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Evaluation of rice different varieties optical degree of milling (DOM_{mm}) and mass degree of milling (DOM_m) under the factors affecting on drying in fluidized bed dryer

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Abstract

One of the most important parameters for assessing the quality of rice is degree of milling that affected by temperature and moisture content to some extent. to assessing effects of variety, temperature and moisture in fluidized bed paddy drying process on optical and mass degree of milling qualitative index, 250 gram samples of *Tarom-domsiah*, *Hashemy* and *Shiroody* to moisture levels, 8-10, 10-12 and 12-14% based on dry weight and with four temperatures 40, 45, 50 and 55°C, with three replications in a fluidized bed dryer were dried. The results indicated that main effects of variety, moisture, temperature and their interactive effects on optical degree of milling are significant in level of one percent ($p<0.001$) but interactive effect of temperature and moisture that is significant in level of five percent ($p<0.05$). Whereas main effects of variety, moisture, temperature and Interactive effects of variety*temperature, moisture*temperature and variety*moisture*temperature on mass degree of milling are significant in level of one percent ($p<0.001$). Main effect of temperature and interactive effect of variety*moisture was not significant. Mass degree of milling is much lower than optical degree of milling and both increase with increasing moisture. *Tarom-domsiah* optical degree of milling on moisture content of 12-10%, not significantly different from each other at different temperatures but mass degree of milling at temperatures 40°C is lower than mass degree of milling at three levels of temperatures. On moisture content of 14-12 % at a temperature that mass degree of milling is maximum value, optical degree of milling is minimal and vice versa.

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Introduction

Rice is one of the most important grains for human consumption and among grains it is the only product which is produced only for human. There are many problems in producing rice, part of which is related to structure of production and various steps of production and the other part is for steps after production to degree of milling (Permeh and Gilanpour, 2009). Changing paddy to white rice includes some steps and using various machines. The stages include drying, whitening, milling and grading. Output product of stripper machine is brown rice. This rice is ready to use and from aspect of food industry, it has more value to white rice. Since it is not favorable in the market, it is turned into white rice in another step called whitening step. Whitening operation may be done in several steps so that fine milling can be obtained for delivering product to market. Therefore, one of the key indices for qualitative assessment of the rice produced is degree of milling (DOM) (Nasrnia *et al.*, 2012). Some of physical and thermal features of rice are influenced by its moisture content to a great extent, and according to moisture content of rice, this feature changes substantially and the changes will be influential on milling quality and degree of milling (Cnossen and Siebenmorgen, 2000). One of the key factors on milling quality of rice is its moisture content. Equilibrium moisture content (EMC) is the moisture where the product under that moisture is in a balanced condition with the environment. Rice equilibrium moisture content depends on thermal level, relative moisture of air, grain moisture content, variety and amount of grain maturation (Zamani Qand Alizadeh, 2007). Applying new and efficient methods along with maintaining qualitative features, with which we can reduce drying time, have always been favorable for producers of different products (Khodadadi, 2013). One of the methods which are applied for reducing rice moisture especially in areas with high level of humidity is applying mechanical dryers. In these dryers the speed of falling moisture in product increases using mandatory moving of hot air. But if this process is done in an uncontrolled way, it will increase wastes in step of changing paddy to white rice and as a result economic value of rice will be reduced and also some significant changes will appear in milling rice (Brooker *et al.*, 1992; Sahay and Singh, 1994). One of the modern methods in drying paddy is fluidized bed dryer that finding its optimum point can be helpful in designing, producing and applying the system, and in improving qualitative indices of drying paddy. Also it will set the stage for its entrance to rice industry of the county. Fluidized bed method is recognized as a quiet and uniform way for drying and it is the capability of reducing material moisture with high level of yield. Too many studies have been done on optimizing drying condition for reducing wastes and for improving performance of head rice yield during milling operation (Cnossen and Siebenmorgen, 2000; Aquerreta *et al.*, 2007). On the other hand, despite conducting too much studies on drying paddy (Minaei *et al.*, 2005; Firuozi and Alizadeh, 2013) so far no research has been reported regarding investigating mass and optical milling degree and comparing these two parameters for various varieties; the numbers which are influenced by effective factors on dryness of paddy in fluidized bed dryer. According to necessities mentioned, the objective of the research is studying effect of variety, temperature and final moisture of paddy in process of drying paddy with fluidized bed dryer method on qualitative index of mass and optical degree of milling.

