



Investigation of rice quality milling in abrasive and blade whiteners in terms of breakage percentage and degree of milling

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ABSTRACT

Reduction of rice losses is very important. In this study, appropriate moisture contents for milling of three common rice cultivars were determined in abrasive and blade whiteners. To this end, a factorial test based on a randomized complete block design with three replications was carried out in two milling systems: abrasive and blade whiteners, on three paddy cultivars: Sorkheh, Sazandegi, and Tarom and at four moisture contents: 8, 10, 12 and 14% (on wet basis). The paddy cultivars were dried and converted into white rice in abrasive and blade systems. In each treatment, the rice-breakage percentage, the DOM, the working capacity and the power consumption of each system were measured. The results showed that cultivar Sorkheh had the lowest rice-breakage rate. In addition, the mean breakage rate and DOM were significantly lower in the abrasive whitener than in the blade whitener. Based on results, most appropriate milling moisture contents for the cultivars Sorkheh, Sazandegi, and Tarom were 10, 12, and 10%, respectively, in the abrasive system, and 10, 12, and 12%, respectively, in the blade system. The working capacity and power consumption in the abrasive system were 1.7 and 3.43 times as much as those in the blade system, respectively.

Contribution/ Originality

Rice is the most commonly consumed agricultural product after wheat in Iran. The amount of rice losses in the milling stage is high and there is a need for research that can introduce the appropriate conditions of it. In the present study, the conditions for the transformation of paddy to white rice have been evaluated and local farmers have been using these results to reduce the waste production.

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1. INTRODUCTION

Rice is the most commonly consumed agricultural product after wheat in Iran. Appearance and breakage percentage are among the factors determining the quality of rice, in a way that the presence of broken rice in the final product will reduce the price. Rice breakage is a function of many factors such as cultivar, environmental factors, agronomic management, and moisture content at the time of harvesting and milling, drying method, and the equipment used in the milling system (Heidariesoltanabadi, 2005). The majority of rice losses (broken rice) occur during the milling stage. The milling process is including paddy dehusking and bran removing from brown rice. According to study of Prabhakaran *et al.* (2017), parameters of paddy dehusker such as rubber roller speed, rubber roll pressure, paddy feed rate and fissures of kernel were another factors affecting the rice breakage.

According to a report by Peyman (1999), in most parts of the country, rice whitening machines are blade whiteners, which are sometimes used as husking machines as well, which in turn increase the rice-breakage rate. Rafiee and Tabatabaefar (2005) studied the effect of using a blade whitener on the percentage of head white rice. The results showed that the mean numbers of head rice grains in one gram of the sample were 30 and 28 before and after whitening, respectively. In other words, 4.4% of the rice is broken at the whitening stage. The conducted studies show that breakage percentage is under the influence of DOM (Degree of Milling) too, in a way that in a milling machine, as milling duration increases, breakage percentage and DOM increase (Cooper and Sibenmorgen, 2005). In a study, a factorial based on randomized completely design with three levels of moisture content of 8-9, 10-11 and 12-13% (w.b.)¹ and three types of universal rice whitener machines, abrasive type whitener (AW), blade-type whitener (BW) and frictional-type bladeless whitener (FBLW) was conducted in triplicates. The obtained results indicated that the lowest percentage of broken white rice (10.14%) took place in the AW with moisture level of 8-9%, whereas the highest percentage of broken rice (17.19%) was defined in FBLW with 12-13% moisture (Firouzi and Alizadeh, 2011). Analyzing the milling characteristics of white rice depending on the guide angles of the cutting roller in a cutting-type milling machine showed that the cutting roller guide angles of 0° and 10° are suitable for producing high quality rice during milling with acutting-type milling machine (Byeong-Hyo *et al.*, 2017). The performance of a locally fabricated rice-milling machine was evaluated to determine the behavior of different paddy varieties at different conditions during milling. Performance test revealed that the milling efficiency, cleaning efficiency, input capacity, output capacity and average percentage of head rice yield obtained were 90.22%, 90.2%, 27.3kg/hr, 16.47kg/hr, and 44.2%, respectively (Dauda *et al.*, 2012).

