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The Physical Quality of Milled Rice as Affected by Moisture Content and Relative Humidity during Delayed Rough Rice Drying

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A R T I C L E I N F O

Research Article

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A B S T R A C T

Delayed rough rice drying was often found in tidal low land in Indonesia due to rice harvesting used to be in rainy season. Moisture re-absorption of rough rice during delayed drying caused fissures and breakage after rice milling. This experimental works condition the rough rice in some different moisture content and relative humidity during delayed drying. This aim of this study was to develop an alternative condition of delayed rough rice for drying so as not to significantly affect the physical quality of milled rice. The experiment was arranged as a factorial-randomized block design. Each treatment was repeated three times. Rough rice of IR42 variety was selected at three level of moisture content (24.89%, 18% and 22%), and was stored in a closed vessel at the relative humidity of 76% and 86%. The percentage of whole grain, head rice, large broken grain, and small broken grain were daily assessed until 7 days of delayed drying duration. The results showed that the moisture content and relative humidity had a significant effect on all parameters on each day of delayed rough rice drying duration. Rough rice would be better delayed for drying at the conditions for moisture content of 22% and relative humidity of 86%.

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Introduction

Land for rice production in Indonesia is decreasing due to loss of agricultural land for urbanization, industries and infrastructures; therefore the marginal land such as tidal low land was used for rice production. The tidal low land gives beneficial for rice growth for its water supply. Rice harvesting in tidal low land used to be in dry season; however, due to global climate change, rice harvesting is often in rainy season. It is unavoidable that there would be delayed rough rice drying due to lack of sunlight in rainy season as well as limited amount of rice mills.

During delayed drying, rough rice was stacked without an appropriate cover; therefore it would absorb moisture from surrounding environment and increase its moisture content. Rice farmers used to delay rough rice drying for two to seven days. The moisture content of the rough rice fluctuates during delayed drying due to differences in temperature and humidity in day and night. This condition would have an effect on the physical and physicochemical properties of milled rice.

There were some studies on the effect of environmental condition on rice quality. Ondier et al. (2010) determined the rice quality of rice as affected by low-temperature and low-relative humidity drying of rough rice. Luangmalawat et al. (2008) investigated the effect of temperature on drying characteristics and quality of cooked rice. Allameh and Alizadeh (2013) evaluated the rice losses during delayed rough rice drying in Iran. Wiset et al. (2005) assessed the physicochemical properties of various cultivars of rice as affected by high-temperature during rough rice drying. Unfortunately those studied did not evaluate the physical quality of milled rice during delayed rough rice for drying. This finding would be the basis for determining the best condition of delayed rough rice for drying, particularly in tidal low land rice field in Indonesia.

Materials and Methods

Rough Rice Variety

The rough rice variety of IR42 was harvested from Mulya Sari village, Tanjung Lago sub-district, Banyuasin District, south Sumatera, Indonesia.

Rough Rice Preparation

Rough rice samples were grouped in three levels of moisture content (MC), they were freshly harvested rough rice (designated as A1, at MC 24.89% wet basis (wb)), rough rice was conditioned at MC 18% wb (A2) and 22%

wb (A3) wet basis. Rough rice sample as amount of 600 g was placed in a closed vessel that had been conditioned to a certain relative humidity (RH), namely RH 76% (designated as B1) and 86% (designated as B2). The RH of 76% was adjusted by using saturated salt solution of potassium chloride (KCl) and the RH of 86% was adjusted by using sodium chloride (NaCl) (Greenspan, 1977).

Rough rice in the closed vessel was left for 4 hours to achieve the equilibrium RH. Rough rice in the closed vessel was periodically taken out in every 24 hours as amount of 50 g to be dried to achieve 14% of MC. The rough rice sample was then milled with mini rice mill to remove all bran layers (Satake Rice Machine, type THU, class 35A, Satake Engineering Co. Ltd., Japan) at degree of milling of 15% (all bran layers removed).

The obtained milled rice was analyzed for the percentage of whole grains (WG), head rice (HR), large broken grain (LBG) and small broken grains (SBG). WG was defined as no broken kernel occurred in milled rice kernel; HR is defined as milled rice grain with the length of > 75% of the original length of WG; LBG is in between 25% and 75% of the original length of WG, whereas SBG was less than 25% of the original length of WG (SNI 01-6128:2008).

Statistical Analysis

The experiment was designed as a Factorial-Randomized Block Design. The first factor (A) was the MC of rough rice, and the second factor (B) was the storage RH in a closed vessel. Each treatment was repeated three times. Statistical analysis was carried by ANOVA (analysis of variance), and the significant effect of the treatment ($p<0.05$) was further analyzed by Tukey's Honestly Significant Difference (HSD) Test.

Results and Discussion

Percentages of WG, HR, LBG, and SBG during delayed rough rice drying (daily observed for 7 days) were presented in Fig. 1 to 4. Analysis of variance shows that rough rice MC, and storage RH had significant effect on WG, HR, LB and SBG of milled rice in each daily observation. The interaction between rough rice MC, and storage RH had significant effect on HR on day 1, 2 and 3 (Table 1).