Materials and methods

The experimental dryer and Samples preparation

In this research, to dry samples, a fluidized bed dryer device was used. According to cultivation level and paddy performance in surface unit also due to significance of production in the areas, *Tarom-domsiah* and *Hashemy* varieties which were among long-grain varieties and *Shirudy* which is among highly produced varieties, were used (Zamani and Alizadeh, 2007; Mohaddesi *et al.*, 2008). These varieties were prepared from Iranian rice research institute located in Rasht City. To determine initial moisture of rice, American Society of Agricultural Engineers Standard was used (ASAE 2000) and initial moisture of paddy samples were measured

19/38, 18 and 18 percent, respectively based on dry weight for *Tarom-domsiah*, *Hashemy* and *Shirudy*. During drying, samples were weighted by using a digital scale with accuracy of ±0/1 %. 250 gram samples from three varieties of *Tarom-domsiah*, *Hashemy* and *Shirudy* to moisture level of 8-10, 10-12 and 12-14 percent were dried based on dry weight and in four temperatures of 40, 45, 50, and 55 °C with three replications and Experiments were carried out according to researches of other researchers (Habibian *et al.*, 2006) and according to device dimensions with a constant input air speed of 4 m/s.

Measuring of mass degree of milling and optical degree of milling

Quality of milling rice is usually expressed using two indices of mass degree of milling and optical degree of milling (Yan *et al.*, 2005). Mass degree of milling is in fact mass of brown rice compared to ratio of bran mass took from white rice, and we can show it with the symbol DOM_m. Optical degree of milling is an index of level of attraction of light reflection by white rice, and they are measured by milling meter, you may show it with the symbol DOM_{mm}. Mass degree of milling was measured using milling meter (C300 Model) made by KETT Company. to strip the samples, and for measuring mass degree of milling, rice stripper machines were used with trading mark of SATAKE [(Model THU) made in Japan)] and for milling the samples, a milling device was applied with trading mark of BALDOR (made in Germany). Each of the samples was put in the device for 45 seconds. To separate healthy rice from broken one, a rotary sieve with trademark of SATAKE (made in Japan) was used. After operation of milling, weight of brown and white rice was gained and index of optical degree of milling was calculated.

Statistical Analysis

tests were done in four levels of input air temperature (40, 45, and 55 °C), three moisture levels (8-10, 10-12 and 12-14percent) and three rice varieties (*Tarom-domsiah*, *Hashemy* and *Shiroudy*) and three repetitions within factorial design of three-factor 3×3×4. Data analysis was conducted within a randomized complete design and three-factor variance decomposition using SPSS (PASW statistics 18) statistical software and charts were drawn through Microsoft Office Excel 2010.

Results

Analysis of variance

In table 1 results of analysis of variance related to effect of rice varieties, temperature and moisture on mass degree of milling (DOM_{mm}) and optical degree of milling (DOM_m) are indicated. The results show that main effects of variety, moisture and also interactive effects of variety*temperature and variety*moisture on mass degree of milling are significant at 1% level and interactive effect of moisture*temperature is significant at 5% level. While main effects of variety and moisture and interactive effects of variety*temperature, moisture*temperature and value*moisture is significant at 1% level and main effect of temperature and interactive effect of variety*moisture is not significant. Therefore, averages of mass and optical degree of milling were compared by combining these treatments and the results gained and in figures 1, 2 and 3 and in table 2 the comparisons gained out of interactive effects are provided using Duncan Test.

Statistical analysis of interactive effects

Statistical analysis of interactive effects of temperature*moisture on mass and optical degree of milling and also comparing average of both degrees of milling in moistures and various temperatures in fig. 1 indicate that mass degree of milling in these four temperature levels and the moistures is less than optical degree of milling substantially. In moisture of 8-10 percent, temperature of 40 °C will cause the creation of the highest and temperature of 50 °C will cause the creation of the lowest level of optical degree of milling, while mass degree of milling in 8-10 percent moisture does not have a substantial difference. In moisture of 10-12 percent, when the temperature changed, no significant difference was observed in degree of milling, but in 12-14 percent moisture, temperature of 55 °C can cause the highest and 45 °C temperature can cause the least optical degree of milling level. While mass degree of milling in 40 and 55 °C temperatures was the highest and the lowest level, respectively. In other words, in low-level moistures, lower temperatures and in high level of moistures, higher temperatures will cause the highest level of optical degree of milling during milling operation. Also both degrees of milling in four temperature levels can increase with the rise of moisture and results of other researchers approve this finding as well (Yan *et al.*, 2005; Sadeghi *et al.*, 2012). Also, in a research Alizadeh obtained similar results regarding effect of moisture on degree of milling (Alizadeh, 2011).

Table 1. Results of analysis of variance related to effect of rice variety, temperature, and moisture content on mass degree of milling (DOMm) and optical degree of milling (DOMmm).

