A Note on the Studies of Physical Properties of Brown Rice

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***Abstract* — The objective of this study is to determine some of the physical properties of Brown rice of MTU1010 variety of paddy .The physical properties Length or Longitudinal (L), Width (W) and Thickness (T) were measured at moisture content 14.23 ± 0.60 (dry basis). The length, width and thickness for the brown rice kernels ranged from 5.35 to 7.25 mm, 1.95 to 2.3 mm and 1.64 to 1.77 mm respectively. The surface area and volume ranged from 22.2 to 27.88 mm^2 and 9.90 to 13.90 mm^3 respectively. The sphericity and aspect ratio varied from 40.27 to 51.21percent and 28 to 42.61percent respectively. The bulk density, true density and porosity were ranged from 543.4 to 568.1 kg/m^3, 1190 to 1315.7 kg/m^3 and 53.31 to 58.69 percent respectively. The thousand gain weight ranged varied from 23.27 to 25.3 gm.**

***Index Terms*— Raw paddy, Brown rice, Physical properties, Variety MTU1010**

INTRODUCTION

Brown rice is unpolished whole grain rice that is produced by removing only the hull or husk using a mortar and pestle or rubber rolls. It is distinctly brown, reddish or purplish. There is some benefit of brown rice – economics. The fuel savings in milling is 50-60% because the polishing and whitening steps are eliminated. It follows that the milling time is also shortened; labour requirements less; and the cost of equipment (if the mill is dedicated to brown rice) is much lower because the miller doesn't have to install polishers. Also, the enhancement in output volume and the economy in milling constitute the business opportunity in brown rice.

Brown rice has high dietary fiber (a gentle laxative, prevents gastro-intestinal diseases and good for diabetes sufferers); rich in B vitamins and minerals (prevents beriberi); and high in fat (energy source). Also it has been reported that brown rice contains high phytic acid (antioxidant, anti-cancer); it decreases serum cholesterol (prevents cardio-vascular diseases); and it is considered a low glycemic index food (low starch, high complex carbohydrates which decreases risk to diabetes). The enhancement of rice supply is another advantage of brown rice relative to polished or white rice. Post harvest researchers say that the milling recovery in brown rice is 10% higher than polished rice

Rice (*Oryza sativa* L.) is one of the commonly cereals and food staples for more than half of processing, drying, handling equipment, breeding and the world's population. In Asia, where 95% of the world's rice is produced and the percentage of whole grain is the most important consumed; it contributes 40-80% of the calories of Asian parameter for the rice processing industry.

The marketing values of rice as an agricultural product depend on its physical qualities after the harvesting. The percentage of whole grain is the most important parameter for the rice processing industry [1]. Broken grain has half the market value of head rice (head rice=75-100% of whole kernel) (Trop Rice International Rice Research Institute, 2004).However, kernel breakage is undesirable side effect of rice polishing. In commercial scale rice milling operation, rice kernel breakage is one of the single most important factor, which affects the economics of the rice milling breakage of rice kernels in polishing /whitening is an unavoidable phenomenon [2].

Grains handling, storage processing, preservation, quality evaluation, distribution and marketing and utilization demands comprehensive information on engineering properties of these materials. For this purpose size, volume, surface area, thousand grain weights, density, porosity, angle of repose, coefficient of friction, colour, hardness, cooking and eating qualities are of prime importance. These properties influence the design and evaluation of rice processing including drying, husking, whitening and polishing as well as grading machines, storage and grain moving equipment.

MATERIAL AND METHODS

Procurement of raw material

MTU1010 variety of paddy was procured from the Department of Physics and Agrometerology, College of Agricultural Engineering, JNKVV, Jabalpur. The moisture content was 14.23±0.60 % dry basis at the time of procurement.

Cleaning and grading

The raw material procured was clean and graded by three screen air cleaner (Osaw Grader and Cleaner, Model – Delux, S.No: T.S.G./135/85) at seed processing plant College of Agricultural Engineering, Jawaharlal Nehru Krishi Vishwa Vidhyalaya Jabalpur. The impurities which were present in the paddy lot were removed. And clean graded paddy was used for shelling.