One of the most important factors affecting the rice-breakage rate is the moisture content of paddy at the harvesting and milling. A study was carried out to establish the effects of three factors, final moisture content, shade-cooling time and paddy variety on rice milling quality (Furahishal *et al.*, 2016). Paddy was sun dried to final moisture contents ranging from 9.0 to 15.5% (on wet basis) and shade-cooled for 0, 6, 12, 18, and 24 h at ambient temperature (27.20 to 35.10oC). Physical properties and milling quality in terms of total rice yield (TRY), head rice yield (HRY) and whiteness index (WI) were analyzed. The result showed that higher yields, which were significantly different for TRY and HRY, were obtained at moisture content between 9.0 to 12.5% for TRY, but between 10.5 to 14.0% for HRY. Ilieva *et al.* (2014) stated that the highest milling yield (74.81%) and head rice yield (64.64%) was obtained from paddy with the highest average moisture content (22.8%) at harvest time. In addition the milling yield and head rice yield was the largest in the processing of paddy one month after harvest.

¹ - On wet basis

Research conducted by [Shaker and Alizadeh \(2004\)](#) showed that during the conversion of several different paddy cultivars into white rice, moisture contents of 16 to 18% on wet basis were associated with the highest rice-breakage percentage equal to 26.1%, and moisture contents of 8 to 10% with the lowest breakage rate equal to 6.15%. Analyzing three levels of moisture content in paddy cultivars, [Hedayatipoor et al. \(2005\)](#) found out that the suitable milling moisture for cultivars Fajr and Nemat was 10 to 11%, and for cultivars Sahel and Neda 11 to 12% on wet basis. Studies have also been conducted on the impact of different factors such as the paddy condition, the RPM of the rice miller shaft, the feeding rate of the machine (the inlet and outlet flows) and/or making changes in order to improve the milling performance in terms of breakage rate. Through conducting research on the impact of the RPM (rotation speed per minute) shaft of the horizontal rice miller on the breakage rates of two rice cultivars: Amol-3 and Kamfiroozi, [Shaker \(2003\)](#) showed that a speed of 600 rpm is suitable for both cultivars. In a study by [Heidariesoltanabadi and Hemmat \(2007\)](#), a blade rice whitener was equipped with a full transmission spiral. Experiments showed that the breakage rate of rice cultivar, Sazandegi, was 23% at wet basis moisture of 13% in the conventional blade whitener, and 20.5% in the optimized whitener. By analyzing three outlet flow rates (915, 654, and 412 kg/h) and three distances between the blade and stirrer, 11, 12, and 13 mm in their study, they also concluded that the lowest mean breakage percentage occurred at the outlet flow rate of 412 kg/h when the distance between the blade and the stirrer was equal to 11 or 12 mm. By conducting a study on white rice production in a vertical abrasive milling system, [Yan et al. \(2005\)](#) showed that the RPM of the miller shaft and moisture content had significant effects on degree of milling (DOM), in a way that DOM increased with an increase in moisture content and the RPM of the miller shaft.

Moisture and temperature gradients induce the development of fissures during drying the paddy kernels. This affects the milling quality of the paddy eventually reducing the head rice yield. A study was conducted to investigate the influence of drying temperature and storage duration on the cracking behavior and head rice yield of a local rice variety. It was proved that paddy can be dried by using a mechanical dryer at higher temperatures of 45°C and 50°C without affecting its milling qualities ([Akowuah et al. 2012](#)). [Nasirahmadi et al. \(2014\)](#) investigated the effects of moisture content, variety and parboiling on milling quality of rice as a function of milling recovery (MR), head rice yield (HRY), degree of milling (DOM) and whiteness. As a result of parboiling, the DOM, MR and HRY were increased. Moreover, decreasing moisture content maximized MR and HRY.

The results of some experiments revealed that as paddy mixture ratio increased from 2 to 6%, the values of fissured kernels and whiteness percentage decreased, while Head Rice Yield decreased by increasing the paddy mixture ratio from 2 to 6%. At all the evaluated paddy mixture ratios, the values of Head Rice Yield, whiteness percentage and whiteness index decreased by decreasing moisture contents from 14 to 8% (w.b.). It was observed that with decreasing moisture contents from 14 to 10% (w.b.), the number percentage of fissured kernels decreased, and then the further decrease in moisture contents from 10 to 8% (w.b.) caused the fissured kernels to increase ([Peyman et al., 2014](#)). According to research on inclined bed dryer (IBD) and fluidized bed dryer (FBD) combined with IBD performance, poor performance of the industrial fluidized bed dryer was observed in the case of drying in low capacity causing higher specific energy consumption ([Sarker et al., 2013](#)). However, the quality of milled rice obtained from both drying systems was found to be almost similar. Minimal process time (i.e., up to 24.5% less) was found in the paddy dried with FBD as the first-stage drying followed by IBD as the second-stage drying. Studies on the effects of high-temperature fluidized bed drying and tempering on physical properties and milling quality of two freshly harvested long-grains showed that head rice yield significantly improved with extended tempering time. Head rice yield tended to increase with decreasing cracked (fissured) kernels. The hardness and stiffness of sound fluidized bed dried rice kernels were higher than those conventionally dried ([Truong et al., 2009](#)).

