Comparison of different rice milling methods

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Afzalinia, S., Shaker, M. and Zare, E. 2004. **Comparison of different rice milling methods.** Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **46**: 3.63- 3.66. This study was conducted to determine the best rice milling method in the Fars province of Iran. First, the effect of the paddy moisture content on the milled rice breakage was evaluated. Then four different milling systems were compared and, finally, an economic evaluation was performed to justify the economic performance of the selected method. Results of this study showed that the optimum paddy moisture content for the milling process was 12 to 14% wet basis (wb), and using three abrasive whiteners in series and one friction whitener as a polisher resulted in the least rice breakage, proving this method to be the best choice for the rice milling operation in the province of Fars. Economic evaluation confirmed the results of the method of comparison.

Le but de cette étude était de déterminer la meilleure méthode pour le décorticage du riz dans la province de Fars en Iran. L'effet de la teneur en eau des grains de riz non décortiqués sur le bris des grains de riz a d'abord été évalué. Ensuite, quatre systèmes de décorticage différents ont été comparés et finalement, une évaluation économique a été faite pour justifier les performances économiques de la méthode sélectionnée. Les résultats de cette étude démontrent que la teneur en eau optimale des grains non décortiqués pour le procédé de décorticage était de 12 à 14% (base humide) et que l'utilisation en série de trois blanchissants abrasifs et d'un blanchissant de friction pour le polissage final provoquait le moins de brisure des grains, prouvant ainsi que cette méthode constitue le meilleur choix pour les opérations de décorticage du riz dans la province de Fars. L'évaluation économique a confirmé les avantages de cette technique.

INTRODUCTION

A rice kernel is covered by two layers. The outer layer is called the husk or hull and the inner layer is the bran. The whole rice kernel, including these two layers, is called paddy (rough rice). Husk is not edible and bran reduces the rice luster; therefore, they must be removed from the paddy. The husk is not tightly attached to the kernel and is easily removed. When this layer is removed, the kernel is called brown rice. The bran is more difficult to remove because it is tightly attached to the kernel. The process of removing the bran is called whitening or pearling. During this process, rice kernels are subjected to intensive mechanical and thermal stresses which might damage or break some of the kernels. Some parameters such as the type of whitening machine, the paddy characteristics, and the environmental factors affect the rice kernel damage and breakage during the milling process. In this study, the effect of the paddy moisture content and the milling system components on the rice kernel breakage during the milling process was investigated under the prevailing conditions in Fars, Iran, and an economic evaluation was performed to determine the most economical method of milling rice.

LITERATURE REVIEW

Rice kernel breakage during the milling process is affected by different parameters such as paddy harvesting conditions, paddy drying, physical properties of the paddy kernels, the environmental conditions, and the type and quality of the milling system components. Many studies have been conducted in this area. Davis (1944) reported that the optimum harvest moisture content for the paddy of the Caloro variety was 20 to 24%. Pominski et al. (1961) showed that the paddy moisture content had a significant effect on milling yields of Bluebonnet 50 long-grain rice. They selected samples with moisture content ranging from 10 to 14% and concluded that for each one percent decrease in rice moisture content, head yields and total yields increased 3 and 0.7%, respectively. Matthews et al. (1970) found that rice breakage at milling was mostly due to mechanical stresses rather than thermal stresses. Matthews and Spadaro (1975) evaluated the effect of the harvesting method on rice breakage during the milling process. They found that the samples that had been harvested by combine contained 5% more broken kernels than the samples that had been harvested manually. Matthews and Spadaro (1976) also found that rice breakage during the milling process increased when the kernel diameter decreased. Dilday (1987) studied the effect of moisture content on the rice breakage during the milling process. He used samples with moisture content of 12 to 16% and concluded that rice breakage decreased with increase of paddy moisture content. Luh (1991) reported that to have a high quality head rice with minimal breakage, paddy must be harvested at the optimum moisture content.

Clement and Seguy (1994) found that long and tiny rice kernels were more susceptible to breakage during the milling process as compared to wide short kernels. Peuty et al. (1994) reported that the paddy drying conditions affected the rice breakage during the milling process so that rice breakage increased rapidly with decreasing moisture content of the air used to dry the paddy. Autrey et al. (1955) showed that the difference between the paddy temperature and the milling environment temperature decreased the performance of the rice milling system. They also found that the relative humidity of the milling environment had a significant effect on the milling yield.