Determination and removal of moisture content

According to the standard procedure hot air oven method of [3].weighed samples (5g) of finely ground material is kept in a dried and pre-weighed pertidish and dried in a hot air oven at 100°C for 24 hours. Later, it was cooled in a desiccators. The process of heating and cooling is repeated till a constant weight is obtained. Cooled petridish with dried material is then weighed:

$$\text{Moisture}(\%)(\text{d. b.}) = \frac{\text{Loss in weight(g)}}{\text{weight of sample(g)}} \times 100$$

Shelling of paddy

The procured paddy was converted into brown rice through rubber roll sheller (Indosaw, Mc Gill type - 0.5 hp, 230V) at rice milling laboratory of Post Harvest Process and Food Engineering department. The rubber roll Sheller removes the husk of paddy grain with the help of two rubber rolls rotating in opposite direction at different speeds.

Physical properties of different paddy varieties

Physical dimension

One hundred seeds were randomly selected to determine the size and shape of the rice kernels of different samples. Three principal linear dimensions namely, length (l), breadth/width (w) and thickness (t) were measured using a digital dial gauge (least count – 0.01 mm). Length was taken as the largest intercept of the kernel at resting position, breadth was taken as the largest intercept perpendicular to the length and thickness was measured as the largest intercept perpendicular to the length and breadth.

Size

Size and shape are important physical properties. Size measurement affects behavior of grain during handling, processing, storage and helps in designing the machinery.

$$\text{Size} = (\text{length x width x thickness})^{1/3}$$

$$\text{Size} = (\text{L x W x T})^{1/3}$$

Geometric mean diameter

The geometric mean diameter Dg (considering a spheroid shape for a rough rice grain) was calculated by the following expression [5]

$$\text{Dg}\ (mm) = \frac{(4L(W+T)^2)^{1/3}}{4}$$

Sphericity

The criteria used to describe the shape of the seed are the sphericity and aspect ratio. Thus, the sphericity (S_p) was accordingly [6] computed as:

$$\text{Sp} = \frac{(\text{L} \times \text{W} \times \text{T})^{1/3}}{\text{L}}$$

The aspect ratio (R_a) was calculated [6] as:

$$R_a = \frac{W}{L} \times 100$$

Surface area

The surface area of the individual rice kernels was measured by the analogy with a sphere of the same geometric mean diameter (D_g), using the following equation [5]

$$\text{Surface Area (S) mm}^2 = \pi.D_g^2$$

Volume

The unit volume of the rice kernels was calculated by the following relationship [5]:

$$\text{Volume (V)} = \frac{\pi \text{ x l x b x t}}{6}$$

Where, V = unit volume in mm^2.
l, b, t = length, breadth and thickness in mm.

Thousand grain weight

In handling and processing of grains, it is customary to know the weight of 1000 grain kernels. The 1000 grain weight is a good indicator of the grain size, which can vary relative to growing conditions and maturity, even for the same variety of a given crop. When compared with other crops at the same moisture level, the 1000 kernel weight will also provide an idea of relative size of the kernel for handling purposes. Generally, this is measured directly by taking the weight of 1000 grain kernels.

Density

The density value of the grains helps in designing of storage bins, silos, separators and cleaning and grading equipments.The bulk density of cereal grains is determined by measuring the weight of a grain sample of known volume. The grain sample is placed in a measuring cylinder. The bulk density of the grain sample is obtained simply by dividing the weight of the sample by the volume of the container. From the storage point of view, it is important to determine the effect of moisture content on the bulk density of grains because the bulk density of some grains increase with an increasing moisture content, whereas it decreases for some other grains.

$$\text{Bulk density}(\rho b) = \frac{\text{Mass of sample(kg)}}{\text{Total volume } (m^3)}$$

