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Effect of moisture content on some of physical properties of two paddy grain varieties (Domsiah and Rezajoo)

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Abstract

Determination of physical properties of agricultural products is essential to analyzing their behavior during processing operations such as moving, peeling, cleaning, sorting, drying and storage. In this research, the effects of grain moisture content (at levels of 10, 14 and 18%) and kind of cultivars were investigated on the physical properties of two cultivars of rice paddy grain, namely Rezajoo and Domsiah. Based on the results, by increasing the moisture content, except for sphericity coefficient, other physical properties such as length, width, thickness, geometrical diameter, arithmetic diameter, surface, volume and the gravity properties such as bulk density, true density, porosity and 1000 grain mass increased while the kind of cultivar has not significant effect on these properties.

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Introduction

Rice is an annual plant from the "Gramminae" family and the genus of *Oryza sativa* L. with various species. In Iran, it is more planted in Northern Province of the country, Isfahan and Shiraz and after wheat; it is the most important source of food and in most parts of the country is eaten as rice grain. Paddy is defined as rice that its outer shell is not taken but brown rice is rice that its outer shell is taken and the bran layer is attached to its endosperm (Movahed, 2011). Processing of agricultural products include operations that are performed in order to maintain or improve the quality that in this regard, determining the physical properties of agricultural products is necessary to design the machinery of planting, storing and harvesting as well as to analyze their behavior during processing operations such as moving, peeling, cleaning, separating, drying and storing. Therefore, designing these devices will accompany with poor results without considering these properties. The most important dimensional properties depending on the moisture content of biological material include dimension, volume, geometric diameter and sphericity (Mohsenin, 1970). In order to design the equipment of transportation, packaging and storage, studying the gravity properties as a function of various factors including moisture content and variety is essential. Knowing the bulk density and porosity of the material is most widely used for designing dryers and silo. The bulk density is the main parameters used in the theory of predicting the pressures on the matter during storage (Ghasemi Varnamkhasti *et al.,* 2008). Gupta *et al.* (1997) determined some physical properties of sunflower seeds in a moisture content range from 4 to 20 (d.b%). They found that the seed length has a significant relationship with its width and thickness while its relationship with seed mass is not significant. Based on the results, by increasing the moisture content from 4 to 20(d.b%) the true density, porosity, static friction coefficient and velocity increased but the bulk density decreased (Gupta and Das, 1997). Amin *et al.* (2003) studied the different levels of moisture content on the physical properties of lentil seeds such as dimension, true and bulk density, porosity, friction properties and stability angle. Based on the results, by increasing the moisture content the dimension and repose angle increased but the true and bulk density decreased (Amin *et al.,* 2003).Erica *et al.* (2004) found that the volume, volume expansion coefficient, the geometric mean of diameters and sphericity have a linear relationship with increasing the moisture content. They stated that by increasing the moisture content, the true density of safflower seed increases nonlinearly and the porosity increases linearly while the bulk density decreases linearly (Erica *et al.,* 2004). Reddy *et al* (2004) studied some physical properties of paddy seeds in the moisture content from 7.19 to 28.28(d.b%). Based on the results, by increasing the moisture content of product, 1000 seed weight, bulk density and repose angle increased but true density and porosity decreased (Reddy and Chakravertty, 2004). The effect of moisture content was studied on some physical properties of two cultivars of paddy (Sepidrud and Binam). These properties include the length, width, thickness, geometric diameter, arithmetic diameter, sphericity coefficient, grain surface and volume, 1000 seed weight, bulk density, true volume, true density at four moisture levels of 10, 14, 18 and 22 (w.b%). Based on results, by increasing the moisture content of the product, the main dimensions, geometric diameter, arithmetic diameter, grain surface and volume, 1000 seed weight, bulk density and true density increased significantly but true volume decreased. The effect of moisture content of grain on sphericity coefficient was not significant (Askari Asli Ardeh *et al.,* 2011). In studying the physical properties of wheat, Shiraz cultivar, in the grain moisture content ranging from 8 to 18 (d.b%), by increasing the moisture content of product, 1000 seed weight , surface area and porosity percent increases but sphericity, bulk density and true density decreases (Kheiralipour *et al.,* 2008). The rice cultivars in Gilan province have a high percentage of breakage that most of these breakages occurs in stage of transformation .Therefore, recognizing the factors influencing this process is necessary. So, the aim of this study is to investigate the effect of moisture content on some physical properties of rice paddy in two cultivars of Domsiah and Rezajoo.