F		Mean Square		Sum of Squares		df	Source
(DOM$_{m}$)	(DOM$_{mm}$)	(DOM$_{m}$)	(DOM$_{mm}$)	(DOM$_{m}$)	(DOM$_{mm}$)		
159.368**	78.967**	53.732	54.857	107.463	109.713	2	variety
278.416**	111.898**	93.869	77.733	187.738	155.465	2	moisture
2.835^{ns}	4.354**	0.956	3.025	2.868	9.075	3	temperature
1.880^{ns}	4.246**	0.634	2.949	2.535	11.797	4	variety*moisture
14.741**	5.786**	4.970	4.019	29.820	24.116	6	variety*temperature
4.492**	2.615*	1.515	1.816	9.087	10.898	6	moisture*temperature
9.649**	3.313**	3.253	2.302	39.040	27.620	12	variety*moisture* temperature
		0.337	0.695	24.275	50.017	72	Error
				24352.536	116628.785	108	Total

** Significant at P = 0.01. * Significant at P = 0.05, ns= Not significant.

Statistical analysis of interactive effects of variety*temperature on optical and mass degrees of milling and also comparing average both degrees for various varieties in temperatures studies in fig. 2 indicate that optical degree of milling of *Shirudy*, *Hashemy* and *Tarom-domsiah* varieties in all four temperature levels is much more than mass degree of milling of these values significantly. *Shirudy* variety mass and optical degrees of milling are more than other two varieties; this result can be due to natural and genetic feature of *Shirudy* variety. Both degrees of milling for *Shirudy* variety decreased significantly after the temperature increase of 40 to 45 °C but with the rise of temperature from 45 to 50 and 55 °C *Shirudy* variety increased. This can approve the research result of Saboury and Roufy Gary Haghighat regarding increase of degree of milling due to temperature increase (Saburi and Roofigari Haghighat, 2012). Tarom mass degree of milling increased with temperature rise of 40 to 45 °C. But with temperature rise from 45 to 50 and 55 °C, it decreased. While optical degree of milling decreased with temperature rise of 40 to 45 °C but it increased with temperature rise from 45 to 50 and 55centigrade. *Hashemy* variety mass degree of milling had no considerable change despite short decrease but optical degree of milling first increased with temperature rise from 40 to 45 °C and it decreased in temperatures higher than 45 centigrade.

According to fig. 3 results of statistical analysis indicate interactive effect of variety*moisture, it can be observed that *Shirudy* variety has the maximum and *Hashemy* variety has the minimum level of degree of milling. Also degree of milling in all variety can increase with moisture rise. In a research Nasrnia *et al* achieved similar results regarding increase of optical degree of milling in spite of moisture rise on varieties of *Shafaq* and *Sazandegi* (Cnossen and Siebenmorgen, 2000). Therefore, to gain the maximum level of optical degree of milling it is better for all three values to become dry with higher temperatures and to be milled with moisture of 12-14 percent.

Table 2. interactive effects of variety*moisture* temperature and Duncan Test related to optical degree of milling (DOM_{mm}) and mass degree of milling (DOM_m), (Average ±standard deviation).

