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Note

Physical properties of two rough rice varieties affected by moisture content

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A b s t r a c t. The effect of moisture content on some physical properties of two common rice varieties (Sorkheh and Sazandegi) was determined. Moisture content had a significant effect on minor diameter, geometric mean diameter, mass, bulk and true densities, porosity, static coefficient of friction and angle of repose. The geometric mean diameter, sphericity, true density and angle of repose increased and bulk density decreased as moisture content increased from 12 to 16% (w.b.). The highest coefficient of static friction was observed on concrete surface and the lowest on glass surface among the materials tested.

K e y w o r d s: rice, varieties, moisture content, physical properties

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the commonly consumed cereals for more than half of the world's population. It is an important source of energy, vitamins, mineral elements and rare amino acids. World rice production increased from 520 to 605 mln t, while Iran rice production increased from 1.3 to 3.4 mln t in 1980 and 2004, respectively (FAOSTAT, 2005).

Physical and mechanical properties of agricultural materials are important in optimum design of machinery for planting, harvesting, storing and processing operations, such as threshing, handling, cleaning and drying. Principal dimensions of rough rice are used for selecting sieve separators and in calculating power requirements during rice milling operation. They are also useful to calculate the surface area and volume of kernels which are necessary in drying and aeration processes modelling. The length of rough rice affects its head rice yield (HRY) which is defined as the mass percentage of rough or unprocessed rice that remains as head rice (equal to or greater than 3/4 intact kernels) after milling. The head rice yield reduction of long and medium grain rice varieties was studied in relation to different harvesting and drying conditions (Fan *et al.*, 2000). The results revealed that the medium-grain Bengal cultivar showed a higher head rice yield reduction than did long-grain Cypress or Kaybonnet cultivars.

In spite of good aroma and flavour of cooked rice of rice varieties common in Isfahan province (central Iran), their breakage losses are excessive. As mentioned earlier, variation in rice milling quality could be as a result of variation in its physical properties, especially regarding variety type and its conditions.

The aim of this study was to investigate the effect of moisture content on the physical properties of two common rough rice varieties.

MATERIAS AND METHODS

Two common rough rice varieties (Sorkheh and Sazandegi) which are grown in Isfahan province (central Iran) were acquired from the Isfahan Centre for Research of Agricultural Science and Natural Resources (ICRASN). The samples were cleaned manually to remove stones, straw and dirt, and then sieved to remove broken and damaged kernels. Initial moisture content of samples was determined by drying them in an oven according to ASAE Standard (2001). Initial moisture content (MC) of Sorkheh and Sazandegi cultivars was 20.5 and 21.2% (w.b.), respectively. The samples were then air-dried under sunlight at mean day temperature of 26.2°C until they reached to desirable moisture content levels of 11-13, 13-15, and 15-17% (w.b.) (henceforth referred to as 12, 14, and 16% (w.b.), respectively). The selected moisture content levels were due to perform the milling operation in this range in the region. The rough rice samples were finally sealed in double plastic bags and stored at approximately 4°C before conducting the experiments.

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The desired physical properties, including dimensions, mass, geometric mean diameter, sphericity, true density, bulk density and porosity, static coefficient of friction and angle of repose, were determined based on a standard method (ASAE, 2001).

The experimental design was randomized complete design with factorial layout in which two tested varieties and three levels of moisture content were the independent parameters and the physical characteristics were the dependent parameters. Treatment effects were analysed using analysis of variance by the procedure of SAS. When the analysis of variance was significant ($P<0.05$), treatment means were separated by the Duncan multiple-range test at a probability level of 0.05.

