O., ADAMU, M.A. and JIM, D.L., 2010, Some physical properties of pearl millet (Pennisetum glaucum) seeds as a function of moisture content. Afr. J. Gen. Agric., 6(1): 236-239.

RAZAVI, S.M.A., and FARAHMANDFAR, R., 2008, Effect of hulling and milling on physical properties of rice grain. Department of Food Science and Technology, Ferdowsi University of Mashhad (FUM), Thesis Book, Iran.

SWAMI, S.S. and. SWAMI, S.B., 2010, Physical properties of finger millet (Eleusine coracana). Intl. J. Agric. Engg., 3(1): 156-160.

SINGH, K.P., MISHRA, H.N. and SAHA, S., 2010, Moisture-dependent properties of barnyard millet grain and kernel. J. Food Engg., 96: 598-606.

[SUNIL, C.K., VENKATACHALAPATHY, N., SHANMUGASUNDARAM, S., AKASH PARE and LOGANATHAN, M., 2016, Engineering properties of foxtail millet (Setaria Italic l): variety- HMT 1001 International Journal of Science, Environment and Technology, 5(2): 632-637.

TAVAKOLI, T., PAYMAN, M.H., ALIZADEH, M. and KHOSHTAGHAZA, M.H., 2002, Effect of moisture content and linear speed difference on paddy dehulling quality. International Conference on Agricultural Engineering. BUDAPEST, 68 - 69.

Table 1: Physical properties of kodo millet grain, kodo rice and husk

Property	Grain			Rice			Husk		
Longitudinal diameter (mm)	2.983 ± 0.65			-			-		
Lateral diameter (mm)	2.514 ± 0.43			-			-		
Shape	Spheroid			Spheroid			-		
Weight of 1000 seeds (g)	75.234 ± 2.07			30.154 ± 1.50			-		
Bulk density (kg/m^3)	653 ± 5.40			835 ± 3.13			287 ± 2.10		
True density (kg/m^3)	1176 ± 3.46			1106 ± 2.41			1029 ± 3.10		
Porosity (%)	40.0 ± 0.50			18.1 ± 0.45			74.5 ± 0.30		
Tristimulous Colour (L* a* b*)	40.5	4.00	7.93	46.8	3.83	12.33	37.8	3.86	7.83

Table 2: Frictional and aerodynamic properties of kodo millet grain, kodo rice and husk

Property	Material	Grain	Rice	Husk
Angle of Repose	-	18˚34	24˚30	25˚12
Coefficient of Friction	Glass sheet	0.785	0.859	1.072
	Aluminum sheet	0.700	0.819	1.060
	Wooden sheet	0.708	0.910	1.150
Terminal velocity (m/sec)	-	5.66	6.38	2.20