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Research Paper :

Study of moisture based physical properties of Indian bean

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ABSTRACT

The objective of this study was to investigate some moisture dependent physical properties of the Indian bean, namely, physical dimension, size, sphericity, bulk density, thousand grain mass, true density, bulk porosity, angle of repose, grain volume, static coefficient of friction. The physical properties of Indian bean were determined at moisture level 9.77, 16.33 and 25.11per cent. The grain size and grain volume increased from 7.33 to 7.69 mm and 195 to 240 mm^3, respectively whereas, sphericity increased from 0.72 to 0.75 due to change in moisture content from 9.77 to 25.11 per cent (d.b). The bulk density and true density decreased from 833.66 to 738.2 kg/m^3 and 1282 to 1202.7 kg/m^3, respectively, while the bulk porosity increased from 34 to 38 per cent in the specified moisture content. The angle of repose increased from 29.18 to 32.21 degree and the static coefficient of friction varied between 0.24 and 0.41 with different material surfaces at the specified moisture level.

Key words : Indian bean, Physical properties, True density, Angle of repose

Now a days all developed and developing countries are boosting the production of pulses as it is very important to increase the amount of pulses in vegetarian diet. This needs better understanding of the properties for advanced applications in handling and processing. Only little is known about the basic physical characteristics and properties of agricultural products and of pulses in particular (Grover and Kumar, 1985). For developing a new innovative consumer product from Indian bean which is consumed in the form of dal in Maharashtra, although Indian bean is one of the minor pulse crop with productivity 400-500 kg/ha (Vadia *et al.*, 1998). Shape, size, volume, surface area, density, colour and appearance are some of the physical characteristics in combination with moisture content need understanding to save energy. The handling and flow of the material requires better knowledge of the frictional properties, angle of repose etc. This all helps in design of belt conveyors, screw conveyors, etc. In view of above the study was undertaken to find out properties like size, shape, density, crushing load, colour, angle of repose, coefficient of friction for machine design purpose. The data on the moisture dependent physical properties of pulse grain is scanty. Therefore, the present study was undertaken to find out effect of moisture content on physical properties of Indian bean and to determine the varietals influence of Indian bean on physical properties.

METHODOLOGY

The present study on "Study of moisture based physical properties of Indian bean" was undertaken at Padmashree Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, Kolhapur. The Indian bean pulse grain sample commercially available variety was procured from local market. The photograph of these grains with various moisture levels is shown in Fig. 1, 2 and 3. These grains contained about 10 per cent moisture (d.b.). Thousand gram of sample was taken randomly for testing purpose. The damaged and faulty grains were removed manually. The test sample of Indian bean was sundried in order to reduce moisture content about 9.77 per cent (d.b.). The moisture content was measured by standard oven dry method. The sundried samples were moistened with calculated quantity of water by using equation 1 and conditioned to raise moisture

Fig. 1 : Test sample of Indian bean at 10 per cent moisture content

Fi.g 2 : Test sample of Indian bean at 15 per cent moisture content

Fig. 3 : Test sample of Indian bean at 20 per cent moisture content

content to desired three different levels. The predetermined quantity of tap water was added to the grain lot of 1kg and was thoroughly mixed in rotating drum. These rewetted grain lots were sealed in high molecular high density polythene bags (thickness 60 micron) of size 40 X 30 cm., and subsequently kept inside gunny bags for 6 hour at room temperature and were stirred at regular interval of 2 hour for 2 days to insure uniform rewetting.

$$W_1(100+M_2) = W_2(100+M_1) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where,

W_1 and W_2=initial and final weight of sample, g and

M_1 and M_2=initial and final moisture content in per cent (d.b.).

Physical properties:

Grain size:

The geometric mean diameter was considered as the size criterion. It is the cube root of product of three axes of the grain. Three major principle axes of grain were measured with the help of micrometer screw gauge having least count of 0.005 mm. Average of observations of 100 randomly selected sound grain from each samples was calculated as follows.

$$\text{Size} = (abc)^{1/3}$$

Grain volume:

Grain volume was determined by toluene displacement method. Grain sample of about 5 g was dipped into the toluene. The volume displaced by the grains was noted. The true volume of grains was divided by the number of grains to find the grain volume.

