American-Eurasian J. Agric. & Environ. Sci., 10 (3): 470-474, 2011
ISSN 1818-6769

Effect of Whitener Type and Paddy Moisture Content on Rice Grain Damage During Milling Process

[1]*Saeed Firouzi* and [2]*Mohammad Reza Alizadeh*

[1]Department of Agronomy, Islamic Azad University, Rasht Branch, Rasht, Iran
[2]Department of Agricultural Engineering, Rice Research Institute of Iran, Rasht, Iran

Abstract: Rice (*Oryza sativa L.*) grain damage in common rice mills of Guilan province of Iran was evaluated. A factorial based on randomized completely design with three levels of moisture content of 8-9, 10-11 and 12-13% (w.b.) 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. A typical rice variety in Guilan's paddy cultivated area namely *Hashemi* was considered. The obtained results indicated that the effect of moisture level and whitener type on the broken rice was significant ($p<0.01$). 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. The main effect of paddy moisture level and the whitener type on the cracked grains was significant ($p<0.05$). So that, the lowest percentages of cracked grains of 3.29% and 2.84% were measured in AW and paddy moisture content of 8-9%, respectively. It seems that using abrasive type whitener with paddy moisture level of 8-9% is the most proper choice for milling of *Hashemi* variety.

Key words: Rice whitener · Broken rice · Cracked grains · Breakage · Paddy moisture · Hashemi

INTRODUCTION

Rice (*Oryza sativa L.*) as a staple food of two third of world populations, has key role to supply mankind required calories. About 40 to 80% of required energy of Asian people is provided through rice crop [1]. In Iran, 75% of rice is cultivated in northern part of the country and rice has been counted as main crop. Rice production record has increasing trends; in 1980 and 2007, the annual production rate has been reported from 1.3 million to 3.5 million tons, respectively [2].

Milling is the final step in rice post-harvest processing. It includes pre-cleaning, destoning, husking, bran removal, cleaning and grading. The type of rice mills and the method of operations significantly affect on recovery of rice [3]. The quantity of interest in efficiency judgment of any paddy milling operation is the amount of unbroken kernels remaining [4]. Among all preformed operations for paddy milling, bran removal is major step of operation. During this process, rice kernels are subjected to intensive mechanical and thermal stresses which might damage or break some of the kernels. The process of bran removal is called whitening or pearling [5-8]. Rice whiteners are divided into two main groups including frictional and abrasive types [2, 8-11]. In frictional-type whiteners, bran removal is performed by rubbing of paddy on brown rice kernels in milling chamber. Use of blade on blade-type frictional whiteners (Engleberg whiteners) intensifies the mechanical stresses in milling chamber; consequently, more cracked rice would appear. However, in frictional bladeless type whiteners, moving upper part of milling chamber with respect to perforated screen frame has replaced blade. Also in abrasive ones, milling process is performed by abrasion stone over brown rice grains. Thus, it is necessary to separate brown rice kernels from unhulled paddies. This procedure is conducted by paddy separators [1, 7, 12]. Farmers in northern Iran, usually utilize Englebreg rice whiteners in which rice breakage is very high, therefore alteration of mills structure should be the main priority to investigate on rice crack. However, the key question raised for the replacements would be the mill structure in what extent will be efficient? According to the conducted studies during rice milling operations, a few researches have focused on comparison of milling systems and most of them were based on effect of mechanical parameters and varietal factors on the

Corresponding Author: Saeed Firouzi, Department of Agronomy, Islamic Azad University, Rasht Branch, Rasht, Iran.
Tel: +98-1313462235, Fax: +98-1313462255, E-mail: firoozi@iaurasht.ac.ir.