Materials and methods

In order to study, the paddy grains of Domsiah and Rezajoo prepared from the Rice Research Institute of country, located in Gilan province. At first the seeds were manually cleaned and any outer matter and the broken and damaged grains were separated from them and then their moisture content was determined. Notably, the physical tests were conducted at three moisture levels of 10, 14 and 18 (w.b%). To reach the paddy grains to desired moisture level the distilled water were used. First the amount of distilled water needed to provide the moisture of paddy grains was calculated by using the equations 1 and 2 and then added to the paddy grains. After mixing with water the grains were poured into a sterile plastic bag and were kept in the refrigerator for two days at 10°C so that the paddy grains can absorb distilled water and be so-called conditioned and reach to the desired moisture level (Reddy and Chakravertty, 2004).

$$w_i\left[1-\left(\frac{m_i}{100}\right)\right] = w_f\left[1-\left(\frac{m_f}{100}\right)\right] \qquad (1)$$

$$W_i - W_f = W_w \qquad (2)$$

In which: W_i= mass of sample with initial moisture content (g); W_f= mass of sample with desired moisture (g); W_w= mass of distilled water added (g); m_i= the percent of initial moisture content (w.b); m_f= the percent of last moisture content, (w.b).

Physical tests

Geometric tests

Geometric tests include determining the dimensions, geometric diameter, arithmetic diameter, sphericity coefficient, surface and volume. To determine the dimensions of length, width and thickness of the grains, 50 healthy paddy grains were randomly selected from both two cultivars at three different moisture levels and then their dimensions, i.e. length (L), width (W), thickness (t) were measured. Also, the geometric diameters (D_g), arithmetic diameter (D_a), sphericity coefficient (φ) of the healthy paddies were calculated according to the equations 3 to 5 (Mohsenin, 1970).

$$D_g = (L \times W \times t)^{1/3} \qquad (3)$$

$$D_a = (L + W + t)/3 \qquad (4)$$

$$\varphi = (t \times W \times L)^{\frac{1}{3}}/L \qquad (5)$$

On the other hand, surface (S) and volume (V) of the grains were calculated by using equations 6 to 8.

$$S = (B \times \pi \times L^2)(WL - B) \qquad (6)$$

$$B = (W \times t)^{1/2} \qquad (7)$$

$$V = 0.25\left[\left(\frac{\pi}{6}\right) \times L \times (W + t)^2\right. \qquad (8)$$

Gravity tests

These tests included the bulk density, true density, true volume, porosity and 1000 seed weight. For measuring the true density (ρ_s), true volume (V_t) the standard pycnometer method was used and for measuring the true volume and density of paddy grains the equations of 9 and 10 were used (Mohsenin, 1970).

(2)

$$V_t = \left[(M_{tp} - M_p) - (M_{pts} - M_{ps})\right]/\rho_t \qquad (9)$$

$$\rho_s = (M_{ps} - M_p)/V_t \qquad (10)$$

In which: V_t = volume of solid object (cm^3); M_{tp} = mass of toluene and Pycnometer (g); M_p= mass Pycnometer (g); M_{tps}= mass of toluene and Pycnometer and object (g); M_{ps}= mass of Pycnometer and object (g); ρ_t = density of toluene (g/cm^3) and ρ_s= density of solid object (g/cm^3).

Bulk density (ρ_b) of paddy grains was determined by using a cylindrical container graded by dimensions and weight. For this, a mass of grains were poured into a cylindrical container with 500cc volume from a height of 15 cm with a funnel. This situation is similar to that which occurs in grain storage warehouses.

After filling the container, it was smoothed by a ruler so that the additional grains exit without compression of lower grains. After this, paddy grain container was weighed and the bulk density of each sample was calculated by dividing the grain mass weight located in container by the container volume.

$$\rho_b = m/v \qquad (11)$$

Where: m= mass of grains (g); v= volume of container (m^3).