Isfahan rice cultivars have a high quality for cooking, and good aroma and flavor. However, for various reasons, they have a high breakage percentage, which is a considerable factor in reducing their marketability. In a study, Hosseinian (2007) milled three Isfahan rice cultivars including Sorkheh, Nogaran, and Sazandegi at four wet basis moisture contents: 8, 10, 12, and 14% in 2 laboratory milling systems: a blade whitener and an abrasive whitener. The study results showed that cultivar Sorkheh had lower breakage percentage than the other two cultivars did, just the same as the abrasive whitener did compare to the blade whitener.

This study was conducted in order to investigate the breakage rate of Isfahan rice cultivars in abrasive and blade whiteners, and to determine their appropriate milling moisture contents.

2. MATERIAL AND METHOD

In this study, in order to investigate the effects of cultivar and milling moisture content on the quality of the rice milled in an abrasive and blade system, an experiment was carried out. In this experiment, the effects of three paddy cultivars including Sazandegi (the corrected form of cultivar Nogaran), Sorkheh, and Tarom cultivated in Isfahan, and four milling moisture contents including 8, 10, 12, and 14% on wet basis, and two types of milling systems with an abrasive whitener and a blade whitener, on the quality of the rice milled in a factorial experiment in the form of a randomized complete block design with three replications were investigated. The apparent characteristics of the said cultivars are presented in Table 1. The experiments were carried out in two miller systems equipped with abrasive and blade whitener, individually. The first milling system consisted of a winnowing machine, two rubber-roller husking machines, two serial blade whiteners, a grading screen, and six lifting machines. The second milling system was equipped with a winnowing machine, a rubber-roller husking machine, a box-shaped paddy separating machine (brown rice separator), two serial horizontal abrasive whiteners, a polishing machine, a grading screen, and eight lifting machines.

The paddy cultivars Sazandegi, Sorkheh, and Tarom were used in the experiments. A fixed-bed dryer was used in order to bring the moisture content of the paddy to the required moisture contents. The internal surface of the horizontal fixed-bed dryer was divided into three equal parts, and the desired moisture contents including primary moisture contents of 17 to 20% were separated from each other. Then, 130 kg of each paddy cultivar was poured into the cells created in the dryer bed.

Table 1: Apparent characteristics of the rice cultivars

Cultivar	Length (mm)	Width (mm)	Thickness (mm)	Slenderness ratio*	1000-grain weight (g)
Sazandegi	6.48	2.24	1.73	2.89	17.7
Sorkheh	6.36	2.17	1.77	2.93	16.4
Tarom	7.3	1.78	1.70	4.1	17.8

*Slenderness ratio is the rice length- to-width ratio

The dryer temperature was set to 45°C. The moisture contents of the paddy cultivars inside the dryer were measured using an electronic moisture meter model SP-1D2 kitte. As the paddy moisture content reached the desired moisture contents, the paddy was removed from the dryer and was collected in a nylon bag. Approximately 90 kg and 30 kg of dried paddy were packed for each experiment in the abrasive and blade whitener, respectively. These amounts were the minimum amounts of paddy needed to carry out the experiments in the two whiteners. The samples were whitened and in each experiment, three 150 g samples were taken from the outlet of the last whitener. These samples were used to measure the percentage of broken rice and DOM through the following method:

- a) Percentage of head and broken white rice: From the 150 g samples, which were a mixture of head and broken rice, rice grains larger and smaller than 3/4 of a whole white rice grain were separated. The ratio of the weight of rice grains larger than 3/4 of a whole white rice to the total weight of the sample represents head white rice percentage, and the ratio of the weight of rice grains smaller than 3/4 that represents rice breakage percentage ([Test Code and Procedure for rice Mills, 1990](#)).
- b) Degree of milling (DOM) of rice: In order to measure the DOM of rice, the percentage of brown rice weight loss due to milling was measured based on the standard ([Test code and Procedure for rice Mills, 1990](#)). In this method, one thousand grains of head brown rice and one thousand grains of head white rice were weighed. Hence, the degree of milling (D) was obtained through relation (1).

$$D = \frac{W_b - W_w}{W_b} \times 100 \quad (1)$$

Where W_b is the 1000-grain weight of head brown rice, and W_w is the 1000-grain weight of head white rice.