performance of each single machine. It has been reported that modern mills using rubber roll huller combined with abrasive and frictional whiteners yield an average overall increase in total rice recovery of 2.5% over a disc huller type rice mill and 6.6% over Engleberg mills [11, 13, 14]. Afzalinia *et al.* [15] have demonstrated that the optimum moisture level of paddy in milling operation for *Khamfirouzi* variety was 12-14% (w.b.), using three abrasive whiteners in series and one friction whitener as a polisher resulted in the least rice breakage. This method was identified as the best choice for the rice milling operation in the province of Fars, Iran. It has been reported that the breakage of a long paddy variety, namely *Tarom* in laboratory abrasive whitener was 10.23% less than that of frictional whitener [16]. The recent investigation conducted on performance of frictional and abrasive whitener showed that the average broken rice in abrasive whitener was significantly less than that of blade-type whitener [16, 17]. The highest broken rice was resulted with moisture level of 14%. It has also been concluded that abrasive milling system caused less broken compared to milling systems include rubber roll huller and blade whitener as well as system with blade husker and blade whitener [17]. The overview of reports reveals that some of the studies were performed on laboratory scale and some others were on local paddy varieties and also the role of grain moisture level has not been considered in all researches. Therefore, the objective of present study was to examine the effects of whitener type and paddy moisture level on broken and cracked kernels of a common long-grain variety namely *Hashemi* during milling process.

MATERIALS AND METHODS

The present study was carried out in order to compare three common types of rice whiteners, namely blade-type whitener (BW), frictional bladeless whitener (FBLW) and abrasive type whitener (AW) in rice mills of Guilan, Iran. In order to eliminate any error and also to unify the experimental material, the paddy was bought from one farm for lessening the effects of agronomical and environmental effects. The experiments were carried out in factorial based on randomized completely design in triplicates [18]. According to methodologies stated by other researchers; special attention was paid for the uniformity and sampling [19, 20].

For evaluation of the effect of paddy moisture, three moisture levels; 8-9, 10-11 and 12-13% moisture (w.b.) were considered. These moisture levels were selected according to rice moisture limit in Guilan's mills. For each experimental run, 40 kg of paddy was prepared for milling. The moisture level of paddy was measured by the means of grain moisture meter (GMK-303 RS Model, Korea). In order to obtain the desired moisture level, the paddy samples were dried in a batch type dryer (HASAN-MANSOR Manufacturing Co. Ltd. Iran). The drying process was performed at constant air temperature of 43 ºC until the desired moisture level was obtained [21, 22]. For the uniformity of dried paddy, the depth of paddy in the dryer bin was reduced to 20 cm [23].

For prevention of moisture absorption, the dried paddy was kept in thick plastic bags. For husking process, the paddy samples were loaded into a rubber-roll husker (Iseki Manufacturing Co. Ltd. Japan). It should be noted that in BW and FBLW the outlet of paddy husker which is the mixture of paddy and brown rice was fed to the whitener machine. However in AW it is necessary to separate paddy grain from brown rice using a paddy separator which is located after the paddy husker. In each experimental run, five samples of 200g of white rice were collected from the outlet of the whitener. The broken rice was separated from head rice by means of a rotating sieve (TRG058 Model, SATAKE Test Rice Grader, Japan). A kernel having equals to or more than 75% intact was considered as whole kernel [10, 13, 20]. The percentage of broken kernels was calculated from the mass ratio of broken milled rice to the total milled rice. In order to determine the percentage of cracked milled rice, 50 complete kernels from each treatment were randomly sampled and put over an optical crack tester and the number of cracked kernels was counted by means of magnifier and its number was multiplied by two.

The obtained results were subjected to statistical analysis applying a factorial trial based on randomized completely design (RCD) with 9 treatments and three replicates. Since the data of broken kernels were non accountable percentage amounts, so the transformation of $Arc\,Sin\sqrt{X}$ was used for normalization of them and transformation of $\sqrt{x+0.5}$ was used for normalization of accountable percentage amounts of cracked kernels [2, 11, 14, 18].

RESULTS AND DISCUSSION

Analysis of variance of the effects of whitener type and paddy moisture level on percentage of broken and cracked milled rice is shown in Table 1. According to obtained results, the whitener type and paddy moisture level had significant effect on the broken grains ($p<0.01$) and cracked grains ($p<0.05$). Also, the interaction effect of whitener type and moisture level was significant ($p<0.01$) on broken milled rice.

