

SOME PHYSICAL PROPERTIES OF RICE SEED (ORIZA 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, 7.43mm, 2.75mm, 2.53mm 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.

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KEY WORDS

Rice; Angle of repose;
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[I] INTRODUCTION

Rice (*Oryza sativa* L.) is the basic food for two-thirds of the world population and is the most important cereal crop cultivated in the world [1, 2]. 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 [3, 4, 5]. 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 [6]. 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 [7]. Other researchers have determined the properties of different types of grains and seeds: canola and wheat [8] lentils; [9]; sunflower seeds [10]; black pepper [11]; pigeon peas [12]; cotton [13]; millet [14]; popcorn [15]; caper seeds [16]; pistachio nuts [5]; and barley [17].

Many studies have reported on the physical, chemical and surface properties of wheat husks, rye husks and soft wood and their polypropylene composites [18]; rheological properties of dough and sensorial quality of bread made from a whole meal rye wheat blend with the addition of gluten [19]; and rheological properties of rye mash prepared by pressure less liberation of starch in mashing and fermentation [20]. 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.

[II] MATERIALS AND METHODS

2.1. Sample Preparation

Rice seeds were collected in October 2010 from a farm in north province of Iran. The 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 [21].

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 desiccator. Before

each test, the required quantity of samples was taken out of the desiccator 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 [22, 23, 24, 25, 26, 27] 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 [26]. The bulk density was determined with a weight per hectoliter tester which was calibrated in kg per hectoliter [27, 28, 29, 30]. This may also be done using the air comparison pycnometer [31]. The porosity was then calculated using Eq. (8).

According to Mohsenin (1970), the degree of sphericity, ϕ can be expressed as follows [25]:

$$(1) \phi = \frac{(LWT)^{1/3}}{L}$$

Where L is the grain length, W the grain width and T is the grain thickness.

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

$$(3) \phi = \frac{D_g}{L}$$

The geometric mean diameter, D_g is given by (Sreenarayanan, Subramanian, & Visvanathan, 1985; Sharma, Dubey, & Teckchandani, 1985): Jain and Bal (1997) have also stated that the sphericity, ϕ seed volume, V and grain surface area, S may be given by [28, 30, 32]:

$$(4) \phi = \left[\frac{B(2L - B)}{L^2} \right]^{1/3}$$

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

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

The surface area, S was also found by McCabe, Smith, and Harriott (1986) [33] to be given by:

$$(7) S = \pi D_g^2$$

The bulk density was determined by dividing this weight by the 20 cc volume. This method was repeated five times; the averaged bulk density was thus determined. True density – defined as the ratio of the volume of particles – was determined using the water displacement method to the known volume of the sample.

According to Mohsenin (1970) [25] and Thompson and Isaacs (1967) [31], the porosity (ϵ) is given by:

$$\epsilon = \frac{[(\rho_g - \rho_b)100]}{\rho_g}$$

(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 [Figure-1] of diameter 75mm and depth 50mm 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 [34].

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 [Figure-2] consisting of a plywood box 140 x 160 x 35 mm and two plates: fixed and adjustable. The box was filled with the sample, and the adjustable plate was inclined gradually, allowing the seeds to follow and assume a natural slope [21]. 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.

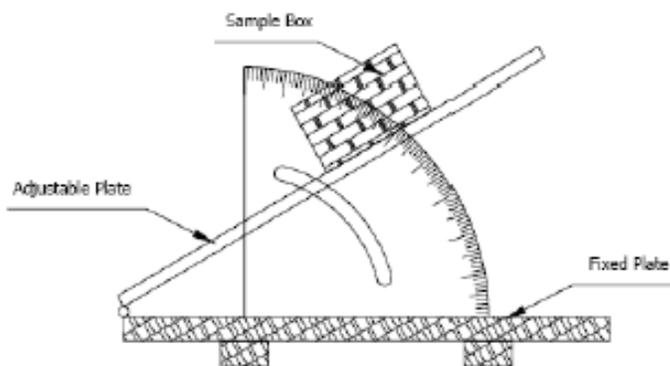


Fig: 1.



Fig: 2.

Fig: 1. Apparatus to determine emptying Angle of Repose. Fig: 2. Apparatus to Determine Coefficient of Static Friction

[III] 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 7.43mm, width 2.75mm and thickness 2.53mm. 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 [35]. 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.

Table: 1. Some physical properties of Sadri variety

Property	Variety (Sadri)
	Mean± SD
Length ^{ns} (mm)	7.43±1.02
Width ^a (mm)	2.53±0.33
Thickness ^{ns} (mm)	2.75±0.68
Equivalent diameter ^b (mm)	3.48±0.42
Sphericity ^{ns} (%)	4.352±0.31
Thousand weight of grains ^{ns}	28±3.41
Porosity (%)	46±1.08
Bulk density (kg m ⁻³)	541±3.02
True density (kg m ⁻³)	1108.98±35.70
Angle of repose ^{ns} (deg.)	34±0.28

Table: 2. Static Coefficient of friction of Sadri variety against different surface

Property	Variety (Sadri)
	Mean± SD
Length ^{ns} (mm)	7.43±1.02
Width ^a (mm)	2.53±0.33
Thickness ^{ns} (mm)	2.75±0.68
Equivalent diameter ^b (mm)	3.48±0.42
Sphericity ^{ns} (%)	4.352±0.31
Thousand weight of grains ^{ns}	28±3.41
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[IV] CONCLUSION

This investigation into the properties of rye grains gives rise to a number of conclusions. This paper 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 hoppers 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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CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest.

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