Table 1 Tukey's HSD test of HR on day 1, 2 and 3

Treatment	Day 1	Day 2	Day 3
A1B2	19.30^{a}	19.62^{a}	19.86^{a}
A2B2	26.68^{b}	28.58^{b}	27.86^{b}
A1B1	27.12^{b}	27.66^{b}	28.68^{b}
A2B1	32.94^{c}	33.72^{c}	34.92^{c}
A3B2	36.40^{c}	37.46^{c}	38.62^{c}
A3B1	38.30^{c}	39.51^{c}	39.80^{c}
$HSD_{0.05}$	4.53	5.10	4.26

Means with different superscript letters are significantly different (P<0.05)

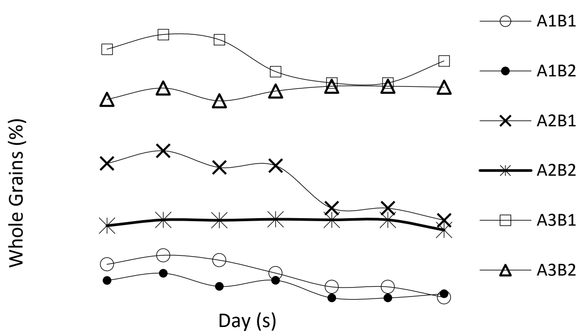

Figure 1 Whole grains (%) during delayed rough rice drying
(A1, A2, A3 = rough rice at MC 24.89%, 18%, 22%, respectively. B1 = RH 76%, B2 = RH86%)

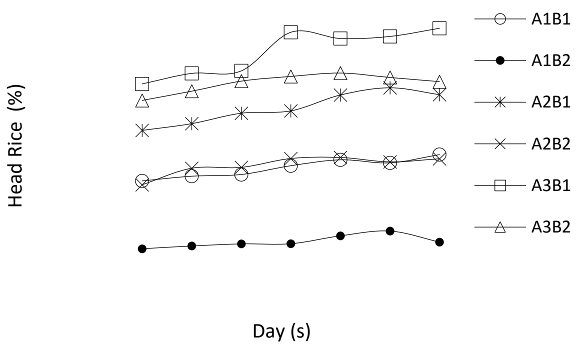

Figure 2 Head rice (%) during delayed rough rice drying
(A1, A2, A3 = rough rice at MC 24.89%, 18%, 22%, respectively. B1 = RH 76%, B2 = RH86%)

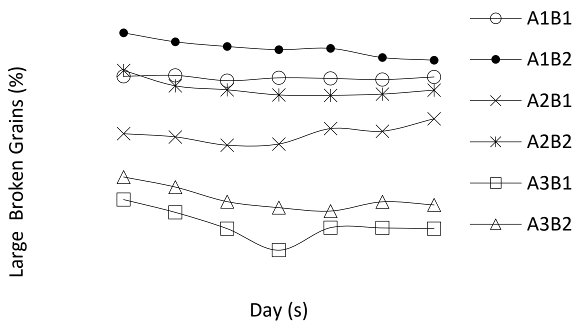

Figure 3 Large broken grains (%) during delayed rough rice drying
(A1, A2, A3 = rough rice at MC 24.89%, 18%, 22%, respectively. B1 = RH 76%, B2 = RH86%)

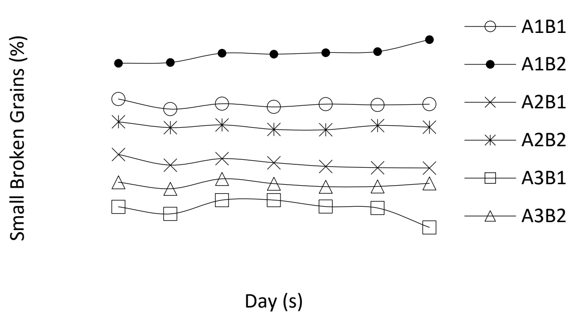

Figure 4 Small broken grains (%) during delayed rough rice drying
(A1, A2, A3 = rough rice at MC 24.89%, 18%, 22%, respectively. B1 = RH 76%, B2 = RH86%)

The delayed rough drying at the MC of 22% resulted in higher percentage of WG and HR in both RH of 76% and 86%. The RH of 76% and 86% are considered as high humidity which are common in tropical countries, particularly in tidal low land. There would be small amount of moisture transfer in high MC of rough rice; therefore rice would be resistant to form fissures during rice drying. Fissures in rice would result in breakage during rice milling. As stated by Lan and Kunze (1996), fissures were formed due to internal stresses in the rice grains during moisture re-adsorption from the surrounding environment.

WG and HR are two important indices in judging the quality milled rice in Indonesia; however, in some countries, HR is frequently used as important quality in assessing milled rice quality. There were some physicochemical changes in endosperm of rough rice. The kernel would absorb moisture from the surrounding environment; the lower MC of rough rice, more absorption would be in rough rice. The increase of MC in rice would result in volumetric changes in rice kernel. Due to rough rice is protected by rice husk, the absorption mostly occurs on the surface layer of its endosperm. Internal fissures might develop during rough rice drying and resulted in rice breakage (Siebenmorgen et al., 2005). Moisture increase in rice resulted in a different changes between the inner and outer section of rice kernel; and the internal rice kernel might be stressed due to a tight and compact husk. If there was a great different between the moisture in inner and outer kernel, fissures might develop in the rice grain (Iguaz et al., 2006). The breakage of milled rice would increase due to the mechanical stress during rice milling. As shown in Fig. 1 to 4 that the breakage kernels distribution is increasing along with the delayed drying duration for the LBG and SBG; on the other hand, the WG and HR are decreasing. The significant finding in this study was the delayed rough rice drying would be better in the MC of 22% and RH of 86% (high humidity).

Conclusion

Most of rough rice in low land of Indonesia was not dried immediately after harvested due to lack of sunlight in rainy season. In such condition, the rough rice was better delayed for drying at a higher MC (22% wb) (slightly higher than safe MC for rough rice storage) and high RH (86%) for increasing the percentage of WG and HR. The best delayed rough rice drying duration in such conditions should not exceed 3 days.

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