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RESEARCH ARTICLE

Study of moisture based physical properties of paddy

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ABSTRACT : The objective of this study was to determine some moisture based psysical properties of paddy, namely, size, sphericity, bulk density, true density, bulk porosity, angle of repose, thousand grain mass, elongation ratio and flatness ratio. The physical properties of paddy were determined at moisture content 10.01, 13.42, and 19.81 per cent. At 10.01 per cent (d.b.) moisture content the average length, width and thickness of paddy were 8.23, 2.26 and 1.77 mm, respectively. The grain sizes were found increased from 3.20 to 3.42 mm, whereas sphericity increased from 0.38 to 0.41 due to change in moisture content from 10.01 to 19.81 per cent (d.b).The bulk density and true density increased from 562.81 to 688.68 kg/m^3 and 1147.31 to 1224.68 kg/m^3, respectively. While the bulk porosity decreased from 50.88 to 43.54 per cent in the specified moisture content. The angle of repose increased from 34.29 to 39.25 degrees, whereas the elongation ratio and flatness ratio decreased from 3.64 to 3.51 and 1.27 to 1.14, respectively. Thousand grain weight increased from 14.43 to 16.21 g due to change in moisture content from 10.01 to 19.81 per cent (d.b).

KEY WORDS : Paddy, Physical properties, True density, Elongation ratio, Flatness ratio

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INTRODUCTION

Paddy (*Oryza sativa* L.*)* is the most important and extensively grown crop in the world. It is the staple food of more than 60 per cent of world population. Rice is the second most important crop after Jowar in Maharashtra state. The total area under rice in the state is 15.24 lakh ha with an annual rice production of 42.11 lakh tonnes and average productivity is 2.76 t/ha. Major rice area of Kolhapur and Ratnagiri district (Maharashtra) is covered under variety, Ratanagiri-24. The duration of the crop is about 110-115 days having yield potential of 35-59 q/ha. Now a day all developed and developing countries are boosting the production of cereals as it is very important component of vegetarian diet. This needs better understanding of the physical properties. Shape, size, density, and appearance are the crucial physical characteristics in combination with the moisture content for handling, processing and to save energy. The handling and flow of the material requires better understanding of the frictional properties, angle of repose etc. The parameters in design of belt conveyors, screw conveyors, etc. Therefore, the study was under taken to find out the properties like size, shape, sphericity, elongation ratio, flatness ratio, 1000-grain wt., angle of repose, true density, bulk density, moisture content, for machine design purpose. In order to design equipment for handling, aeration, storing, and processing rice, its physical properties need to be known. The data on the moisture dependent physical properties of the cereal grains is scanty. In view of this the present study was undertaken to find out effect of moisture content on physical properties of paddy (Ratnagiri-24).

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EXPERIMENTAL PROCEDURE

The present study on study of moisture based physical properties of paddy was undertaken at Padmashree Dr. D. Y.

Patil College of Agricultural Engineering and Technology, Talsande, Kolhapur. The paddy cereal grain sample of commercially available variety (Ratnagiri-24) was procured from local market. The test sample of variety, Ratnagiri-24 was sun dried in order to reduce the moisture content and the corresponding moisture content was 9.21 to 11.18 per cent (d.b). Sun dried samples were moistened with a calculated quantity of water by using equation 1 and conditioned to raise their moisture content to the desired three different levels. The predetermined quantity of tap water was added to the grain lot of 3 kg and was thoroughly mixed. These rewetted grain lots were sealed in high molecular high density poly ethylene bags, which were kept inside wet gunny bags for 24 hrs at room temperature.

$$W_1(100+M_2) = W_2(100+M_1) \quad \text{.....(1)}$$

where,

W_1 and W_2 = Initial and final weight(g) of the sample,

M_1 and M_2 = Initial and final moisture content of the sample per cent (d.b), respectively

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 axis of grain were measured with the help of micrometer screw gauge having a least count 0.005mm. Average of observations of 100 randomly selected sound grains from each sample was calculated as follows:

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

Sphericity :

The sphericity of grains was calculated using following formula.

Degree of sphericity can be expressed as follows :

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

$$i.e.\ \Phi = \frac{(abc)^{1/3}}{a} \quad \text{.....(2)}$$

where,

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

Thousand grains 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 variety, Ratnagiri-24 at various moisture level were collected and weighed on an electronic top pan balance having least count of 0.01 g.

Bulk density :

Bulk density of the grain 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 different cereal 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 an accuracy of 0.1 ml. The increase in 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 density and bulk density to the true density volume and expressed in percentage from the following equation.

$$\varepsilon = \frac{\rho_t - \rho b}{\rho_t} \quad \text{.....(3)}$$

where,

ε = Porosity per cent

ρ_t = True density, kg/m^3

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 granular material is allowed 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 a cylindrical cone method was used, having dimensions 9cm in height and 5cm internal diameter. The cone filled with grain was placed on the floor and discharged quickly allowing the grains to slide down. The angle of repose was calculated by using the following formula :

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

where,

θ= angle of repose in degree

h = height of pile, mm

d = diameter of disc, mm

Elongation ratio :

It was determined by using the following formula:

$$\text{Elongation ratio} = \frac{A}{B} \quad \text{.....(5)}$$

where,

A-Length (major axis) in mm.

