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Performance assessment of a modified blade-type whitener (frictional milling machine) considering rice output flow rate

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To reduce rice losses during production, improvement and optimization of rice milling machines and assessment of effective factors on rice losses are useful. In this study, a rotor equipped with screw conveyor was used. The effect of output flow rate (in three levels 400, 500 and 600 kg/h) on rice quality was investigated. Experiments were conducted on Sorkheh variety at rotor speed of 600 rpm. In each treatment breakage percentage and degree of milling were measured. The results obtained proved that the effect of output flow rate is significant at 5% level probability on rice quality. The highest breakage percentage and lowest degree of milling occurred at an output flow rate of 600 kg/h. Significant differences in rice quality (broken rice & degree of milling) were not found between output flow rates of 400 & 500 kg/h. It is concluded that an output flow rate of 600 kg/h is not suitable, but lower output flow rates are favorable.

Key words: blade-type whitener, Rice; breakage percentage, degree of milling, output flow rate

Introduction

Rice (*Oryza Sativa* L.) is one of the leading food crops of the world and is second only to wheat in terms of annual production for food use. The world's rice production increased from 520 million tons in 1990 to 605 million tons in 2004. In the meantime, Iran's rice production increased from 1.3 million tons in 1980 to 3.4 million tons in 2004 (FAOSTAT, 2005).

The head rice yield (75-100% of whole kernel) and degree of milling (DOM) in rice processing are among the major interests in studying the factors influencing rice quality. Degree of milling is an index of bran removal from rice grain and refers to whiteness of rice. In some countries, degree of milling

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is not a profound index of rice quality; while in Iran, people prefer to consume the rice with high degree of milling (high whiteness). Therefore degree of milling is considered as a substantial parameter affecting the marketing value (Courtois *et al*., 2001). Milling of rice increases its shelf life and provides consumers with an attractive appearance they have come to desire which is the whiteness. Along with longer shelf life, white rice cooks faster than that of the brown rice.

One of the major problems of the rice industry is breakage of kernels during milling. As the cooking quality of broken rice is very poor, the market price with broken grains is much less than that of the whole grains (Li *et al*., 1999). The ultimate aim of the rice industry is to achieve maximum head rice yield (minimum breakage percentage) from the milling process. Breakage percentage is the current standard to assess commercial rice milling quality. The marketing value of rice as an agricultural product depends on its physical quality after the processing. The breakage percentage is the most important parameter for the rice processing industry (Marchezan, 1991). Studies have shown that presence of broken rice in the final product can lower the price to even one tenth compared to that of the same product in its high quality status in the world market. From the economic point of view, the quality of milled rice is of paramount important since the grain size and shape, whiteness and cleanliness are strongly correlated with the transaction price of rice (Conway *et al*., 1991).

Two types of milling machines, namely, abrasive and frictional types, are used for whitening of grain. In the frictional type, brown rice (dehusked paddy by rubber roll dehusker) kernels are rubbed against each other under pressure to get the desired whiteness. In such machines, HRY (head rice yield) and DOM are affected by such factors as the pressure in milling chamber and the duration of milling which are attributed to proper design, adjustment and control operations. Therefore, optimization and improvement of the machines used in rice milling process contribute to the best rice quality. In this regard, a new rotor was designed and developed in Agriculture and Natural Resources Center in Esfahan, a central province in Iran. It had been equipped with a screw conveyor which facilitates the longitudinal movement of milled rice and reduces the rice losses compared to prevalent rotor (Heidarisoltanabadi & Hemmat, 2007). This study was conducted to evaluate the performance of blade whitener (frictional type milling machine), common in Esfahan province, equipped with the tested rotor considering the effect of rice output flow rate on the rice quality.

Material and methods

All experiments in this study were conducted in Sahebzaman industry located in southwest of Esfahan city. The blade type whitener machine had been equipped with a screw conveyor developed by the Agricultural and Natural Resources Research Center in Esfahan as mentioned earlier. The length of the rotor was 46 cm from which 15 cm was used for conveying and the rest was used as the agitator (Fig. 1). The rotor diameter was 12 cm and six embossed treads with dimensions of 1x1 cm which were distributed evenly on its perimeter. The clearance of the first part (where material enters) of the rotor was 9 mm and the clearance of the last part (where the material exits) of the rotor which was 7 mm from the fixed blade. The most common rice variety in the region, Sorkheh, was considered for this study. An electronic moisture meter (model of SP-1D2 Kitte) was used for rice moisture measurements. Since the samples used in the experiment that had been stored for one year, the initial moisture content was 10% (w.b). This is desirable moisture content for rice milling and hence no further drying was required.

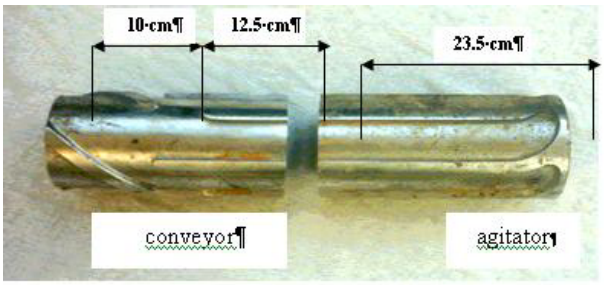
Using two roller type dehusker machines (model ISEKI HC600) adjusted for 1050 rpm and 800 kg/h throughput capacity (the real condition of hulling in the region), the sampled variety was cleaned. The resulted brown rice with 10% rough (paddy) rice impurity was collected.