- c) Working capacity and power consumption: During the conversion of paddy into white rice in the abrasive and blade system, the working capacity and power consumption were measured in kg/hr and Kw, respectively. To this end, 290 kg of paddy from one cultivar (the maximum amount available) was milled in each of the abrasive and blade systems. The duration of the paddy milling process and the amount of electric energy consumption (through reading the electricity meter) were recorded during the milling process.

The obtained data were analyzed by the SAS software program, and the significant mean values were categorized at a probability level of 5% (Duncan's multiple range tests).

3. RESULT AND DISCUSSION

3.1. Rice breakage percentage

Table 2 shows the ANOVA of the effects of cultivars, the type of whiteners, and the milling moisture content on rice breakage percentage and DOM. Accordingly, the simple effects of cultivars, the type of whiteners, and moisture content, as well as their interaction effects on rice breakage percentage became significant at a probability level of 1%. The three-way interaction effects of cultivars, the type of whiteners, and moisture content on rice breakage percentage also became significant at a probability level of 5%.

3.2. Degree of milling (DOM) of rice

According to the results in Table 2, the simple effects of cultivar, the type of the whitener, and moisture content, as well as their interaction effects on the DOM of rice became significant at a probability level of 1%.

3.3. Measuring the working capacity and power consumption

This measurement showed that the working capacity of the abrasive system being tested was 1240 kg/h, and the power consumption was 42.85 kW.

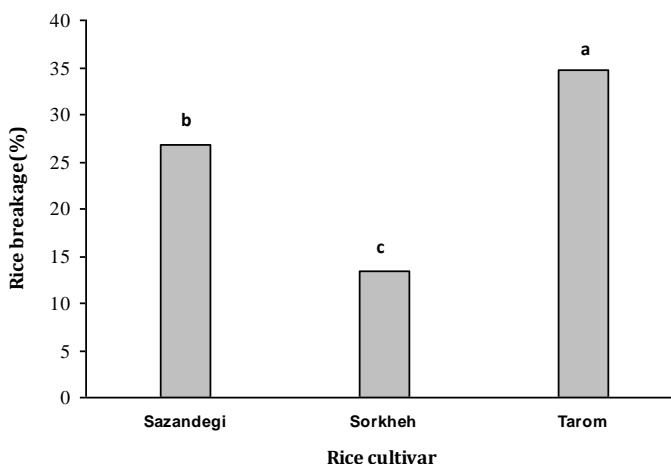
Table 2: The ANOVA of the effects of cultivars, the milling moisture content, and the type of whiteners on rice breakage percentage and DOM

Source of changes	Degrees of freedom	Mean squares	
		Rice breakage percentage	DOM of rice
Replication	2	1.81	0.38
Cultivar	2	2795.04**	363.6**
Milling moisture content	3	532.18**	25.45**
The type of the whitener	1	3729.07**	270.32**
Cultivar × Milling moisture content	6	6.18**	8.4**
Cultivar × The type of the whitener	2	22.68**	50.95**
Milling moisture content × The type of the whitener	3	220.99**	4.02**
Cultivar × Milling moisture content × The type of the whitener	6	3.56*	9.85**
Error	46	1.16	0.08
Coefficient of variation		4.33	2.50

* and **: Significant at a probability level of 1 and 5%

These parameters were measured to be 725 kg/h and 12.5 kW in the blade system. Therefore, the working capacity and power consumption in the abrasive system are 1.7 and 3.43 times as much as those in the blade system, respectively, which is due to the presence of more machines and their higher capacity in the milling line of the abrasive system than in the blade system.

According to Figure 1, cultivar Sorkheh has the lowest rice-breakage rate, and cultivar Tarom has the highest. This shows that differences in appearance and physical properties between the native cultivars and the northern cultivar have resulted in the increased breakage percentage in the northern cultivar because the latter is a type of long-grain rice with a lower thickness.

