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Some Physical Properties of Rice Seed (*Oryza sativa*)

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Abstract: Physical and mechanical properties of rice are necessary for the design of equipment to handle, transport, process and store the crop. These properties were evaluated as a function of moisture content of grain. The objective of this work was to determine the physical and mechanical properties of rice. The grain was tested for bulk density, true density, sphericity, porosity, angle of internal friction and coefficient of friction with various materials at 12% moisture content (dry basis, db). The average length, width, thickness and the average thousand grain weight of the rye grains were, 7.43, 2.75, 2.53 mm and 26.91 g. The static coefficient of friction 0.4835, 0.4061 and 0.3670 for wood, galvanized iron and glass surfaces respectively. The higher friction coefficient values were observed on wood surface and the lowest on steel surface.

Key words: Angle of repose, bulk density, coefficient of friction, physical properties, rice

INTRODUCTION

Rice (*Oryza sativa* L.) stands out, constituting the basic food for large number of human beings, sustaining two-thirds of the world population (Zhout *et al*., 2002). Rice *(Oryza sativa* L.) is the most important cereal crop cultivated in the world, which feeds more than half the world population (TRIRRI, 1998-2004). It grows widely and finds many uses.

The physical and mechanical properties of rice, which are important in the design and selection of storage structures and storage and processing equipment, depend on grain moisture content. Therefore, the determination and consideration of properties such as bulk density, true density, angle of internal friction and static coefficient of friction of grain has an important role (Mohsenin, 1980; Molenda *et al.*, 2002; Kashaninejad *et al*., 2006). The principal axial dimensions of rye seeds are useful in selecting sieve separators and in calculating power during the rye milling process.

Knowing the grain's bulk density, true density and porosity can be useful in sizing grain hoppers and storage facilities: they can affect the rate of heat and mass transfer of moisture during the aeration and drying processes. A grain bed with low porosity will have greater resistance to water-vapor escape during the drying process, which may lead to the need for higher power to drive the aeration fans. Cereal-grain kernel densities have been of interest in breakage susceptibility and hardness studies (Chang, 1988). The static coefficient of friction is used to determine the angle at which chutes must be positioned to achieve consistent flow of materials through the chute. Such information is useful in sizing motor requirements for grain transportation and handling (Ghasemi *et al*., 2008). Other researchers have determined the properties of different types of grains and seeds: canola and wheat (Bargale *et al*., 1995) lentils; (Çarman, 1996); sunflower seeds (Gupta and Das, 1997); black pepper (Murthy and Bhattacharya, 1998); pigeon peas (Baryeh and Mangobe 2002); cotton (Ozarslan, 2002); millet (Baryeh, 2002); popcorn (Karababa, 2006); caper seeds (Dursun and Dursun, 2005); pistachio nuts (Kashaninejad *et al*., 2006); and barley (Özturk and Esen, 2008).

Many studies have reported on the physical, chemical and surface properties of wheat husks, rye husks and soft wood and their polypropylene composites (Bledzki *et al*., 2010); rheological properties of dough and sensorial quality of bread made from a whole meal rye wheat blend with the addition of gluten (Saiz *et al*., 2007); and rheological properties of rye mash prepared by pressure less liberation of starch in mashing and fermentation (Czuprynski *et al*., 2003). But there has been no study to date on the physical properties of rice seeds.

This study investigated the some physical and mechanical properties of the variety of rice typically cultivated in Iran. The parameters measured were bulk density, true density, angle of internal friction and static coefficient of friction.

MATERIALS AND METHODS

Sample preparation: Rice seeds were collected in October 2010 from a farm in north province of Iran. The

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variety (Sadri) used in the study is the prevalent variety in the studied region. This work was carried out in the Laboratory of Physical Properties and packaging in Department of Food Science and Technology in University of Tehran, Karaj, Iran. The seeds were cleaned in an air-screen cleaner to remove all foreign matter such as dust, dirt, stones, chaff and immature and broken seeds. The seeds' initial moisture content was determined by the oven method (Tabatabaeefar, 2003).

The samples were placed into polyethylene bags and sealed. The sealed samples were kept in a curing room for two days to enable the moisture to distribute uniformly throughout the grains. After the grains reached equilibrium moisture, each sample was placed in a dessicator. Before each test, the required quantity of samples was taken out of the dessicator and allowed to warm to room temperature.

For grain moisture content considered, 50 grains were selected at random from the chamber, dried down to the desired moisture content and the length, width and thickness were measured in three mutually perpendicular directions using a micrometer gauge reading to 0.001 mm. Several investigators (Shepherd and Bhardwaj, 1986; Dutta *et al*., 1988; Joshi *et al*., 1993; Mohsenin, 1970; Singh and Goswami, 1996; Deshpande and Ojha, 1993) have measured these dimensions for other grains and seeds in a similar manner to determine size and shape properties. The sphericity was calculated using (1) and (4), the volume using Eq. (5) and the surface area using (6) and (7). Grain mass was measured with a sensitive electronic balance of 0.001 gm sensitivity.

After the determination of the dimensions, all other measurements which followed were replicated five times at the moisture content considered and the averages were calculated. The grain or true density was determined using the toluene displacement method (Singh and Goswami, 1996). The bulk density was determined with a weight per hectolitre tester which was calibrated in kg per hectolitre (Deshpande and Ojha, 1993; Sharma *et al*., 1985; Suthar and Das, 1996; Jain and Bal, 1997). This may also be done using the air comparison pycnometer (Thompson and Isaacs, 1967). The porosity was then calculated using Eq. (8).

