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Effect of paddy husked ratio on rice breakage and whiteness during milling process

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Abstract

Paddy husking operation is one of the most important stages during milling process, which effectively determines the quantitative and qualitative losses of rice. In this study, the effect of four levels of husked ratio (HR) of 0.6, 0.7, 0.8 and 0.9 on broken brown rice (BBR), broken milled rice (BMR) and rice whiteness (RW) was examined. Three common Iranian rice varieties, namely Binam, Khazar and Sepidroud were used as raw materials. A commercial rice milling system including rubber rolls husker and blade-type whitener was considered in the experiment. The results revealed that the BBR increased significantly (P<0.01) from 7.42 to 10.28%, 9.17 to 13.39% and 15.17 to 21.82% for Binam, Khazar and Sepidroud varieties, respectively as the HR increased from 0.6 to 0.9. The lowest BMR for varieties of Binam (17.83%), Khazar (23.35%) and Sepidroud (28.90%) were obtained at the HR of 0.8. By increasing the HR from 0.6 to 0.9, the RW decreased from 36.1 to 30.8, 36.5 to 30.1 and 35.4 to 29.8 for Bianm, Khazar and Sepidroud varieties.

Keywords: Husked ratio, rubber rolls husker, milling quality, rice whiteness.

Abbreviation:	
HR	Husked ratio
BBR	Broken brown rice (%)
BMR	Broken milled rice (%)
W_f	Mass of paddy after husking operation (g)
W_i	Mass of the paddy sample before husking (g)
W''	Mass of broken brown rice (g)
W'	Mass of the sample of total brown rice (g)
W_1	Mass of the sample of total milled rice (g)
W_2	Mass of broken milled rice (g)
RW	Rice whiteness (degrees)
HRY	Head rice yield (%)

Introduction

Within the worldwide-cultivated cereals, rice (*Oryza sativa* L.) is one of the leading food crops of the world and is second only to wheat in terms of annual for food consumption. In Asia where 95% of the world's rice is produced and consumed, it contributes 40-80% of the calories of Asian diet. Rice is a major crop in Iran with a total paddy production of about 3.0 Mt on an area of 615000 ha (Alizadeh et al., 2006; Farahmandfar et al., 2009). Milling, an important step of paddy processing (rough rice), is usually done in order to produce white and polished grain. A common rice milling system is a multi-stage process where the paddy is first subjected to husking by using a husker and then to the removal of brownish outer layer, known as whitening (Yadav and Jindal, 2008). Rubber rolls husker and blade-type whitener (frictional type) are two typical milling machines used in Iran's rice mills and many Asian rice cultivation regions. In such milling system, the outlet of husker, which is the mixture of brown rice and paddy, is fed to the rice whitener without any separation. The reason is that in blade-type whitener, the presence of some paddy and husk causes frictional increase in whitening chamber, resulting higher rice whiteness. Therefore, it is important to determine the appropriate paddy husking percentage in the rubber rolls husker for different rice varieties to maintain milling quality during husking and whitening process. The head rice yield and degree of milling in rice processing are the major interests in studying the factors influencing rice quality. Head rice yield (HRY) is an important factor as the cooking quality and the market prices which makes the broken rice much less than completes grains. Degree of milling is the rate of bran removal from the rice grain and refers to whiteness of rice. In some countries, degree of milling is not a profound index of rice quality, while Iranians people prefer to consume the rice with high whiteness (Ghasemi-Varnamkhasti et al., 2007). Among the parameters influencing rice milling quality, the optimization of the husker and whitener machines is a prerequisite for maximize head rice yield with desired kernel whiteness. Many researchers have already identified effective parameters improving the performance of milling machines. Firouzi and Alizadeh (2005) found that the rotor speed of

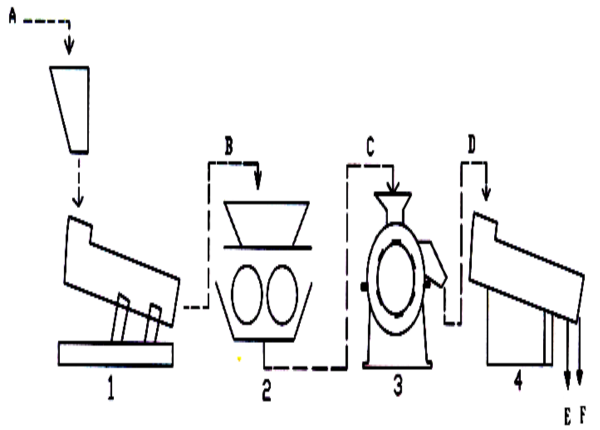

Fig 1. Major components of a commercial rice milling systems in Iran mills. 1. Paddy cleaner, 2. Rubber roll husker, 3. Blade-type whitener, 4. Oscillating grading sieves, A. Dried paddy B. Cleaned paddy, C. Mixture of paddy and brown rice, D. Broken kernels, F. Head rice