The true density of the kernels is the density of grains excluding the voids. This was determined by the toluene (C_7H_8) displacement method. In this method, 50 ml toluene was filled in a 200 ml measuring cylinder and then same mass of sample that was taken for bulk density was put into the vessel containing toluene. The displacement of toluene level in the vessel on putting rice kernels was noted down. The ratio of the mass of rice kernels to the volume of displaced gave the true density:

$$\text{True density } (\rho t) = \frac{\text{Mass of sample (kg)}}{\text{Volume of displaced toluene}(m^3)}$$

Porosity

The porosity of rice grains refers to the fraction of the pore spaces in the bulk grain that is not occupied by the grain. It is calculated from the values of true density and bulk density by the following relationship:

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

Where, True density = ρ_t
Bulk density = ρ_b

Preparation of brown rice samples

One thousand sound grains were selected randomly dehusked and brown rice was produced from them by hand pounding method. This was done very gently so that minimum damage caused to the bran layer of the kernel. The thousand kernels then weighed using weighing balance (0.01mm least count).

STATISTICAL ANALYSIS

In the present study, the results are expressed in terms of mean values and standard deviations (S.D.).

RESULTS AND DISCUSSION

Three major dimensions i.e. length, width and thickness of hundred kernels of brown rice (MTU1010) was measured by digital dial gauge (0.01 mm). The average values of linear dimensions along with the standard deviation are shown in Table 1. Length of the kernels varied from 5.35 to 7.25 mm, width 1.95 to 2.3 mm, thickness 1.64 to 1.77 mm. The standard deviation was calculated as ± 0.51, ± 0.09 and ± 0.045 for length, width and thickness respectively. Length was taken as maximum dimension followed by width and thickness. The above observations are in agreement with the findings of [5]

The geometric mean diameter ranged from 2.09 to 2.98 mm with standard deviation ±0.20 mm. The thousand grain weight of paddy was 23.27 to 25.3 gm with standard deviation ± 0.74 .

The calculated values of surface area of kernels are average of hundred grains are shown in the Table 1. The surface area ranged was observed from 22.2 to 27.88 mm^2 with standard deviation ± 3.14. The above finding are in agreement with the findings of [5]

The sphericity of brown rice kernels are is shown in the table 1. The values of sphericity varied from 40.27 - 51.21 percent with standard deviation ± 2.51. This revealed that the grains could not be considered as spherical because the value of sphericity was less than 70% [4]

The bulk density, true density and porosity were found to be 543.4 - 568.1 kg/m^3, 1190 - 1315.7 kg/m^3, 53.31 - 58.69 percent respectively. The standard deviation of bulk density, true density and porosity were observed ± 10.30, ± 49.64 and ± 1.92 respectively. The bulk density gives a good idea of the storage space required for a known quantity of particular grain. Bulk density also influences the effective conductivity and other transport properties. This values of true density indicates that , the kernel density is higher than water, which important property in case of food grains. These observations are in agreement with the observations of [5]

The calculated values of volumes of individual rice kernels are the average of hundred grains are shown in the Table 1. The volume of the brown rice kernels was observed 9.90 - 13.90 mm^3 with standard deviation ± 1.22. The above results are in agreement with the findings of [5]. The aspect ratio of the brown rice kernels ranged 28 - 42.61 percent with standard deviation ± 1.72.

Table 1 Some physical properties of Brown rice

Property	Number of observation	Mean value	Standard deviation	Minimum value	Maximum value
Length, mm	100	6.393	0.51	5.35	7.25
Width, mm	100	2.14	0.09	1.95	2.3
Thickness, mm	100	1.9	0.05	1.64	1.77
Geometric Mean Diameter, mm	100	2.84	0.20	2.06	2.98
Sphericity, %	100	42.68	2.51	40.7	51.21
Aspect Ratio	100	33.71	1.72	28	42.61
Volume, mm^3	100	12.17	1.22	9.9	13.9
Surface area, mm^2	100	25.49	3.14	22.2	27.88
Bulk density kg/m^3	5	553.18	10.30	543.4	568.1
True density kg/m^3	5	1251.44	49.64	1190	1315.7
Porosity, %	5	55.7	1.92	53.31	58.69
Thousand grains weight, gm	5	24.23	0.74	23.275	25.3

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