According to Mohsenin (1970), the degree of sphericity, φ can be expressed as follows:

$$\varphi = \frac{(LWT)1/3}{L} \tag{1}$$

where L is the grain length, W the grain width and T is the grain thickness:

$$D_g = (LWT)^{1/3} \tag{2}$$

$$\varphi = \frac{D_g}{L} \tag{3}$$

The geometric mean diameter, D_g is given by Sreenarayanan *et al*., (1985) and Sharma *et al*. (1985). Jain and Bal (1997) have also stated that the sphericity, φ seed volume, V and grain surface area, S may be given by Sharma *et al*. (1985), Jain and Bal (1997) and Sreenarayanan *et al*. (1985):

$$\varphi = \left(\frac{B(2L-B)}{L^2}\right)^{1/3} \tag{4}$$

$$V = \frac{\pi B^2 L^2}{6(2L-B)} \tag{5}$$

$$S = \frac{\pi B L^2}{2L-B} \text{ where } B = (WT)^{0.5} \tag{6}$$

The surface area, S was also found by McCabe *et al*. (1986) to be given by:

$$S = \pi D_g^2 \tag{7}$$

According to (Mohsenin, 1970; Thompson and Isaacs, 1967), the porosity, ϵ is given by:

$$\epsilon = \frac{\left[(\rho_g - \rho_b)100\right]}{\rho_g} \tag{8}$$

where ρ_b is the bulk density and ρ_g is the true or grain density

The static coefficients of friction were determined with respect to three surfaces: wood, glass and galvanized iron. A hollow metal cylinder (Fig. 1) of diameter 75 mm and depth 50 mm and open at both ends was filled with the seeds at the desired moisture content. It was then placed on an adjustable tilting surface such that the metal cylinder. The surface was tilted gradually until the filled cylinder just started to slide down (Razavi and Milani, 2006).

The static angle of repose is the angle with the horizontal at which the material will stand when piled. This was determined by using an apparatus (Fig. 2) consisting of a plywood box 140×160×35 mm and two plates: fixed and adjustable. The box was filled with the sample and the adjustable plate was inclined gradually,

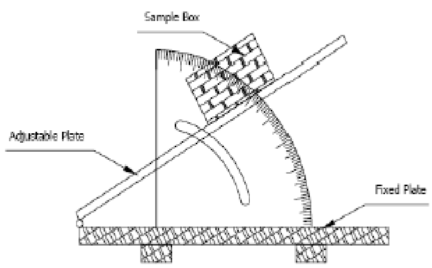

Fig. 1: Apparatus to determine emptying angle of repose

Fig. 2: Apparatus to determine coefficient of static friction

Table 1: Some physical properties of Sadri variety

	Variety (Sadri)			
Property	Mean	Max	Min	CV (%)
Length[ns](mm)	7.43	8.31	7.26	1.02
Width[a] (mm)	2.53	2.62	2.11	0.33
Thickness[ns](mm)	2.75	2.97	1.88	0.68
Equivalent diameter[b]	-	-	-	-
(mm)	3.48	3.87	3.21	0.42
Sphericity[ns](%)	4.352	4.631	4.107	0.31
Thousand weight	-	-	-	-
of grains[ns]	28	31	23	3.41
Porosity (%)	46	49	41	1.08
Bulk density(kg/m^3)	541	589	520	3.02
True density (kg/m^3)	1108.98	1218.06	1048.47	35.70
Angle of repose[ns](deg.)	34	36	31	0.28

ns: Not significiant

Table 2: Static coefficient of friction of Sadri variety against different surface

		Sadri			
Surface	No. of observation	Mean	Max	Min	SD
Plywood	40	0.4835	0.5021	0.4330	0.4420
Glass	40	0.3670	0.3984	0.3176	0.3244
Galvanized iron sheet	40	0.4061	0.4248	0.3752	0.3781

allowing the seeds to follow and assume a natural slope (Tabatabaeefar, 2003). Finally, the data were analyzed statistically and figures were plotted using Excel software (2003).

All the experiments were replicated three times, unless stated otherwise and the average values calculated. All the data was statistically analyzed for various parameters of study at different moisture contents using the SPSS statistical program. Duncan's multiple comparison was used to determine the difference existing at a 1% level of significance.

RESULTS AND DISCUSSION

The average values of the physical properties, grain specific gravity, bulk density and porosity for the studied factors are shown in Table 1. The mean dimensions of about 40 samples at a moisture content of 12% (wb) were: length 7.43 mm, width 2.75 mm and thickness 2.53 mm (Table 2).

A summary of the physical properties of rice is shown in Table 1. Seeds graded uniformly, according to size, provide uniform germination and usually give increased harvesting yield. Effective grading according to width, through sieves with round holes, occurs when the particles lie along the axis perpendicular to the surface of the sieve. For this, the sieve must be vibrating vertically. When the length of the particle is no more than twice the width, the grading is satisfactory even on sieves which vibrate horizontally (Klenin *et al*., 1986). Considering the latter fact, for grading the tested cultivars, grading based on horizontal vibration can be performed. The equivalent diameters for Sadri cultivar were 3.48.

CONCLUSION

This investigation into the properties of rye grains gives rise to a number of conclusions. This study concludes with information on engineering properties of Sadri variety which may be useful for designing much of the equipment used for rice processing. The static coefficient of friction was highest for wood, followed by galvanized iron and glass. The static coefficient of friction and angle of repose is necessary to design conveying machine and hopers used in planter machines. When seeds are ground in mills, the rupture force must be known in order to achieve desirable properties without unnecessary expenditure of energy.

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