Table 1: Results of analysis of variance (ANOVA) for broken brown rice and cracked kernel

		Mean Square	
Source of variations	Degree of freedom	Broken rice	Cracked rice
Type of whitener	2	0.00359**	0.44*
Paddy moisture level	2	0.00849**	0.608*
Type of whitener × Moisture level	4	0.00207**	0.049 ns
Error	18	0.00034	0.110
Total	26		
c.v.		4.9%	16.25%

* significant at α =5% ** significant at α =1% ns non significant difference

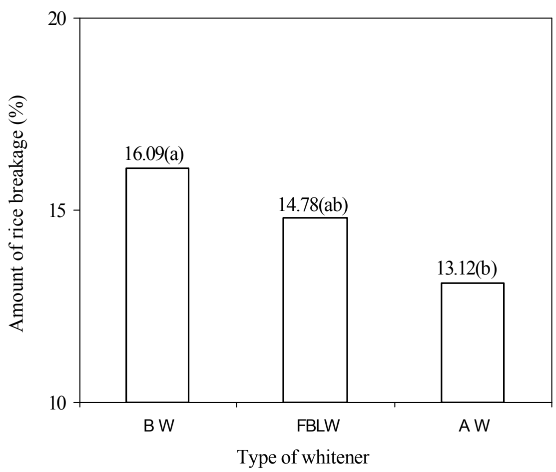

Fig. 1: Effect of whitener type on rice kernel breakage

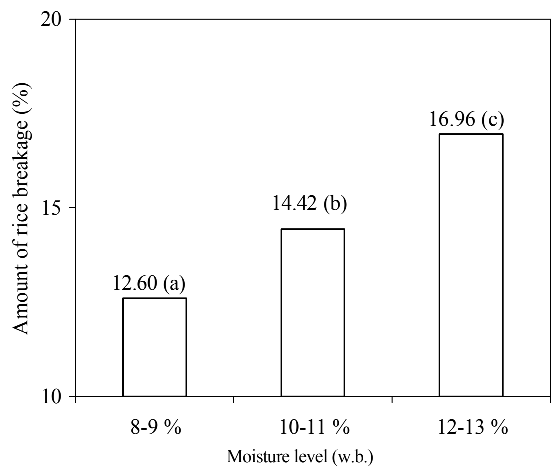

Fig. 2: Effect of paddy moisture level on rice kernel breakage

Fig. 1 illustrates the lowest broken milled rice (13.12%) which was obtained with AW whitener. Meanwhile, the amount of broken milled rice in FBLW (14.78%) was less than BW (16.09%). However there was no significant difference between the FBLW and BW. Also there was no significant difference between the AW and FBLW in broken milled rice. This could be attributed to different type and severity of stresses on rice kernels in milling chamber. In BW, the pressure exerted by the blade caused more pressure on milling chamber and more friction between brown rice and paddies. Obstruction of grains movement in whitener by blade and the contact of grains with them resulted in more mechanical stresses. In FBLW, the horizontal movement of upper cap toward to the perforated screen container has been replaced by blade. It seems that this action tempers the pressures on grains during milling operation and consequently decreases the grain breakage. In abrasive whitener (AW), the grains are whitened through rubbing on roller grinder stone. Therefore, regarding the toughness of grinder roller, less pressure is required in milling chamber than the fictional whiteners. Once, there are not physical obstructions like blade on grain movement route; then the amount of rice breakage is reduced. The obtained results were in good agreements with the reported data by Afzalinia *et al.* [5]. Their investigation showed that using three abrasive whiteners in series and one friction whitener as a polisher resulted in minimum amount of the rice breakage for the local variety of Kamfirouzi. Another conducted experiment indicated that the average broken rice in abrasive whitener was significantly less than the blade-type whitener [12].

The maximum (16.96%) and the minimum percentages (12.60%) of the broken milled rice took place when the paddy moisture level was around 12-13% and 8-9% (w.b.), respectively (Fig. 2). This may be due to low grain hardness at high paddy moisture level. It seems to be due to high brittleness of the grains at low moisture content; the kernel breakage most probably increase at moisture level lower than 8-9%. However, more investigation may be required to define the exact cause of the kernel breakage.

Table 2: Amounts of kernel breakage and crack at different treatments

Treatments[1]		Broken rice[2] (%)	Cracked rice (%)
(FBLW)	M3	[a] 17.19	4.00
(AW)	M3	[a] 17.02	4.33
(BW)	M2	[a] 16.51	4.67
(BW)	M3	[a] 15.97	6.33
(BW)	M1	[a] 15.60	4.00
(FBLW)	M2	[ab] 14.99	4.00
(FBLW)	M1	[bc] 12.34	2.33
(AW)	M2	[bc] 12.15	2.67
(AW)	M1	[c] 10.14	2.33

1- M_1, M_2, M_3 = paddy moisture levels of 8-9, 10-11 and 12-13% (w.b.), respectively.