**Figure 1: The simple effect of cultivar on rice breakage percentage**

In a study, [Lu and Siebenmorgen \(1995\)](#) investigated the relationship between the thickness of the paddy grain and its resistance to pseudo-static compressive loading and three-point bending for two long-grain cultivars, Tebonnet and Lemont, at different harvest times. The results of their study showed that there was a direct relationship between thickness and resistance to loading. Breakage

percentage is higher in cultivar Sazandegi than in cultivar Sorkkeh, which is due to the physical properties of cultivar Sorkkeh and its resistance to fracture. Hosseini (2007) explained that the lower breakage percentage in cultivar Sorkkeh compared to that in the two cultivars Sazandegi and Nogaran was due to its higher failure force and maximum bending stress relative to that of the other two cultivars. Based on the results in Figure 2, the highest breakage rate occurred at 14% moisture content. No particular trend was observed between breakage percentage values at moisture contents of 8 to 12%. The results of Figure 3 show that the mean rice breakage percentage is significantly lower in the abrasive whitener than in the blade whitener. Hosseini (2007) also achieved similar results when comparing laboratory abrasive and blade whiteners.

The investigation on the interaction effect of cultivar and paddy milling moisture content (Figure 4) shows that in cultivar Sazandegi, moisture contents of 8 and 12% have the lowest breakage rates, and moisture contents of 14 and 10% have the highest breakage rates, respectively. No significant difference is observed between the breakage rates of cultivar Sorkkeh at moisture contents of 8 to 12%. The same trend has also been repeated in cultivar Tarom. In all three cultivars, the moisture content of 14% is associated with the highest breakage rate. Figure 5 shows the interaction effect of moisture content and type of whitener on rice breakage percentage. Accordingly, at each moisture content, rice breakage percentage is significantly higher in the blade whitener than in the abrasive whitener. In both types of whiteners, the moisture content of 14% has caused the highest breakage rate. The lowest rice breakage rate in the abrasive whitener was obtained at moisture contents of 10-12%, and in the blade whitener at moisture contents of 8 and 12%. Figure 6 shows the interaction effect of paddy cultivar and type of whitener on rice breakage percentage. Based on these results, firstly, the breakage percentage of all three cultivars is significantly higher in the blade whitener than in the abrasive whitener. Secondly, in both whiteners, cultivar Tarom has the highest rice-breakage rate, and cultivar Sorkkeh has the lowest, which is due to the mechanical properties of these cultivars such as failure force and energy. The results of Table 3 show that in the abrasive whitener, there is no significant difference between the minimum breakage rates within the moisture range of 8 to 12% in cultivars Sazandegi and Tarom and within the moisture range of 10 to 12% in cultivar Sorkkeh. In the blade whitener, the lowest breakage rates of cultivar Sazandegi were obtained at moisture contents of 8 and 12%. No significant difference was observed between the minimum breakage rates within the moisture range of 8 to 12% in cultivars Sorkkeh and Tarom.

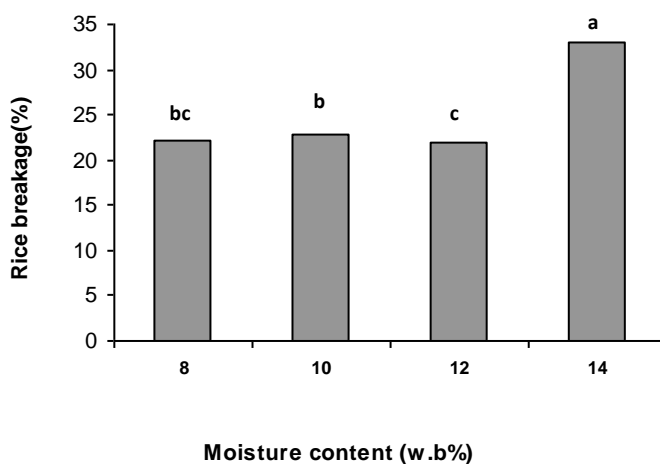


Figure 2: The simple effect of moisture content on rice breakage percentage

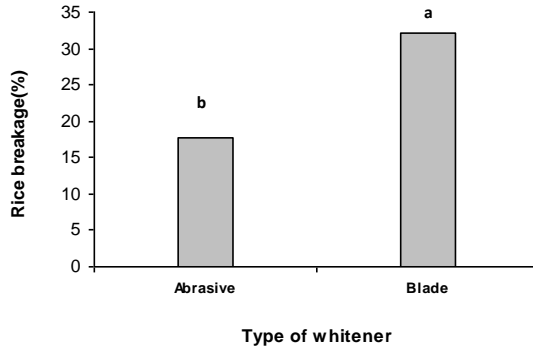


Figure 3: The simple effect of the type of the whitener on rice breakage percentage