Interaction effects			DOM_{mm} (%)	DOMm (%)
variety	moisture	Temperature		
Tarom	8-10	40	32.17±0.49^{ghij}	14.46±0.24^{ijklm}
Tarom	8-10	45	30.00±0.10^{lm}	12.33±0.62^{pq}
Tarom	8-10	50	30.43±0.45^{klm}	12.19±0.14^{pq}
Tarom	8-10	55	0.40±0.62^{klm}	12.33±0.51^{pq}
Tarom	10-12	40	32.33±0.38^{fghij}	3.10±0.35^{op}
Tarom	10-12	45	32.73±0.38^{efghi}	16.06±0.19^{efg}
Tarom	10-12	50	32.70±0.10^{efghi}	15.21±1.44^{ghij}
Tarom	10-12	55	32.40±0.61^{fghi}	13.04±0.28^{op}
Tarom	12-14	40	34.47±0.2^{bcd}	16.06±0.48^{efg}
Tarom	12-14	45	32.27±1.21^{cdefgh}	17.65±0.15^{abc}
Tarom	12-14	50	33.07±0.47^{cdefghi}	16.420±.35^{def}
Tarom	12-14	55	35.17±0.25^{b}	15.10±0.53^{ghijk}
Hasemi	8-10	40	30.30±1.05^{klm}	11.67±0.24^{q}
Hasemi	8-10	45	30.83±0.85^{jklm}	12.97±0.24^{op}
Hasemi	8-10	50	27.93±0.76^{n}	11.63±0.49^{q}
Hasemi	8-10	55	29.83±0.25^{m}	13.26±0.68^{nop}
Hasemi	10-12	40	31.45±0.25^{ijklm}	11.67±0.24^{q}
Hasemi	10-12	45	32.37±0.31^{fghij}	13.62±0.64^{mno}
Hasemi	10-12	50	32.83±1.12^{defghi}	13.84±0.51^{imno}
Hasemi	10-12	55	33.20±0.61^{cdefgh}	13.67±0.34^{mno}
Hasemi	12-14	40	33.33±0.42^{cdefgh}	16.76±0.31^{cdef}
Hasemi	12-14	45	33.93±1.07^{bcdef}	16.06±0.14^{efg}
Hasemi	12-14	50	33.03±0.55^{cdefghi}	15.11±0.51^{ghijk}
Hasemi	12-14	55	32.60±0.53^{efghi}	14.24±0.52^{jklmn}
Shiroodi	8-10	40	33.13±0.95^{cdefgh}	14.05±0.34^{klmno}
Shiroodi	8-10	45	31.77±0.76^{hijklm}	13.69±0.52^{mno}
Shiroodi	8-10	50	33.75±0.95^{bcdefg}	15.78±0.07^{fgh}
Shiroodi	8-10	55	33.80±0.95^{bcdefg}	14.87±0.46^{hijkl}
Shiroodi	10-12	40	34.67±1.86^{bc}	17.06±0.89^{cde}
Shiroodi	10-12	45	33.93±1.52^{bcdef}	15.34±0.76^{ghi}
Shiroodi	10-12	50	34.57±0.77^{bc}	16.7±1.06^{cdef}
Shiroodi	10-12	55	34.57±1.10^{bc}	17.06±0.89^{cde}
Shiroodi	12-14	40	34.23±1.21^{bcde}	18.56±0.51^{a}
Shiroodi	12-14	45	33.47±1.40^{cdefg}	16.56±0.25^{def}
Shiroodi	12-14	50	35.20±0.87^{b}	17.29±0.67^{bcd}
Shiroodi	12-14	55	37.13±0.67^{a}	18.18±1.14^{ab}
	F		14.341**	32.09**
	Sig.		0.000	0.000

Different letters in each column (a, b, c ...) indicate significant differences at the level of one percent.

According to table 2 regarding statistical analysis interactive effects of variety*moisture on optical and mass degrees of milling, it can be observed that for *Tarom* variety in humidity of 8-10 percent, there is no significant difference in degree of both milling in temperatures 45, 50 and 55 °C. At the same time, degree of milling in these three temperatures is considerably less than degree of milling in 40 °C. Optical degree of milling of *Tarom* variety in moisture of 10-12 percent has no significant difference in any levels, while mass degree of milling in 40 °C is significantly less than other three temperature levels. In moisture of 12-14 percent where mass degree of milling is the maximum, optical degree of milling is in minimum level and vice versa. For *Hashemy* variety in moisture of 10-12 percent, both degree of milling in 40 °C are significantly less than degree of milling in other three levels. While degree of milling in these three levels (45, 50 and 55 °C) has no significant difference. In moisture of 12-14 percent, with temperature increase optical and mass degrees of milling both will reduce. There is no significant difference in optical degree of milling in *Shirudy* variety in moisture of 8-10 percent in three levels of 40, 50 and 55 °C. But in temperature of 45 °C it is much less than three temperature levels. There is no significant difference in mass degree of milling in 40 and 45 °C and in this moisture; temperature of 50 °C will cause the maximum degree of milling. In moisture of 10-12 percent, both degrees of milling have significant difference only in 45 °C with degree of milling in other temperatures and their value is less. In moisture of 12-14 percent optical and mass degrees of milling are reduced first with increasing temperature from 40 to 45 °C however with temperature increase of 45 to 50 and 55 °C, degree of milling will increase and reach to its maximum level.