B-Breadth (medium axis) in mm.

Flatness ratio :

It was determined by using the following formula:

$$\text{Flatness ratio} = \frac{B}{C} \quad \text{.....(6)}$$

where,

B - Breadth (medium axis) in mm.

C - Thickness (minor axis) in mm.

Experimental procedure :

In all experiments conditioned test sample was removed from the air tight bags and left at room temperature for 2 hours, so as to equilibrate it with the ambient temperature before using it for physical properties determination. The moisture content of test sample was determined before each trial using the standard oven drying method.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results of the present study as well as relevant discussions had been presented under following sub heads:

Physical properties :

Grain size and sphericity :

The data obtained for grain size and sphericity of paddy at different moisture content are presented in Table 1.

The grain size and sphericity of paddy found linearly increased from 3.20 to 3.42 mm and 0.38 to 0.41 per cent, respectively in the moisture range of 10.01 to 19.81 per cent (d.b.). The grain size, sphericity increased with increase in moisture content.

Elongation ratio and flatness ratio :

The data for elongation ratio and flatness ratio of paddy are presented in Table 1. The elongation ratio and flatness ratio of paddy decreased from 3.64 to 3.51 and 1.27 to 1.14, respectively in the moisture range of 10.01 to 19.81 per cent (d.b.). The elongation ratio and flatness ratio decreased with increased moisture content.

Thousand grain mass :

Experimental values for the thousand grain mass, bulk density, true density, bulk porosity and angle of repose of paddy are given in Table 2. The result shows that thousand grain mass increased from 14.43 to 16.21 g with increase in moisture content from 10.01 to 19.81 per cent (d.b.). The thousand grain mass was found increased linearly with increase in moisture content.

Bulk density and true density :

The data for bulk density and true density of paddy are given in Table 2. The results indicated that the bulk density and true density were increased linearly with increase in moisture content. The per cent increase in bulk density was 22.40 per cent. Average values of bulk density varied from 562.81 to 688.68 kg/m^3. The average value of true density varied from 1147.31 to 1224.68 kg/m^3 and the per cent increase in true density was 6.76 per cent.

Bulk porosity and angle of repose :

The data for bulk porosity and angle of repose of paddy are presented in Table 2. The table shows that the porosity decreased linearly with increase in moisture content. The per cent decrease in porosity was 16.85 per cent. The average value of porosity varied from 43.54 to 50.88 per cent. The result indicated that the angle of repose increased linearly with increase in moisture content. The

Table 1 : Principal dimensions, grain size, sphericity, elongation ratio and flatness ratio of paddy

Moisture content (% db)	Major axis	Medium axis	Minor axis	Grain size (mm)	Sphericity	Elongation ratio	Flatness ratio
10.01	8.23	2.26	1.77	3.20	0.38	3.64	1.27
13.42	8.25	2.32	2.01	3.37	0.40	3.55	1.15
19.81	8.29	2.36	2.06	3.42	0.41	3.51	1.14

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

Moisture content (% db)	Thousand grain mass (g)	Bulk density (kg/m^3)	True density (kg/m^3)	Bulk porosity (%)	Angle of repose (degree)
10.01	14.43	562.81	1147.31	50.88	34.29
13.42	15.18	621.33	1202.98	48.25	37.97
19.81	16.21	688.68	1224.68	43.54	39.25

average value of angle of repose varied from 34.29 to 39.25 degree. The per cent increase in angle of repose was 14.46 per cent.

Conclusion :

- At moisture content of 10.01 per cent (d.b.), the average length, width, thickness of paddy was 8.23, 2.26, and 1.77 mm, respectively.
- The grain size found increased from 3.20 to 3.42 mm, whereas sphericity increased from 0.38 to 0.41 due to change in moisture content from 10.01 to 19.81 per cent (d.b.).
- The bulk density and true density increased from 562.81 to 688.68 kg/m^3 and 1147.31 to 1224.68 kg/m^3, respectively. While the bulk porosity decreased from 50.88 to 43.54 per cent in the specified moisture content.
- The angle of repose increased from 34.29 to 39.25 degrees as moisture content increased from 10.01 to 19.81 per cent (d.b.).
- The elongation ratio and flatness ratio decreased from 3.64 to 3.51 and 1.27 to 1.14, respectively as moisture content increased from 10.01 to 19.81 per cent (d.b.).
- The porosity was found decreased from 50.88 to 43.54 per cent due to change in moisture content from 10.01 to 19.81 per cent (d.b.).
- The thousand grain weight increased from 14.43 to 16.21 g due to change in moisture content from 10.01 to 19.81 per cent (d.b.).

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