FBLW, BW, AW= Frictional bladeless whitener, Blade type whitener, Abrasive whitener respectively.

2-Significant at α=1%

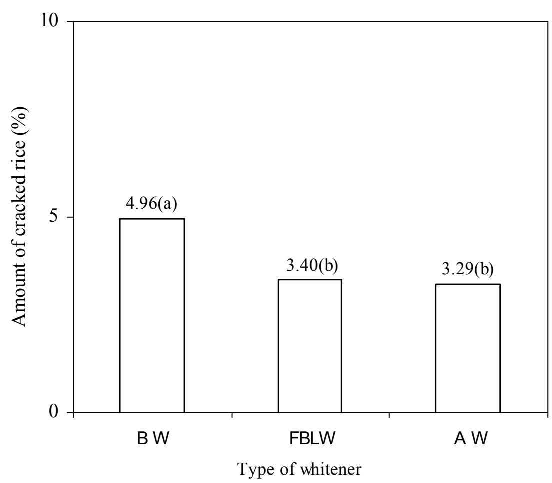

Fig. 3: Effect of whitener type on cracked milled rice

Comparisons for the means of the treatments for the broken grains are summarized in Table 2. The obtained results showed that the treatment includes abrasive whitener with 8-9% paddy moisture level has yielded minimum amount of broken rice. But the means comparisons of the broken rice indicated that there was no significant difference between the AW for the paddy moisture content of 8-9 and 10-11% and FBLW at moisture content of 8-9%.

In addition, Results revealed that there was significant effect ($p<0.05$) of whitener type and moisture level on the cracked grains. However, the interaction effects of whitener type and paddy moisture content was not significant on the cracked grains.

Figure 3 illustrates the maximum percentage of cracked rice (4.96%) was devoted to BW, but there was no significant differences between the AW and FBLW.

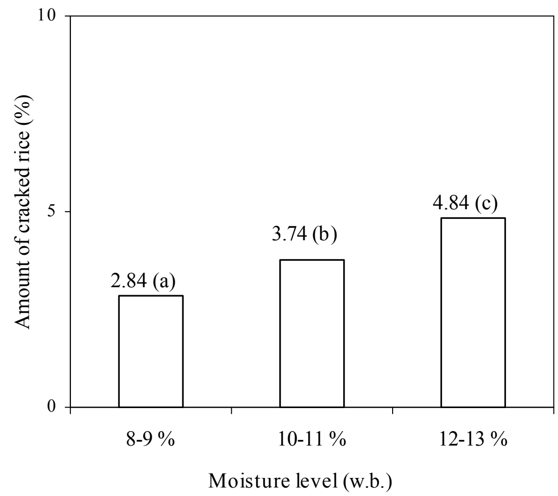

Fig. 4: Effect of paddy moisture level on cracked milled rice

This could be attributed to that in BW, frictional action between the grains led to increased thermal stress in whitening chamber, leading to more crack formation on the grains.

Fig. 4 shows the minimum percentage of cracked grains with the total average of 2.84%; this was found at the lowest percentage of paddy moisture level of 8-9%. Meanwhile the most cracked grain of 4.84% was delivered at the highest paddy moisture level (12-13%). As mentioned before, the reason of thermal tension resulted in grain-grain friction as well as grain-whitener, formed the grain cracks. Perhaps in this level of paddy moisture content, the effect of friction on thermal stresses of milling chamber was at maximum level. Table 2 shows the lowest percentage of cracked rice (2.33%) which was obtained in AW and FBLW with paddy moisture level of 8-9%. According to obtained results, it was concluded that the lowest broken and cracked rice was obtained in AW with paddy moisture content of 8-9%.

ACKNOWLEDGMENTS

Authors are grateful to Islamic Azad University, Rasht branch for the scientific cooperation and financial support provided for the present research. Special thanks devoted to Rice Research Institute of Iran (RRII) for providing laboratory facilities for this project.