RESULTS AND DISCUSSION

The analysis of variance of dimensions, geometric mean diameter (GMD), mass, and sphericity with least square difference (LSD) test indicated that the variety type had a significant effect at 0.1% probability level (PL) on these properties. The moisture content also had a significant effect at 1% PL on dimensions and mass and 5% PL on GMD. But the effect of moisture content on the other properties was not significant. As Table 1 shows, except for length, in other physical characteristics Sazandegi had significantly lower mean values than Sorkheh. According to the length and width values of two cultivars, Sorkheh would have a more significant aspect ratio (the ratio of width to length) compared to Sazandegi. This fact could affect the behaviour of tested varieties during milling operation and, consequently, the obtained HRY. For both varieties, the kernel length is more than twice of its width (Table 1). When the particle major diameter (length) is more than twice its intermediate diameter (width), the grading is satisfactory even on sieves having a horizontally reciprocating motion. According to mean values of diameters for both cultivars (Table 1), their grading could be proposed with horizontally vibrating sieves. In contrary to the length and width, the thickness was significantly affected by moisture content, so that with increasing moisture content from 12 to 16% (w.b.) the average thickness increased from 1.89 to 1.96 mm. It should be mentioned that the mean values of sphericity for Sorkheh (0.435) and Sazandegi (0.400) fall within the range of 0.32-1 reported for most agricultural products (Lewis, 1999; Mohsenin, 1986). The analysis of variance results of true density, bulk density and porosity showed that, except for true density, the effect of variety was significant on the other properties. But the effect of moisture content was significant on abovementioned properties. This finding is supported by the results presented for Brazilian rice (Correa *et al*., 2007). The results showed that Sorkheh variety had significantly higher bulk density than Sazandegi variety (598 vs. 576 kg m^{-3}) (Table 1). This could be due to the higher sphericity of Sorkheh. The higher the spericity value of the kernels, the more regular is the array of them together. Consequently, there would be smaller cavities between the kernels, which in turn results in higher bulk density. Bulk density values are necessary in sizing hoppers and storage equipments of grains. Also they are useful to determine the product mass or volume in the tank of combine harvester which itself is an appropriate parameter for yield monitoring in precision farming. The mean values of true density for Sorkheh and Sazandegi varieties were 1136 and 1131 kg m^{-3}, respectively, and did not show any significant difference. The true density of cereal grains is important to separate different impurities from them as the true density of cereal crops and most impurities widely differ. The moisture content increased to the true density increased significantly (Table 1). The mean values of porosity (47.41 and 48.85% for Sorkheh and Sazandegi, respectively) were lower than the values reported for three Brazilian varieties (64 to 66%) (Correa *et al*., 2007). This difference is due to inherent characteristics of varieties. Similar to the Paksoy and Aydin (2004) study, porosity was increased when moisture content increased.

T a b l e 1. Chosen physical properties of rough rice affected by variety and moisture content

Experimental factor	Length	Width	Thickness	GMD	Mass	Sphericity	Bulk density	True density	Porosity
	(mm)				(g)		(kg m^{-3})		(%)
Variety type									
Sorkheh	8.27^{b}*	2.85^{a}	1.98^{a}	3.596^{a}	0.026^{a}	0.435^{a}	598^{a}	1 136^{a}	47.41^{b}
Sazandegi	8.68^{a}	2.47^{b}	1.88^{b}	3.422^{b}	0.024^{b}	0.400^{b}	576^{b}	1 131^{a}	48.85^{a}
Moisture content (% w. b.)									
12	8.43^{a}	2.63^{a}	1.89^{c}	3.465^{b}	0.026^{b}	0.412^{b}	594^{a}	1 114^{c}	46.70^{b}
14	8.53^{a}	2.68^{a}	1.93^{b}	3.525^{a}	0.026^{b}	0.415^{ab}	584^{c}	1 136^{b}	48.65^{a}
16	8.47^{a}	2.68^{a}	1.96^{a}	3.538^{a}	0.028^{a}	0.419^{a}	587^{b}	1 152^{a}	49.04^{a}

*For each factor, the means followed by the common lower case letter in the columns do not differ statistically at 5% probability level through the least significant difference (LSD) test.