Sphericity:

The Sphericity of gains was calculated using following formula.

$$\text{Sphericity, } \Phi = \frac{\text{Geometric mean diameter}}{\text{Major diameter}}$$

$$\Phi = \frac{(a\ b\ c)^{1/3}}{a} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

a,b,c are semi axes of major, medium and minor of the grain.

Thousand grain mass:

A method as suggested in IS: 4333 (Part IV) - 1972 was used to determine thousand grain mass. One thousand randomly selected sound grains of each variety of Indian bean at various moisture levels were collected and weighed on an electronic top pan balance having a least count of 0.01 g.

Bulk density:

Bulk density of the grains is the ratio of its mass to bulk volume of sample. To measure the bulk density of grains, a standard measuring cylinder of 500 cc was filled up with grain and then the contents were weighed. Bulk density values of the different pulse grains at various moisture contents were determined using this technique.

True density:

The ratio of mass of the sample to the true volume

is termed as true density of the sample. True density was measured at different moisture content. It was determined with toluene displacement method. Grain sample (about 5 g) was submerged in toluene in a measuring cylinder having accuracy of 0.1 ml. The increase in liquid volume due to sample was noted as true volume of the sample which was then used to determine the true density of the sample.

Bulk porosity:

It is the percentage of volume of voids in the test sample at given moisture content. It was calculated as the ratio of the difference in the true and bulk density to the true density value and expressed in percentage from the following equation.

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} \times 100 \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where,

ε = Porosity per cent

ρ_t = true density, kg/m^3 and

ρ_b = bulk density, kg/m^3

Experimentally determined true density and bulk density values of the grain samples at different moisture contents were utilized to determine the bulk porosity values.

Angle of repose:

When a granular material is allowed to flow freely from a point into a pile, the angle which the side of pile makes with a horizontal plane is called angle of repose. For measuring the angle of repose two cylinders of same size of 90×90 mm placed on one another and filled with grain, the upper cylinder taken out and the grains are allowed to slide down to form a pile to measure height and diameter of the pile. The angle of repose is calculated by following equation.

$$\theta = \tan^{-1}(2h/d) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where,

θ= angle of repose, degree

h= height of pile, mm

d= diameter of disc, mm

Static coefficient of friction

The ratio between the force of friction and the force normal to the surface of content is termed as static coefficient of friction. Coefficient of friction is also given by the tangent of the angle of the inclined surface upon which the friction force tangential to the surface and the component of the weight normal to the surface are acting. The static coefficient of Indian bean was determined on 4 different materials, namely, Glass, wood, stainless steel and galvanized iron. The tilting platform of 350×120 mm was fabricated and used for experimentation. A topless and bottomless plastic cylinder dimensions 49.4×90 mm was filled with grain and placed on the adjustable tilting surface. The cylinder was raised slightly so as not to touch the surface. The structural surface with the cylinder resting on it was inclined gradually with a screw device until cylinder just started to slide down and the angle of tilt was read from a graduated scale.

Experimental procedure:

In all experiments conditioned test sample was removed from the refrigerator and left at room temperature for six hours so as to equilibrate it with the ambient temperature before using it for physical properties determination. Moisture content of the test sample was determined before each trial by using standard oven drying method.

RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Physical properties:

Grain size and sphericity:

The data obtained for grain size, sphericity and grain volume of Indian bean at different moisture content are presented in Table 1.