REFERENCES

1. Pingali, P.L., M. Hossain and R.V. Gerpacio, 1997. Asian rice bowls: the returning crisis? CABI.,

2. Witt, C., A. Dobermann and D. Dawe, 2004. Increasing productivity of intensive rice systems through site-specific nutrient management. Int. Rice. Res. Inst.,
3. Rahman, M., M. Miah and A. Ahmed, 1996. Status of rice processing technology in Bangladesh. Agricultural Mechanization in Asia Africa and Latin America, 27: 46-50.
4. Archer, T. and T. Siebenmorgen, 1995. Milling quality as affected by brown rice temperature. Cereal Chemistry, 72(3): 304-307.
5. Araullo, E.V., D. De Padua and M. Graham, 1976. Rice: Postharvest Technol.,
6. Bonifacio, E.P., 1989. Effect of Milling Operations on Grain Quality and Price in Selected Philippine Rice Mills.
7. Greeley, M., 1987. Postharvest losses, technology and employment: the case of rice in Bangladesh. Westview Special Studies in Social, Political and Economic Development (Usa).
8. Lyon, B.G., E.T. Champagne, B.T. Vinyard, W.R. Windham, F.E. Barton *et al.*, 1999. Effects of degree of milling, drying condition and final moisture content on sensory texture of cooked rice. Cereal. Chemistry, 76(1): 56-62.
9. Ojha, T., 1984. Improved post-harvest technology to maximize yield and minimize quantitative and qualitative losses. The United Nations University.
10. Wongpornchai, S., K. Dumri, S. Jongkaewwattana and B. Siri, 2004. Effects of drying methods and storage time on the aroma and milling quality of rice (*Oryza sativa* L.) cv. Khao Dawk Mali 105. Food Chemistry, 87(3): 407-414.
11. Satake, S., Y. Okada and S. Ariji, 1997. Bran-removing Perforated Cylindrical Body of Abrasive Type Grain Milling Machine.
12. Champagne, E.T., K.L. Bett, B.T. Vinyard, B.D. Webb, A.M. McClung, *et al.,* 1997. Effects of drying conditions, final moisture content and degree of milling on rice flavor. Cereal Chemistry, 74(5): 566-570.
13. Yadav, B. and V. Jindal, 2008. Changes in head rice yield and whiteness during milling of rough rice (*Oryza sativa* L.). J. Food Engineering, 86(1): 113-121.
14. Roy, P., T. Ijiri, H. Okadome, D. Nei, T. Orikasa *et al.*, 2008 Effect of processing conditions on overall energy consumption and quality of rice (*Oryza sativa* L.). J. Food Engineering, 89(3): 343-348.
15. Afzalinia, S., M. Shaker and E. Zare, 2002. Comparison of different rice milling methods. Canadian Biosystems Engineering, 46(3): 63-66.
16. Farahmandfar, R., E. Farahmandfar, M. Ghasemi Varnamkhasti and M. Zarei, 2010. Milled Rice Quality Assessment. International J. Food Engineering, 6(2): 1682.
17. Firouzi, S., M.R. Alizadeh and S. Minaei, 2010. Effect of the size of perforated screen and blade-rotor clearance on the performance of Engleberg rice whitener. African J. Agricultural Res., 5(9): 941-946.
18. Mead, R., R.N. Curnow and A.M. Hasted, 2003. Statistical Methods in Agriculture and Experimental Biol., CRC. Press.
19. Cnossen, A., M. Jimenez and T. Siebenmorgen, 2003. Rice fissuring response to high drying and tempering temperatures. J. Food Engineering, 59(1): 61-69.
20. Zhang, Q., W. Yang, L. Howard and C. Earp, 2003. Tracing fissure information by scanning electron microscopy characterization of naturally fissured surfaces of rice kernels. Transactions-american Society of Agricultural Engineers, 46(6): 583-1588.
21. Yang, W., C.C. Jia, T. Siebenmorgen, Z. Pan and A. Cnossen, 2003. Relationship of kernel moisture content gradients and glass transition temperatures to head rice yield. Biosystems Engineering, 85(4): 467-476.
22. Madamba, P.S. and R.P. Yabes, 2005. Determination of the optimum intermittent drying conditions for rough rice (Oryza sativa, L.). Lebensmittel-Wissenschaft und-Technologie,. 38(2): 157-165.
23. Zhang, Q., W. Yang and Z. Sun, 2005. Mechanical properties of sound and fissured rice kernels and their implications for rice breakage. J. Food Engineering, 68(1): 65-72.