The whitening experiments were conducted based on a factorial experiment in randomized complete block design with three replications. Independent variable was output flow rate in three levels of 400, 500 and 600 kg/h. The output flow rate was changed by varying the outlet cross sectional area of the tested whitener for each treatment.

The output flow rate, 18 kg of mixed paddy and brown rice obtained from the dehusker machine was placed in the whitener container. Then, for each treatment, a 150 g processed (whitened) sample was taken randomly from the outlet of the whitener machine for further quality analysis. The breakage percentage (BP) and the degree of milling were calculated by Eqs. 1 and 2 (Anon, 1990):

$$\text{Breakage percentage} = \frac{W'}{W} \quad (1)$$

where W' and W are considered as the mass of kernels with smaller length of 0.75 of that of intact milled rice kernels and the total mass of the sample, respectively.



a

b

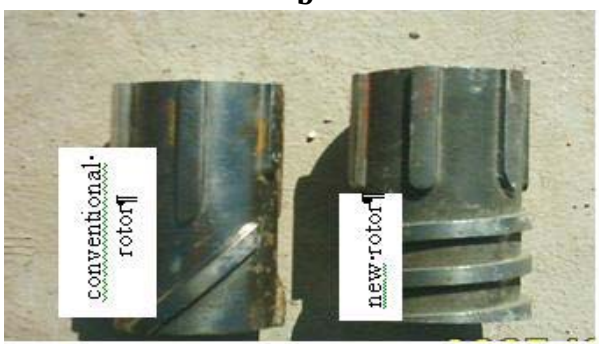


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Fig.1. a) Conventional rotor b) The tested rotor c) Comparison of rice conveyor parts in conventional and the tested rotor

$$\text{Degree of milling} = \frac{W_1 - W_2}{W_1} \qquad (2)$$

where W_1 and W_2 are defined as mass of the 1000 intact brown kernels and the mass of the 1000 intact whitened kernels, respectively.

At last, the collected data were analyzed by statistical software of SPSS13.

Results and discussion

When the output flow rate increases, resident time of rice in the milling chamber decreases which may suggest less breakage percentage. On the contrary, results obtained from this study differs form this suggestion. Statistical analysis revealed the highest breakage percentage (26.36%) occurred at 600 kg/h flow rate. As illustrated in Table 1, the effect of output flow rate on breakage percentage was significant (at $P<0.05$). The breakage percentage point of view, there was no significant difference between the outputs of 400 (21.8%) and 500 kg/h (23.13%) but there was a significant difference between the output flow rate of 600 kg/h and the rest of the output flow rates (Fig. 2). It seems that as the output flow rate is increased, the filling degree of the chamber is reduced; consequently, rice is thrown in milling chamber and is subjected to impact forces, resulting in high breakage percentage (Heidarisoltanabadi and Hemmat, 2007).

Table 1. Variance Analysis of effect of the output flow rate on the breakage percentage.

Variation source	DF	MS	F
Replicate	2	0.316	0.294^{ns}
Output flow rate	2	16.51	15.35^{*}
Total error	4	1.075	-

*Corresponding to 5% probability
^{ns}Corresponding to no significant difference

As shown in Table 2, changes of output flow rate showed a significant effect on degree of milling (whiteness percentage) of the sampled rice variety (at $P<0.05$). As illustrated in Fig. 3, the lowest degree of milling (2.95%) is obtained with output flow rate of 600 kg/h while there was no significant difference between output flow rates of 400 (5.27%) and 500 kg/h (6.23%). Rice kernels in the milling chamber are subjected to frictional and pressure forces. The former, includes frictional forces among grains and between grains and interior surface of the milling chamber and the latter corresponds to gravitational forces of grains. Overall, while the output flow rate is reduced, the number of grains in the chamber is increased as well. As a result, the enclosed grains are subjected to substantial frictional and pressure forces leading to intensification of bran removal of rice kernels. Therefore, reducing the output flow rate has a considerable effect on increasing the degree of milling. This is in agreement with what reported by Bhattacharya (1980) and Ahmed & Mazed (1996). Since there was no significant difference between

flow rates of 400 and 500 kg/h regarding the DOM, the latter is recommended from economical point of view.