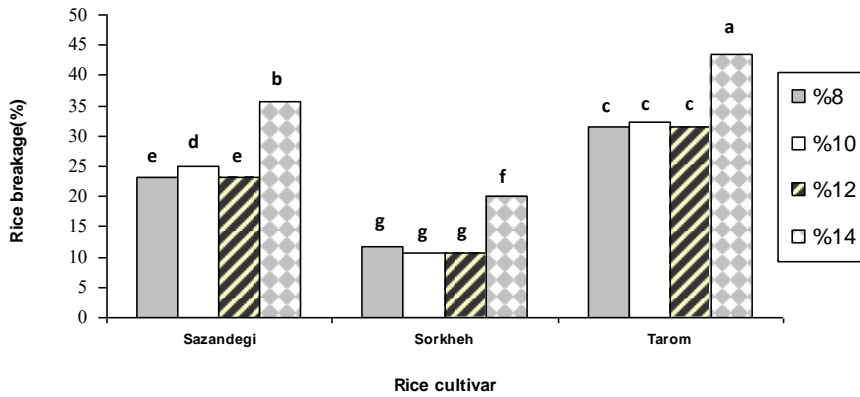


Figure 4: The interaction effect of cultivar and moisture content on rice breakage percentage

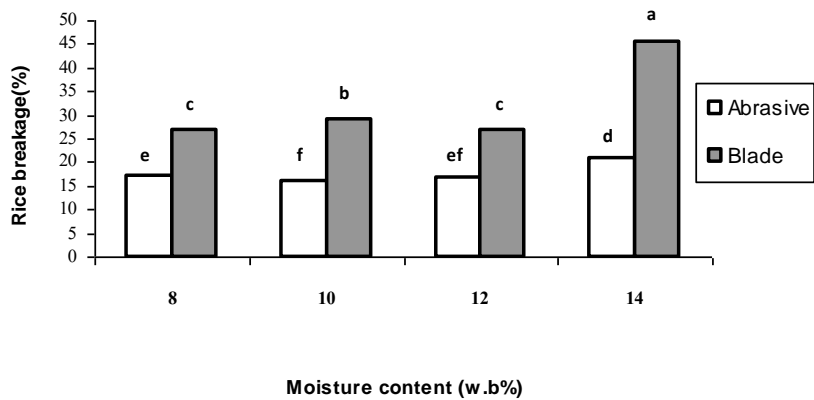


Figure 5: The interaction effect of moisture content and type of whitener on rice breakage Percentage

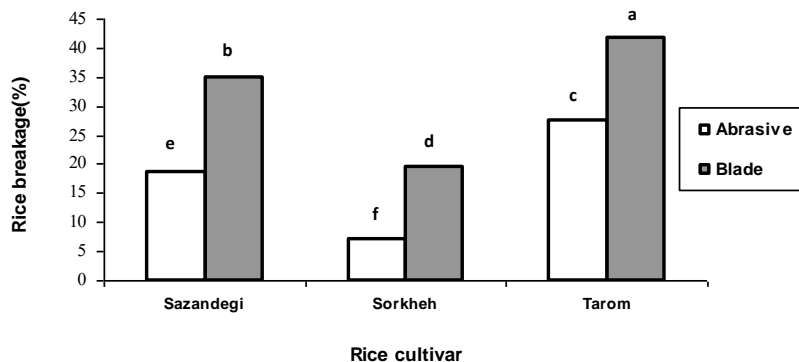


Figure 6: The interaction effect of paddy cultivar and type of whitener on rice breakage percentage