MATERIALS and METHODS

In the province of Fars, where most of this study was performed, diverse combinations of milling components are used in milling plants. In almost all milling plants of the province, rubber roll shellers and paddy separators are utilized. In the old milling plants, a friction type whitener is often used

Table 1. Average rice breakage and shelling performance of two shellers.

Sheller type	Average rice breakage (%)	Average shelling performance (%)	Calculated "t" value	Critical "t" value (p = 0.01)
Rubber roll	9.3	83.7	8.91**	4.6
Friction whitener	17.6	92.4	6.72**	4.6

** 99% level of significance

in such a way that brown rice is whitened by passing it through this whitener without using a polisher. In some cases, these whiteners are used in series. In the modern milling plants, a set of three or four vertical abrasive whiteners in series is used as whitener with a friction whitener as a polisher. The rubber brush polisher which was used in this research was a new polisher that had been designed in Iran.

This study was carried out in three different parts. In the first part, two types of shelling machines were compared from the viewpoint of the shelling performance and the percentage of rice breakage during the shelling process. The second part concerned the evaluation of the effect of paddy moisture content on rice breakage during the milling process and the final part compared four different combinations of milling machines from the standpoint of rice breakage.

Sheller comparison

The rubber roll sheller is the most common sheller in Iran, but in some areas of the country such as the north, friction type whiteners are also used as shellers because of the high variable costs of the rubber sheller. For this reason, a study was conducted in the province of Gilan comparing the rubber roll sheller and friction whitener as a sheller from the viewpoint of the shelling performance and rice breakage. Both machines were used under the same environmental conditions such as relative humidity and temperature and 100 g samples were taken from their outlets. Broken kernels were separated from the whole kernels and the percentage of rice breakage was calculated by dividing the weight of broken kernels by the total weight of the sample. The shelling performance (ratio of the weight of shelled kernels to the total weight of sample) of each sheller was also determined. The rice variety that was used in this research was Safidrood with dimensions of 10.60 mm length, 2.35 mm width, and 2.00 mm thickness at 6% moisture content (wb). To analyze the data of this part of the study, a t-test with two treatments and four replications was used.

Effect of moisture content

This part of the study, which was evaluating the effect of paddy moisture content on the rice breakage during the milling process, was carried out in the province of Fars. Three levels of paddy moisture content (8 to 10%, 10 to 12%, and 12 to 14%) were considered. The most common milling system in the province of Fars which consisted of a rubber roll sheller, an abrasive whitener, and a friction whitener as polisher was used. A local rice variety (Kamfiroozi) with dimensions of 5.9 mm length, 2.32 mm width, and 1.78 mm thickness was utilized. The paddy with the selected moisture content was passed through the milling system and samples of 100 g were taken from the outlet of each machine to measure the percentage of rice breakage by the milling system and its components at each level of moisture content. A randomized complete block design with split plot arrangement of two factors (machine type and moisture content) with five replications was used to analyze the data. Main plots were moisture contents and subplots were machine types.

Milling methods

Four different combinations of whitener and polishers in the milling system were compared from the viewpoint of rice breakage, whitened rice appearance, and financial costs in the province of Fars. Considered combinations were:

1. Three abrasive type whiteners in series and a rubber brush polisher
2. Three abrasive type whiteners in series and a friction type whitener as a polisher
3. Two friction type whiteners in series without polisher
4. Four abrasive type whiteners in series without polisher

The same sheller, paddy separator, and cleaning and grading systems were used for all treatments. An identical amount of rough rice (160 kg) with 12 to 14% moisture content was whitened by each of the considered milling systems and 100-g samples were taken from the outlet of each system. Broken kernels of the samples were separated from the whole ones and finally the breakage percentage of each treatment was calculated.