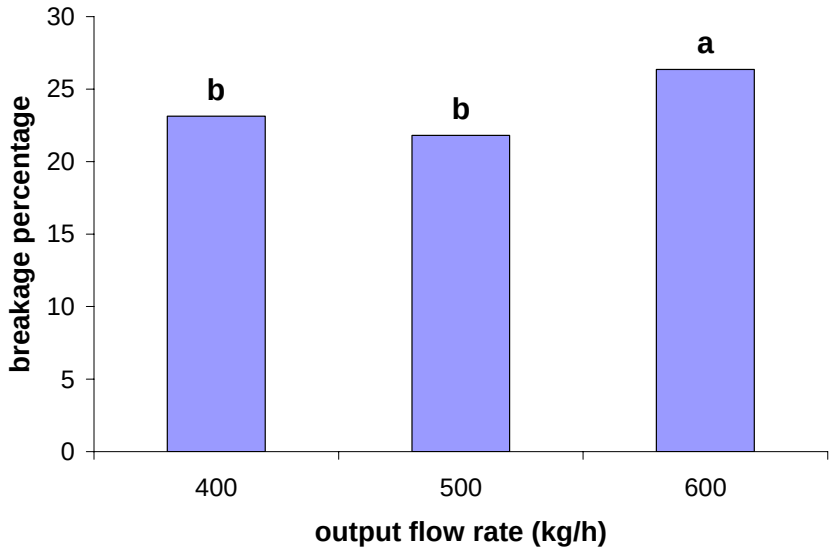

Fig. 2. Effect of output flow rate on breakage percentage.

Effect of rotor speed (varying from 650 to 900 rpm) and outlet cross sectional area of the whitener machine (varying from 605 to 795 mm2) on quality of khazar variety was investigated by Ghavami (2002). He reported that change of the outlet cross section area of the whitener (output flow rate) had a significant difference on degree of milling as the increasing the outlet cross section area of orifice causes the degree of milling to reduce. The reported finding agrees with the concluded result in the present study.

Table 2. Variance Analysis of effect of output flow rate on degree of milling.

Variation source	DF	MS	F
Replicate	2	0.534	0.615^{ns}
Output flow rate	2	8.94	10.3^{*}
Total error	4	0.87	-

*Corresponding to 5% probability
^{ns}Corresponding to no significant difference

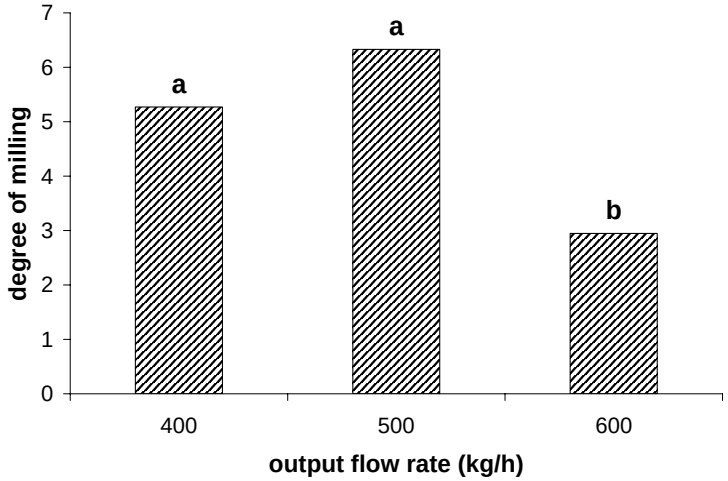

Fig. 3. Effect of output flow rate on degree of milling.

Conclusions

The highest breakage percentage and the lowest degree of milling occurred at output flow rate of 600 kg/h. In terms of rice losses, there was no significant difference between output flow rates of 400 and 500 kg/h. From economical point of view, rice whitening operation with the tested whitener at output flow rate of 500 kg/h is recommended.

References

Ahmed, A., & Mazed, M. A. (1996). Improving the rice post-harvest technology in Bangeladesh. Agriculture and Mechanization in Asia, Africa and Latin America, 27: 37-43.

Anonymous. (1990). Test code and procedure for rice mills. RNAM Test Codes and Procedures for Farm Machinery. Pasay City, Metro Manila, Pilippines.

Bhattacharya, K. R. (1980). Breakage of rice during milling. A review, Tropical Science, 22: p225.

Conway, J. A., Sidik, M. & Halid1, H. (1991). Quality/value relationship in milled rice stored in conventional warehouses in Indonesia. In: Naewbanij, O.J., Manilay, A.A. (Eds), Proceedings of the Fourteenth ASEAN Seminar on Grain Postharvest Technolog, Manila, Philippines, 5-8 November, pp. 55-82.

Courtois, F., Abud, M. & Bonazzi, C. (2001). Modeling and control of a mixed-flow rice dryer with emphasis on breakage quality. Journal of Food Engineering, 49: 303-309.

FAOSTAT., 2005. Rice production available from http://faostat. fao.org.

Gavami, S., (2002). Effect of rotor speed and outlet area in milling machine on breakage and degree of milling of rice grain(Khazar variety). Unpublished thesis, University of Tehran.

Heidarisoltanabadi, M., & Hemmat, A. (2007). Effect of blade distance and output rate on rice quality in a modified blade-type milling machine. Journal of Science and Technology Agriculture and Natural Resources, 11(1): 25-32.

Li, Y. B., Cao, C. W. Yu, Q. L. & Zhong, Q. X. (1999). study on rough rice fissuring during intermittent drying. Drying Technology, 17(9): 1779-1793.
Marchezan, E. (1991).Whole rice kernels in rice. Lavoura Arrozeira (44 pp.3-8), Porto Alegre, Brazail.

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