The effect of variety, moisture content and surface type on static coefficient of fiction was only significant at 0.1% probability level. The same result has been reported for three Brazilian varieties tested at moisture content of 12% (w.b.) (Correa *et al*., 2007). Table 2 shows that the values of coefficient of static friction on the tested surfaces were significantly decreased in the order of concrete (0.432), galvanized iron sheet (0.363), plywood (0.276) and glass (0.082). Between the two tested cultivars, Sorkheh had a significant higher static coefficient of friction (0.303) than Sazandegi (0.237). Table 2 indicates also that increase of moisture content from 12 to 16% (w.b.) had a significant effect on this attribute, so that mean value of the coefficient of static friction increased with increasing moisture content. Amin *et al*., (2004) reported the same result in their study on frictional properties over concrete, galvanized iron sheet, wood and glass surfaces. In their study, static coefficient of friction increased from 0.458 to 0.490 as moisture content increased. Also concrete and glass surfaces showed the maximum (0.432) and minimum (0.082) static coefficient of friction, respectively.

T a b l e 2. Coefficient of static friction of rough rice affected by variety and moisture content

Experimental factor	Static coefficient of friction
Frictional surface	
Plywood	0.276[c]*
Glass	0.082[d]
Concrete	0.432[a]
Galvanized iron sheet	0.363[b]
Variety	
Sorkheh	0.303[a]
Sazandegi	0.273[b]
Mmoisture content (% w. b.)	
12	0.262[c]
14	0.292[b]
16	0.310[a]

*Explanations as in Table 1.

The results revealed that the effect of variety and moisture content was significant on both angles of repose (emptying and fil- ling) at 0.1% probability level. As Table 3 indicates, Sorkheh variety had higher values of both angles of repose (35.6 and 29.6 versus 31.7 and 26.1°, respectively). For each variety and at each moisture content, mean value of emptying angle of repose was higher than the filling angle. Both angles were increased while moisture content increased (Table 3). Angle of repose is useful in determining the flow ability of rough rice which could help in optimum hopper design, since the inclination angle of hopper wall should be larger than the grain angle of repose to ensure continuous flow of grain by gravitational force.

T a b l e 3. Angle of repose of rough rice affected by variety and moisture content

Experimental factor	Angle of repose (°)	
Variety	Emptying	Filling
Sorkheh	35.6[a]*	29.6[a]
Sazandegi	31.7[b]	26.1[b]
Moisture content (% w. b.)		
12	32.6[c]	27.2[c]
14	33.7[b]	27.8[b]
16	34.6[a]	28.5[a]

*Explanations as in Table 1.

CONCLUSIONS

1. In all physical attributes related to the size and shape, as well as coefficient of static friction and angle of repose, Sazandegi had significantly lower mean values than Sorkheh, exept for length.

2. Although there was not a significant difference between true density of tested cultivars, Sorkheh variety had significantly higher bulk density and consequently a significantly lower porosity.

3. The thickness, true density, coefficient of static friction and both angles of repose (empting and filling) of the investigated rice varieties showed a positive significant variation with moisture content.

REFERENCES

Amin M.N., Hossain M.A., and Roy K.C., 2004. Effects of moisture content on some physical properties of lentil seeds. J. Food Eng., 65, 83-87.

ASAE Standard, **2001.** Moisture Measurement-Unground Grain and Seeds. ASAE Press, St. Joseph, MI, USA.

Correa P.C., Schwanz da Silva F., Jaren C., Afonso Jr. P.C., and Arana I., 2007. Physical and mechanical properties in rice processing. J. Food Eng., 79, 137-142.

Fan J., Siebenmorgen T.J., and Yang W., 2000. The head rice yield reduction of long and medium grain rice varieties in relation to various harvested and drying conditions. Transaction of the ASAE, 436, 1709-1714.

FAOSTAT, **2005.** Rice Production. Available from http://faostat.fao.org.

Lewis M.J., 1990. Physical Properties of Food and Food Processing System. Ellis Horward Press, Chichester, UK.

Mohsenin N.N., 1986. Physical Properties of Plant and Animal Materials. Gordon and Breach Press, New York, USA.

Paksoy M. and Aydin C., 2004. Some physical properties of edible squash seeds. J. Food Eng., 65, 225-231.