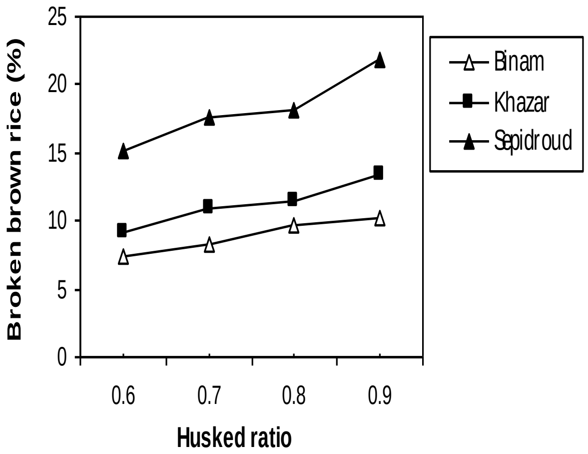

Fig 2. Effect of paddy husked ratio on the broken brown rice

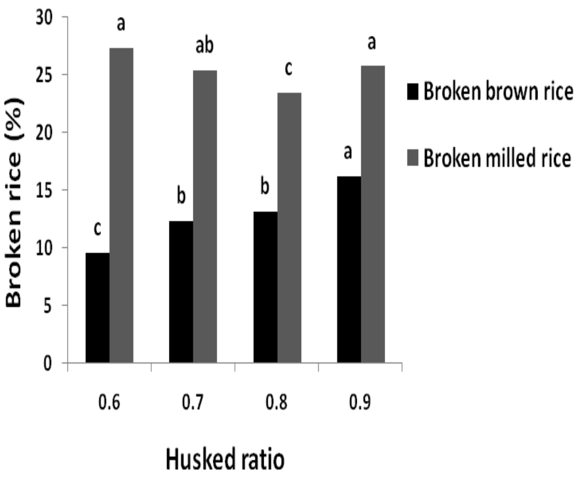

Fig 3. Effect of paddy husked ratio on the broken brown and milled rice

blade-type rice whitener is an important factor affecting rice breakage. Alizadeh and Payman (2004) reported that use of blade-type whitener as a husker in milling process increased rice breakage compared with rubber rolls husker. Payman et al. (1999) determined the most suitable rubber rolls clearance for increasing husking percentage and decreasing rice breakage in a laboratory paddy husker. Yan et al. (2005) found that rice milling quality significantly affected by whitener rotor speed and paddy moisture content. Firouzi et al. (2010) investigated the effect of perforated screen size and blade-rotor clearance on the performance of rice whitener. Shitanda et al. (2001) studied the performance of a paddy husker for different rice varieties with the view of physical properties of paddy. Correa et al. (2007) considered engineering properties of rough rice, brown and milled rice to determine the influence of the rice processing operations on physical and mechanical properties of different rice varieties. Razavi and Farahmandfar (2008) evaluated the effect of husking and milling on the physical properties of rice grains. They reported that the physical characteristics of rice significantly affected by milling process. Although many factors affecting rice breakage have already been studied, however no reports were found about the effect of paddy husking percentage on the rice milling quality. Therefore, the objective of this study is to investigate the effect of paddy husked ratio in rubber rolls husker on the rice breakage and whiteness; to determine the appropriate husking percentage for different varieties in order to achieve minimum rice breakage in a commercial milling system.

Materials and methods

Materials

This study was conducted at the Department of Agricultural Engineering, Rice Research Institute of Iran (RRII), Rasht, Guilan, Iran. Three common Iranian rice varieties, namely Binam, Khazar and Sepidroud were selected as raw materials. Binam is a local and medium-grain variety, while Khazar and Sepidroud are high-yielding and long-grain varieties. A commercial milling system including rubber rolls husker (ISEKI HC 600, Japan) and blade-type whitener (HASAN-MANSOR Manufacturing Co. Ltd., Iran) was considered in the experiment (Fig. 1).