The results in Figure 7 show that cultivar Sazandegi became significantly whiter than the other two cultivars did, and it seems that under identical conditions, it will need smaller force for the separation of rice bran. Cultivar Tarom became less white than the other two cultivars did, indicating that greater pressure is needed in the whitener for further whitening. Figure 8 shows that, in total, the DOM of rice cultivars has increased as moisture content increased from 8 to 10%, and decreased as moisture content increased from 10 to 12 and 14%. Changes in the physical and mechanical properties of rice such as the friction coefficient and resistance to abrasion due to increased moisture content can be considered as the reasons for this issue. According to Figure 9, the mean DOM is higher in the blade whitener than in the abrasive whitener. The magnitude of frictional forces, the manner of exerting them, and the operation intensity in the blade whitener result in the separation of more bran, thus producing whiter rice. Figure 10 investigates the interaction effect of cultivar and moisture content on the DOM of rice. Accordingly, the highest mean values for the DOM of rice were obtained at 12% moisture content for cultivar Sazandegi, and 10% moisture content for cultivars Sorkkeh and Tarom. The results in Figure 11 show the interaction effect of moisture content and type of whitener on the DOM of rice. According to these results, at all moisture contents, DOM is higher in the blade whitener than in the abrasive whitener. In the blade whitener, as moisture content exceeds 12% or falls below it, the mean DOM decreases. In the abrasive whitener, the mean DOM decreases as moisture content exceeds 8%. According to the results in Figure 12, in all cultivars, the blade whitener whitened rice to a significantly greater degree than the abrasive whitener did. On the other hand, in both whiteners, cultivar Sazandegi has the highest DOM, and cultivar Tarom has the lowest. In identical conditions, cultivar Sorkkeh became less white than cultivar Sazandegi did, but whiter than cultivar Tarom did. According to the results in Table 4, in the abrasive whitener, cultivar Sazandegi has the maximum DOM at 12% moisture content. Moisture contents of 8, 10, and 14% are in next places in this regard. Cultivars Sorkkeh and Tarom have the highest values of DOM within the moisture range of 8 to 10%. In the blade whitener, cultivar Sazandegi has the maximum DOM at 12% moisture content. There is no significant difference between the values of DOM at two moisture contents of 8 and 10%. The highest DOM of cultivar Sorkkeh in the blade whitener has occurred at 10% moisture content. The moisture content of 8% is in the next place, and the moisture range of 12 to 14% shows the lowest DOM. The highest DOM of cultivar Tarom is at 14% moisture content. Moisture contents of 10 and 12% fall in next places (Table 4).