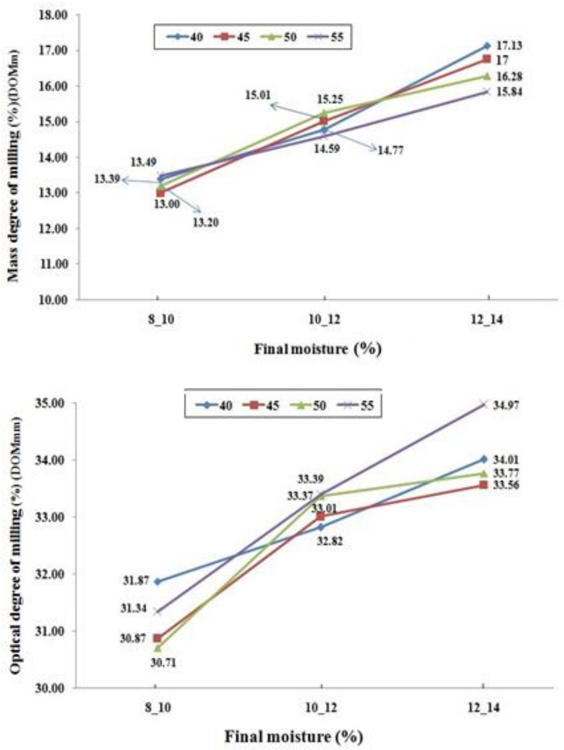

Fig. 1. Chart of average optical and mass degrees of milling in various temperatures for different moistures.

Discussion

Results of the research indicated that both degrees of milling can become more with temperature rise, so to gain the Highest level of milling it is better to use moisture levels more than (12-14 percent) for milling operation. Both degrees of milling for *Shirudy* variety reduced significantly with temperature increase of 40 to 45 °C, but it became higher with temperature increase of 45 to 50 and 55 °C. Therefore, for milling of *Shirudy* variety, using moisture of 12-4 percent with 55 °C is recommended. Mass degree of milling in *Tarom* variety became higher with temperature rise of 40 to 45 °C, but it reduced with temperature increase of 45 to 50 and 55 °C. Also optical degree of milling of this variety reduced with temperature rise of 40 to °C, but it became more with temperature rise of 45 to 50 and 55 °C. Therefore, for *Tarom* variety moisture of 12-14 percent with 45 °C is recommended to achieve the best mass degree of milling and temperature of 55 °C is advised to achieving the best optical degree of milling. Mass degree of milling in *Hashemy* variety with temperature increase has no significant change despite short reduction, but optical degree of milling increased with temperature rise of 40 to 45 °C, but it reduced in temperatures more than 45 °C, so 45 °C for *Hashemy* variety will cause the maximum level of degree of milling.

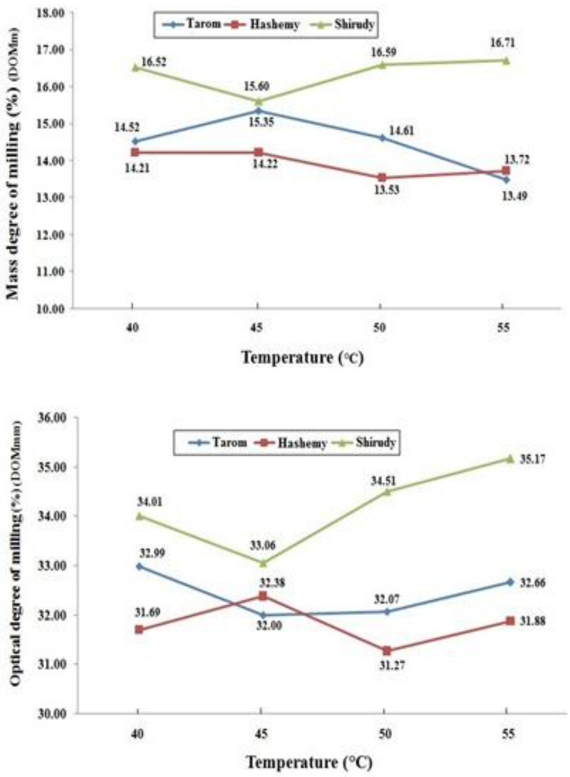

Fig. 2. Chart of average optical and mass degrees of milling for various varieties in different temperatures.

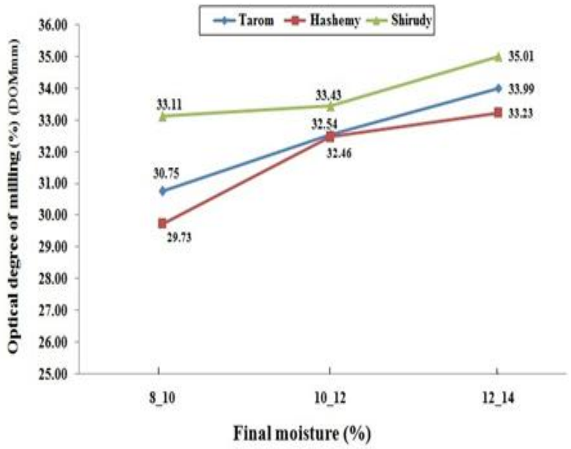

Fig. 3. Chart of optical degree of milling of various varieties in different moistures.

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