The appearance of the whitened rice is an important parameter in the rice market value; therefore, one-kilogram samples were collected to evaluate the appearance of each treatment output. These samples were marked out of ten by nine different experts in the rice market to compare the samples' marketability. In the meantime, an economic evaluation was carried out to find the most economical treatment. A completely randomized design (CDR) with five replications was used to analyze the data. Duncan's Multiple Range test was used for the mean comparison of all tests.

RESULTS and DISCUSSION

Sheller comparison

Comparison between the two types of shellers showed that there was a significant difference ($p<0.01$) between them from the viewpoint of rice breakage. The amount of breakage resulting from the use of the friction whitener as sheller was approximately twice as much as that of the rubber roll sheller, while its shelling performance was only 8.7% higher than that of the rubber roll sheller (Table 1). Even though, the shelling performance of the friction whitener was higher than that of the rubber roll sheller, using it as a sheller is not recommended because of its high percentage of rice breakage.

Effect of paddy moisture content

Paddy moisture content had a significant effect on rice breakage of the whitener and the entire milling system so that rice breakage decreased with increased paddy moisture content in the tested ranges (Table 2). Moisture content had no significant

Table 2. Average rice breakage of the milling system and its components at different paddy moisture contents.

Moisture content (% wb)	Sheller	Whitener	Polisher	Whole milling system
8-10	1.36 a	17.86 a	2.48 a	21.64 a
10-12	3.21 a	15.78 b	2.27 a	21.26 a
12-14	1.69 a	11.5 c	3.9 a	17.09 b
Average	2.09	15.03	2.88	20.00

a, b, c - Averages in a column with different letters are statistically different at the 99% level.

Table 3. Average rice breakage of different milling methods.

Milling system	Average rice breakage (%)
Two friction whiteners without polisher	25.15 a
Three abrasive whiteners with rubber brush polisher	19.05 b
Three abrasive whiteners with friction whitener as polisher	16.9 b
Four abrasive whiteners without polisher	16.77 b
LSD (p=0.01)	3.68

a, b - Averages with different letters are statistically different at 99% level.

Table 4. Marketability of the whitened rice with different milling methods.

Milling system	Average marks (out of 10)
Three abrasive whiteners with friction whitener as polisher	9.49 a
Four abrasive whiteners without polisher	7.17 b
Two friction whiteners without polisher	5.96 b
Three abrasive whiteners with rubber brush polisher	4.35 c
LSD (p=0.05)	1.59

a, b, c - Averages with different letters are statistically different at the 95% level.

Table 5. Average rice milling cost of different milling methods.

Milling system	Average milling cost (Can$/kg)
Three abrasive whiteners with friction whitener as polisher	0.014
Four abrasive whiteners without polisher	0.054
Two friction whiteners without polisher	0.104
Three abrasive whiteners with rubber brush polisher	0.107

effect on the rice breakage of the sheller and polisher; however, rice breakage in these machines showed a small variation with moisture change. The results also revealed that about 75% of the total rice breakage during the milling process occurred in the whitening machine. The minimum total rice breakage occurred at the range of 12 to 14% moisture content; therefore, this range was the optimum moisture content for the paddy at the milling time.

Milling methods

Results of this study showed that the milling method had a significant effect ($p<0.01$) on the rice breakage during the milling process. The method containing a friction type whitener had the highest amount of rice breakage, and the treatment using the abrasive whitener without polisher had the lowest breakage; however, there was no significant difference between the methods using an abrasive whitener from the viewpoint of rice breakage (Table 3). The results of the rice appearance comparison showed that the output of the treatment using three abrasive whiteners in series and a friction whitener as polisher had the best appearance and its marketability obtained the highest mark (Table 4). The economic evaluation also showed that the system containing three abrasive whiteners in series with a friction whitener as polisher was the most inexpensive method to whiten a unit weight of paddy (Table 5), and therefore it was the most economic method.

CONCLUSIONS

The following conclusions were drawn from the results of this study:

1. Using a friction type whitener as a sheller in the rice milling process was not reasonable, because it caused a high rate of rice breakage.
2. The optimum paddy moisture content at milling time for the tested variety was 12 to 14%.
3. The method using three abrasive type whiteners in series with a friction whitener as polisher had the minimum rice breakage and lowest milling cost, and its output had the best appearance and marketability; therefore, it was the best rice milling system for the tested variety and region.

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