The grain size, sphericity and grain volume were found linearly increased from 7.33 to 7.69 mm, 0.72 to 0.75 % and 195 to 240 mm^3, respectively in the moisture range of 9.77 to 25.11 per cent (d.b.). The grain size,

Table 1 : Principal dimension, grain size, sphericity and grain volume of Indian bean

Moisture content (% d.b.)	Major axis (mm)	Medium axis (mm)	Minor axis (mm)	Grain size (mm)	Sphericity	Grain vol. (mm^3)
9.77	10.18	7.08	5.87	7.33	0.72	195
16.33	10.20	7.20	5.59	7.43	0.73	220
25.11	10.22	7.93	5.63	7.69	0.75	240

Table 2 : Thousand grain mass, bulk density, true density and angle of repose values

Moisture content (% d.b.)	Thousand grain mass (g)	Bulk density (kg/m³)	True density (kg/m³)	Bulk porosity (%)	Angle of repose (degree)
9.77	248	833.66	1282	0.34	29.18
16.33	259	822.25	1232.5	0.35	31.01
25.11	282	738.28	1202.71	0.38	32.21

Table 3 : Values of static coefficient of friction for Indian bean against different

Moisture content (%)	Glass	Wood	S.S.	G.I.
9.77	0.274	0.292	0.244	0.25
16.33	0.326	0.418	0.284	0.328
25.11	0.334	0.388	0.260	0.346

sphericity and grain volume increased with an increase in moisture content.

Thousand grain mass:

Experimental values for the thousand grain mass, bulk density, true density and angle of repose of Indian bean are given in Table 2. It was observed that, thousand grain mass increased linearly with increase in moisture content. The results indicated that the per cent increase in thousand grain mass of Indian bean is 4.63 per cent for their corresponding increase in moisture content of 9.77 to 25.11 per cent (d.b.).

Bulk density, True density:

The data for bulk density, true density and angle of repose of Indian bean given in Table 2 Indicated that the bulk density and true density were found to decrease with increase in moisture content. The per cent decrease in bulk density and true density were 2.5 per cent and 6.24 per cent corresponding to increase in moisture content from 9.77 to 25.11 per cent (d.b.). The decrease in bulk density for all the Indian bean with increase in moisture content revealed that the increase in mass owing of moisture gain in the grain sample was lower than the accompanying volumetric expansion of the bulk. The decrease in true density with increase in moisture content might be attributed to the relatively higher volume expansion as compared to corresponding mass enhancement of grain due to adsorption of water.

Angle of repose:

The bulk porosity and angle of repose were found to increase slightly with increase in moisture content. The result indicated that the increase in bulk porosity and angle of repose values of Indian bean were 11.34 per cent and 7.11 per cent with their corresponding increase in moisture content from 9.77 to 25.11 per cent (d.b.), respectively.

Static coefficient of friction:

The data regarding the coefficient of friction of Indian bean against various structural material, namely, stainless steel, glass, wood, galvanized iron are presented in Table 3. From the results it was found that the static coefficient of friction increased with increase in moisture content for their corresponding moisture content of 9.77 to 25.11 per cent (d.b.). The values of static coefficient of friction were found in the range of 0.24 to 0.418 against various surfaces in the specified level of moisture content.

Conclusion:

– At moisture content of 9.77 per cent (d.b.) the average length, width and thickness of Indian bean were 10.18, 7.08 and 5.87 mm, respectively. The average unit mass was 248 g.

– The grain size and grain volume were found increased from 7.33 to 7.69 mm and 195 to 240 mm³, respectively, whereas sphericity increased from 0.72 to 0.75 due to change in moisture content from 9.77 to 25.11 per cent (d.b).

– The bulk density and true density decreased from 833.66 to 738.2 kg/m³ and 1282 to 1202.7 kg/m³, respectively, while the bulk porosity increased from 34 to 38 per cent in the specified moisture content.

– The angle of repose increased from 29.18 to 32.21 degrees and the static coefficients of friction varied between 0.24 and 0.41 with different material surfaces in the specified moisture level.

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REFERENCES

Grover, P.C. and Deepak, K. (1985). Some engineering properties of pulses. Proceeding of Silver Jubilee Convection, ISAE, 29-31 Oct.1985, CIAE, Bhopal Pt. II-27

Indian Standard Institution (1972). Methods of Analysis for food grains. Weight of 1000 grains. (IS: 4333 Part IV-1972), Manak Bhawan, New Delhi.

Vadia, V.G., Sahasrabuddhe, K.P. and Khuspe, V.S. (1998). Crop production and field experimentation.272-285.

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