Methods

In this study, the effect of four levels of husked ratio (HR) of 0.6, 0.7, 0.8 and 0.9 on the broken brown rice (BBR), broken milled rice (BMR) and rice whiteness (RW) was examined. The husked ratio, which defines the ratio of brown rice to input paddy was determined by the following equation (Minaei et al., 2007):

$$HR = 1 - \frac{W_f}{W_i} \qquad (1)$$

Where, HR is the husked ratio (%), W_i is the mass of the sample before husking (g) and W_f is the mass of paddy in the final product (g). The broken brown rice was calculated by the following equation (Alizadeh and Payman, 2004):

$$\text{BBR} = \frac{W''}{W'} \times 100 \qquad (2)$$

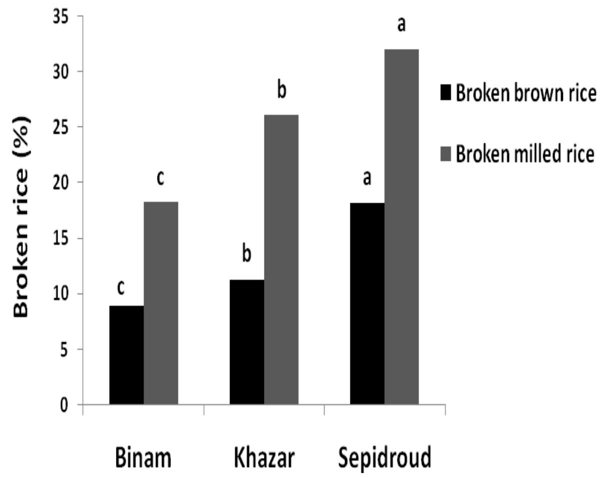

Fig 4. Means comparison of broken rice for the tested varieties.

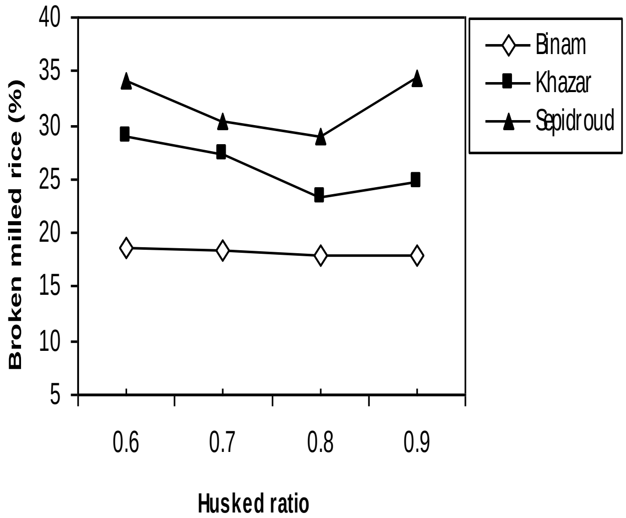

Fig 5. Effect of husked ratio on the broken milled rice for different varieties.

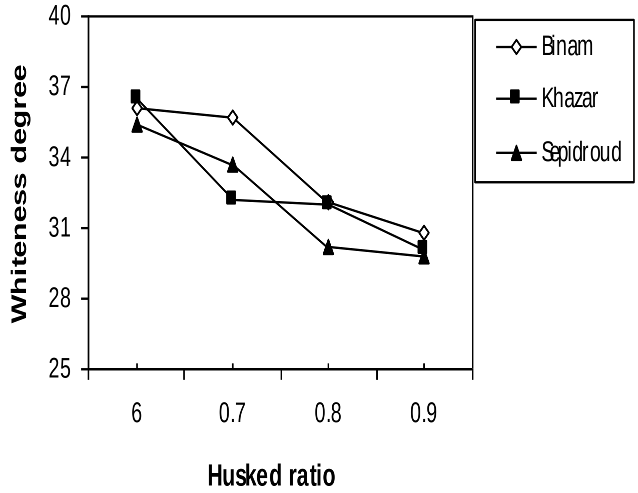

Fig 6. Effect of husked ratio on the whiteness of rice for different varieties

Where, BBR is the broken brown rice (%), W' is the mass of the sample of total brown rice (g) and W'' is the mass of broken brown rice with smaller than of 0.75 of intact grain (g). The initial paddy moisture content was determined by means of a grain moisture meter (GMK-303 RS Model, Korea). The samples of paddy were dried in a batch type bed dryer (HASAN-MANSOR Manufacturing Co. Ltd., Iran) at a constant air temperature of 43 ºC until the desired moisture content was obtained (Minaei et al., 2007). Before the major tests and to achieve the above-mentioned husking levels, rubber rolls clearance was adjusted by using a filler gauge. Then, three samples of 100 g mixture of brown rice and paddy were randomly chosen from the outlet of the husker. The mixtures were separated into paddy and brown rice manually, and then weighted. In order to perform the major tests, samples of 50 kg of dried paddy of each variety were supplied and loaded to the husker machine. The outlet of the husker which was mixture of brown rice and paddy was fed to the blade-type rice whitener for bran removal. To measure the percentage of broken milled rice (BMR), three samples of 100 g were randomly chosen from the outlet of the husker and rice whitener. A rotary indent separator (TRG058 Model, SATAKE Test Rice Grader, Japan) was used for separating head and broken kernels. A kernel having equal to or more than 75% intact was considered as whole kernel (Farouk and Islam, 1995). The broken milled rice was calculated by the following equation (Firouzi et al., 2010):