Porosity percent is the ratio of empty space of the rice mass to the volume of container that was calculated according to equation 12 (Mohsenin, 1970).

$$\varepsilon = [1 - \left(\frac{\rho_b}{\rho_s}\right)] \times 100 \qquad (12)$$

Where: ρ_b= bulk density, ρ_s= true density, ε = porosity.

To measure 1000 seed weight, the samples with 1000 grains were randomly selected and weighed from two paddy cultivars mentioned in three moisture levels.

Method of statistical analysis

In physical tests, the independent variables were 1- the cultivars of paddy in two levels (Rezajoo and Domsiah) 2- moisture in three levels of 10, 14 and 18 (w.b%). On the other hand, the dependent variables included dimensions, sphericity coefficient, geometric diameter, arithmetic diameter, surface, volume, bulk density, true density, porosity and 1000 seed weight. Six treatments were totally performed. A factorial experiment design was laid out in completely randomized design with three replications. All data were subjected to analysis of variance and the Duncan's multiple range tests was used to compare the treatment means at the probability level α=%1 and by SPSS software with the version 14.

Results and discussion

The results of variance analysis of data related to some physical properties of two cultivars of paddy rice (Rezajoo and Domsiah) are given in table 1.

According to table 1, the effect of moisture and the interaction of cultivar × moisture on all physical properties, such as length, width, thickness, geometric diameter, arithmetic diameter, surface, volume, bulk density, true density, porosity and 1000 seed weight, except on sphericity coefficient, were significant for both cultivars of Rezajoo and Domsiah while the type of cultivar had no significant effect on the properties. Askari Asli Ardeh *et al* obtained similar results in a similar research on Sepidrood and Binam cultivars (Askari Asli Ardeh *et al.,* 2011). Table 2 shows the mean comparison of physical properties calculated for paddy grains of two cultivars of Domsiah and Rezajoo in three moisture levels of 10, 14 and 18 (w.b%).

Table 1. The results of variance analysis for some physical properties.

Sources of variations						
Dependant variables	Moisture		Cultivar		Moisture × Cultivar	
	Mean square (MS)	F	Mean square (MS)	F	Mean square (MS)	F
Length (mm)	22.85	78.25**	1.22	4.21ns	11.71	40.1**
Width (mm)	11.265	76.63**	0.527	3.59ns	8.755	59.55**
Thickness (mm)	4.285	64.99**	0.271	4.12ns	2.565	38.86**
Geometric diameter (mm)	5.085	46.65**	0.556	5.11ns	3.19	29.26**
Arithmetic diameter (mm)	15.65	115.92**	0.568	4.21ns	19.06	141.185**
Surface (mm^2)	51.18	187.47**	1.16	4.25ns	24.615	90.164**
Volume (mm^3)	41.155	120.33**	1.21	3.54ns	27.06	79.12**
Sphericity coefficient (%)	49.11	3.1ns	22.456	5.12ns	10.18	44.64**
Bulk density (g/cm^3)	12.18	124.28**	0.376	3.84ns	6.25	63.77**
true density (g/cm^3)	7.28	41.6**	0.68	3.9ns	6.34	36.22**
Porosity (%)	62.16	216.58**	1.176	4.1ns	20.68	72.05**

1000 seed weight (g)	93.075	183.218**	2.473	4.87^{ns}	21.065	41.466**

**Significant at the probability level of1%; ^{ns} no significant differences.

According to table 2, by increasing the moisture, the amount of length increased in both cultivars. The highest length was calculated 10.2 mm for Rezajoo with the moisture of 18 percent and the lowest was calculated 9.55 mm for the same cultivar with the moisture of 10 percent. By increasing the moisture levels from 10 to 18 percent, the amount of length increased in both cultivars but this increasing process was observed more in Rezajoo. By increasing the moisture, the amount of width showed an increasing process in both cultivars. The highest width was calculated 2.39 mm for Domsiah in the moisture of 18 percent and the lowest was calculated 2.24 mm for the same cultivar in the moisture of 10 percent. By increasing the moisture levels from 10 to 18 percent, the amount of width increased in both cultivars. By increasing the moisture, the amount of thickness increased in both cultivars.

Table 2. Comparison of the means for some physical properties.