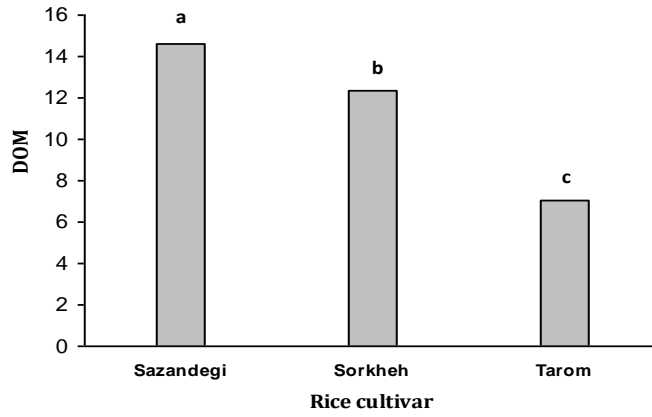


Figure 7: The simple effect of cultivar on the DOM of rice

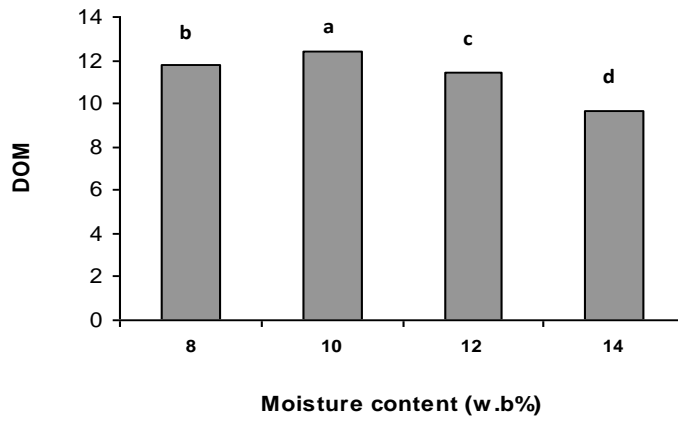


Figure 8: The simple effect of moisture content on the DOM of rice



Figure 9: The simple effect of the type of the whitener on the DOM of rice

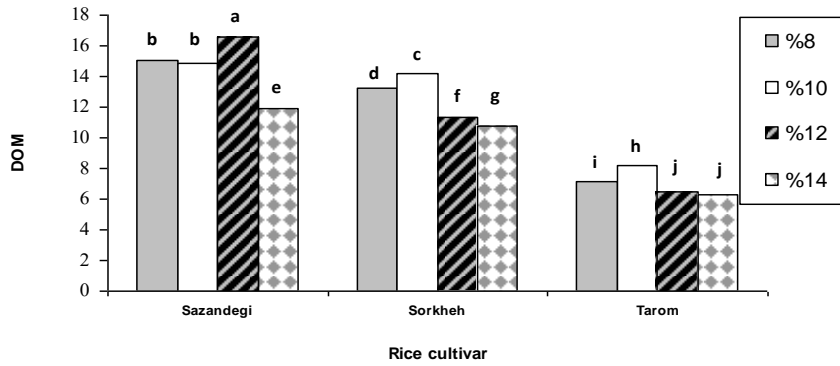


Figure 10: The interaction effect of cultivar and moisture content on the DOM of rice

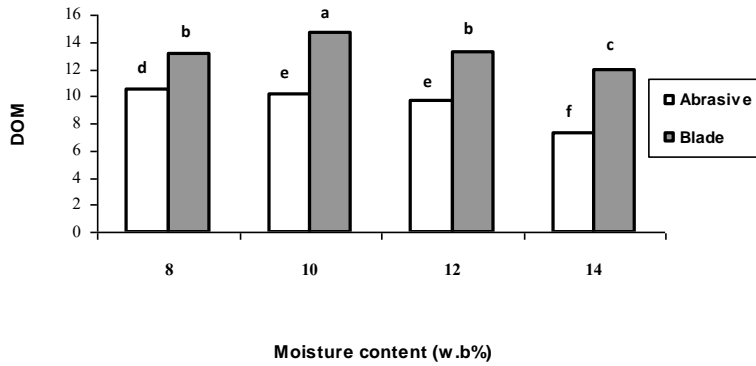


Figure 11: The interaction effect of moisture content and type of whitener on the DOM of rice



Figure 12: The interaction effect of paddy cultivar and type of whitener on the DOM of rice

Table 3: The interaction effect of cultivar, moisture content, and type of whitener on breakage percentage

Cultivar	Moisture content							
	8		10		12		14	
	Abrasive	Blade	Abrasive	Blade	Abrasive	Blade	Abrasive	Blade
Sazandegi	17.36 j	28.86 fg	17.02 j	32.98 e	17.19 j	29.35 f	22.88 i	48.67 b
Sorkheh	8.49 l	14.89 k	5.88 m	15.62 jk	5.91 m	15.68 jk	8.07 l	32 e
Tarom	25.93 h	37.05 d	25.59 h	39.15 c	27.12 gh	35.66 d	31.24 e	55.49 a

The numbers having similar letters are not significantly different at a statistical level of 5% (Duncan's test)

Table 4: The interaction effect of cultivar, moisture content, and type of whitener on the DOM of rice

Cultivar	Moisture content							
	8		10		12		14	
	Abrasive	Blade	Abrasive	Blade	Abrasive	Blade	Abrasive	Blade
Sazandegi	12.80 ef	17.32 b	12.19 gh	17.51 b	14.22 d	18.83 a	11.17 i	12.61 fg
Sorkheh	13.21 e	13.21 e	13 ef	15.44 c	11.38 i	11.38 i	10.16 j	11.38 i
Tarom	5.48 l	8.80 k	5.28 l	11.04 i	3.25 m	9.73 j	0.58 n	11.98 h

The numbers having similar letters are not significantly different at a statistical level of 5% (Duncan's test)

4. CONCLUSION

This study was conducted in order to determine the appropriate milling moisture content in abrasive and blade systems, and to compare the performance of these two systems in terms of rice breakage percentage, DOM, working capacity, and power consumption. Based on result, in the overall comparison of the two types of whiteners i.e. blade and abrasive whiteners, it was found out that rice breakage percentage was significantly lower in the abrasive system than in the blade system. The DOM of rice was also lower in this type of whitener than in the blade whitener. However, given that the increased whiteness of rice causes nutrient loss in rice, it is preferable to use the abrasive whitener. The power consumption and working capacity in the abrasive system were 3.43 and 1.7 times as much as those in the blade system, respectively.

Rice cultivars native had lower breakage percentage than cultivar Tarom. On the other hand, the breakage percentage and DOM of cultivar Sorkheh were also lower than those of cultivar Sazandegi. According to the results obtained in this study, the most appropriate milling moisture contents were 10, 12, and 10% (on wet basis) in the abrasive system, and 10, 12, and 12% (on wet basis) in the blade system for cultivars Sorkheh, Sazandegi, and Tarom respectively.

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