$$\text{BMR} = \frac{W_2}{W_1} \times 100 \quad (3)$$

Where, BMR is the broken milled rice (%), W_1 is the mass of the sample of total milled rice (g) and W_2 is the mass of broken milled rice with smaller than of 0.75 of intact milled rice (g). Kernel whiteness was measured with a pre-calibrated whiteness tester (Kett Whiteness Tester, Model C-100, Japan).

Data analysis

The experimental design was Randomized Complete Design (RCD) with factorial layout in which three tested varieties and four levels of paddy-husked ratio were the independent parameters. Data was analyzed using analysis of variance (ANOVA). Treatment means were compared by the Duncan's Multiple Range Test (DMRT) at significance level of 95% with three replications**.**

Results and discussion

Effect of husked ratio on the broken brown rice

Effect of husked ratio (HR) on the broken brown rice (BBR) for the tested varieties is illustrated in Fig. 2. The results indicated that for each type of variety, the BBR increased significantly ($P<0.01$) with increasing HR in the rubber rolls husker. The BBR increased from 7.42 to 10.28 %, 9.17 to 13.39 % and 15.17 to 21.82 % for Binam, Khazar and Sepidroud varieties, respectively as the HR increased from 0.6 to 0.9. The maximum BBR value (average of three varieties) of 15.16 % was obtained at HR of 0.9, while the least value of 10.58 % was recorded at HR of 0.6 (Fig. 3).

Furthermore, there was a significant difference (P<0.01) between the percentage of BBR for the tested rice varieties. The mean values of BBR for Binam, Khazar and Sepidroud varieties were determined to be 8.94, 11.23 and 18.16 %, respectively (Fig. 4). The HR depends on the operational parameters of husker machine and physical properties of paddy grains. In a rubber rolls husker, the HR increased by decreasing the rubber rolls clearance (Payman et al., 1999). Smaller the clearance between the rolls, more the normal and compressive force was applied to the grains, leading to increase in broken kernels (Sarker and Farouk, 1989).

Effect of husked ratio on the broken milled rice

Effect of HR on the broken milled rice (BMR) is shown in Fig. 5. It was observed that the lowest BMR for varieties of Khazar (23.35 %), Sepidroud (28.90 %) and Binam (17.83 %) was obtained at the HR of 0.8. It was observed that the BMR first decreased up to HR of 0.8 and then increased. This could be attributed to that at lower value of HR, which more paddies were mixture with brown rice in whitening chamber, producing excessive pressure and friction between the grains in the blade-type rice whitener. This caused higher mechanical and thermal stresses in the whitening chamber, resulting in more BMR. At the HR of 0.9, most broken grains were occurred at husking operation in the rubber roll husker, especially for long-grain varieties of Khazar and Sepidroud. However, for Binam variety, a different pattern was observed in which the BMR constant with increasing the HR (Fig. 5). This may be due higher resistance of Binam (as a medium-grain variety) against mechanical and thermal stresses during whitening stage. In other word, for Binam variety, most of the grains were broken in the husking operation than in whitening process. The other researchers have reported that there was a significantly relationship between increased stresses in the whitening chamber and the percentage of broken rice (Mohapatra and Bal, 2004; Pillayar and Govindsamy, 1985). The average BMR for Khazar (26.03 %) and Sepidroud (31.96 %) was significantly more than that of Binam (18.22 %), as shown in Fig. 4. The reason is that the long-grain rice varieties are more susceptible for breakage during milling processing (Goodman and Rao, 1985).

Effect of husked ratio on the rice whiteness

The results showed that rice whiteness (RW) decreased significantly (P<0.01) as the HR increased. It decreased from 36.5 to 30.1, 36.1 to 30.8 and 35.4 to 29.8 for varieties of Khazr, Binam and Sepidroud, respectively as the HR increased from 0.6 to 0.9 (Fig. 6). The average rice whiteness for Khazar, Binam and Sepidroud were 32.9, 33.1 and 32.2, respectively. In blade-type whitener, the rice whiteness (as a measure of milling degree) depends on such parameters as the grains input and output rate, the amount of pressure exerted on the grains in whitening chamber and the time of milling. At low HR, the excessive paddies were mixture to brown rice, producing excessive frictional between the grains in the whitening chamber. As a result, the enclosed grains were subjected to substantial pressure forces, leading to more bran removal and increased degree of milling.

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