Dependant variables	Domsiah			Rezajoo		
	10	14	18	10	14	18
Length (mm)	9.73^{b}	9.89^{ab}	10.03^{a}	9.55^{b}	10.1^{a}	10.2^{a}
Width (mm)	2.24^{b}	2.37^{a}	2.39^{a}	2.25^{b}	2.38^{a}	2.38^{a}
Thickness (mm)	1.81^{a}	1.91^{a}	1.97^{a}	1.8^{b}	1.9^{a}	1.95^{a}
Geometric diameter (mm)	3.46^{b}	3.63^{a}	3.66^{a}	3.39^{b}	3.64^{a}	3.66^{a}
Arithmetic diameter (mm)	4.59^{b}	4.65^{b}	4.8^{a}	4.5^{b}	4.71^{a}	4.75^{b}
Surface (mm^{2})	34.2^{c}	36.3^{a}	37.89^{a}	34.1^{c}	35.86^{b}	38.12^{a}
Volume (mm^{3})	21.47^{b}	23.65^{a}	24.13^{a}	21.65^{b}	23.18^{a}	24.65^{a}
Sphericity coefficient (%)	35^{a}	35.2^{a}	35.14^{a}	35.3^{a}	35.2^{a}	35.4^{a}
Bulk density (g/cm^{3})	1.10^{b}	1.22^{a}	1.23^{a}	1.12^{b}	1.23^{a}	1.25^{a}
true density (g/cm^{3})	0.50^{b}	0.58^{a}	0.58^{a}	0.50^{b}	0.57^{a}	0.57^{a}
Porosity (%)	50.17^{b}	53.54^{a}	53.84^{a}	50.8^{b}	54.16^{a}	54.4^{a}
1000 seed mass (g)	21.43^{b}	21.35^{b}	24.32^{a}	20.16^{b}	20.98^{b}	23.53^{a}

In each row, the means with a common letters have not significant difference at α= 1%.

The highest thickness was calculated 1.97 mm for Domsiah in the moisture of 18 percent and the lowest was calculated 1.8 mm for Rezajoo in the moisture of 10 percent. By increasing the moisture levels from 10 to 18 percent, the amount of thickness increased in both cultivars but this increasing process was a little more in Domsiah. The highest geometric diameter was calculated 3.66 mm for both Domsiah and Rezajoo in the moisture of 18 percent and the lowest was calculated 3.39 mm for Rezajoo in the moisture of 10 percent. By increasing the moisture levels from 10 to 18 percent, the amount of geometric diameter increased in both cultivars but this increasing process was more in Rezajoo. On the other hand, the highest arithmetic diameter was calculated 4.8 mm for Domsiah in the moisture of 18 percent and the lowest was calculated 4.5 mm for Rezajoo in the moisture of 10 percent. By increasing the moisture levels from 10 to 18 percent, the amount of arithmetic diameter increased in both cultivars but this increasing process was in Domsiah cultivar. The highest surface was calculated 38.12 mm^{2} for Rezajoo in the moisture of 18 percent and the lowest was calculated 34.1 mm^{2} for Rezajoo in the moisture of 10 percent. According to the results, the highest volume was calculated 24.65 mm^{3} for Rezajoo in the moisture of 18 percent and the lowest was calculated 21.47 mm^{3} for Domsiah in the moisture of 10 percent. The most important reason for the results obtained is the water absorption by paddy grains. Askari Asli Ardeh *et al* obtained the similar results in similar studies on two paddy cultivars of Sepidrood and Binam (Askari Asli Ardeh *et al.,* 2011). It is considerable that by increasing the moisture, the amount of bulk and true density increased in both cultivars and this increasing process for bulk density was more in Domsiah than in Rezajoo and for true density was more in Rezajoo than Domsiah. Other researchers obtained similar results in their studies (Kheiralipour *et al.,* 2008; Reddy and Chakravertty, 2004; AL-Mahasneh and Rababah, 2007; Correa *et al.,* 2007). Also, by increasing the moisture, the amount of porosity and 1000 seed mass increased in both cultivars. The increasing process for porosity was more in Rezajoo than in Domsiah but for 1000 seed weight was more in Domsiah than in Rezajoo. Gupta *et al* had also obtained similar results in a similar research on sunflower seeds (Gupta and Das, 1997).

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