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Mix Drying Technique to Conserve the Quality of Asian Rice *

—Low Input Technology for Reducing Postharvest Losses of Staples in Southeast Asia —

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Abstract

In Thailand, to avoid the degradation of fresh paddy after harvesting, we investigated a pre-drying storage treatment consisting of uniform mixing of an absorbent such as dried rice husk, dried paddy, or tapioca pearl with fresh paddy. A mixing, storage, and drying model was developed to calculate the mixture ratio and changes in moisture content (MC). The equilibrium moisture content (EMC) of the mixture of fresh paddy and absorbent (dried paddy or tapioca pearl) was almost equal to the average MC of the weight ratio of the mixture. The weight ratio of the mixture was calculated for an EMC below 17%, which is the maximum moisture content necessary to conserve grain quality for short-term storage. Mixing dried rice husk with fresh paddy is a simple and effective pre-drying method for maintaining rice quality. While tapioca pearl served as an effective absorbent, it is necessary to improve its firmness to ensure its reusability.

[Keywords] drying, mixing, Indica rice, quality, absorbent, post harvest, Asia

I Introduction

In Southeast Asia, the post-harvest loss in cereal is estimated to be 20–30%. Because of the high temperature and humidity in this area, post-harvest losses are thought to be caused by the degradation of grain quality due to insufficient drying after harvesting. However, installing and operating storage and dryer systems is costly and therefore not economically viable. Consequently, the development of economical materials and drying and processing techniques are needed.

In Thailand, combines are now used to a large extent to harvest paddy. In fact, more than 40% of paddy is harvested using combines. As a result, the problem of post-harvest deterioration management, especially drying, is increasing. Paddy with high moisture content (MC) is occasionally piled up on the ground after harvesting without treatment, resulting in the deterioration of grain quality. A large quantity of paddy with a high MC that is harvested using combines is brought to rice mills which have dryer facilities; however, the drying capacity and efficiency is comparatively low given the large quantity of paddy. Paddy with a high MC will easily undergo lactic acid fermentation. A critical MC of 17–18% wet basis (w.b.) is considered necessary to avoid fermentation during short-term storage. Therefore, pre-drying is necessary to prevent deterioration in the quality of freshly harvested paddy. Moreover, pre-drying can effectively increase the efficiency of a drying system by adjusting the MC of the fresh paddy.

We examined the effectiveness of a simple pre-drying method of mixing dried rice husk or other absorbents with fresh paddy. This paper reports the results of several experiments conducted in Thailand.

II Experiment 1: Mixing dried rice hull with fresh paddy

1. Objective

This experiment evaluates a simple and low cost pre-drying method of mixing dried rice husk with fresh paddy to maintain the quality of fresh paddy. Rice husk can be easily separated from paddy by using a blower and other low-cost material. This experiment aimed to elucidate the effect of mixing rice husk with fresh paddy and to determine the suitable weight ratio of the mixture based on the MC of fresh paddy and the drying process.

2. Materials and Method

(1) Fresh paddy (Indica Khokhong 23) with an MC of 20% w.b. and rice husk with an MC of 11% w.b. were mixed in small sealed vessels of 600 cc capacity. The mixtures' volumetric ratios were changed to 0.8, 1.0, 1.2, 1.5, and 1.8

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and maintained at a constant temperature of 37°C. The MC of the paddy in each vessel was measured and the weight of each mixture was measured approximately within 5 min every 1 h.

(2) Fresh paddy (270 kg) with an MC of 27.7% and dried rice hull with an MC of 11.8% were mixed in grain bags that had a 1.0 m^3 capacity; the mixture was adjusted to the volumetric mixture ratio of 1.0 and 1.5 of fresh paddy and dried rice hull, respectively. The internal temperature of the bags was measured by a data logger (Iwasaki Co., Ltd., Bringo) every 1 min using K-type thermocouples, and the MCs of the paddy were measured by a single-kernel moisture meter (Shizuoka Co., Ltd., CTR-200E) for 20 h. The MCs of the samples were accurately calculated by preheating at 105°C for 24 h to obtain dry matter.

3. Theoretical equations

Assuming that the total weight of the mixture does not change, the equation used to determine the weight ratios are:

$$W_{D1} \cdot M_{D1} + W_{D2} \cdot M_{D2} = W_{D1} \cdot M_{DE1} + W_{D2} \cdot M_{DE2}$$
$$= W_{D1} \cdot M_{D10} + W_{D2} \cdot M_{D20} = const. \quad (1)$$

where W_D, dry matter; M_D, moisture content [dry basis (*d.b.*), decimal]; M_{DE}, EMC; M_{D0}, initial MC; suffix 1, 2, materials

$$(W_{D1} + W_{D2})\, M_{Ever} = W_{D1} \cdot M_{DE1} + W_{D2} \cdot M_{DE2}$$
$$= W_{D1} \cdot M_{D10} + W_{D2} \cdot M_{D20} \quad (2)$$

where M_{Ever}, average EMC

Then, difference between M_{DE} and M_{Ever} is:

$$M_{DE1} - M_{Ever} = W_{D2}(M_{DE1} - M_{DE2})/W_{D1} + W_{D2}) \quad (3)$$
$$M_{Ever} - M_{DE2} = W_{D1}(M_{DE1} - M_{DE2})/(W_{D1} + W_{D2}) \quad (4)$$

Difference (Hysterics between M_{DE1} and M_{DE2}) is functional to the temperature t [°C] (Murata et al. 1988) and is approximately revealed as

$$H = M_{DE1} - M_{DE2} = a1 - b1 \cdot t \quad (5)$$

By the experiment of equilibrium of paddy, $a1$ = 1.5, $b1$ = 0.04. Then, M_{DE1}, M_{DE2} are

$$M_{DE1} = (W_{D1} \cdot M_{D10} + W_{D2} \cdot M_{D20} + W_{D2} \cdot H)/(W_{D1} \cdot W_{D2}) \quad (6)$$
$$M_{DE2} = (W_{D1} \cdot M_{D10} + W_{D2} \cdot M_{D20} - W_{D1} \cdot H)/(W_{D1} + W_{D2}) \quad (7)$$

At a constant storage temperature, M_{DE1}, M_{DE2}, and M_{Ever} are constant and the average M_{D1} is calculated by the following well-known experimental equation

$$M_{D1} - M_{DE1} = (M_{D10} - M_{DE1})\, exp(-K_1 \cdot \theta) \quad (8)$$

where K_1 [h^{-1}]is the drying constant of paddy, which is functional to the temperature as shown by the Arrhenius equation. θ is time [h].

$$K_1 = C_1\, exp(-C_2/T_p) \quad (9)$$

T_p (absolute temperature of paddy, [K]). C_1, C_2 are determined by drying experiments using different constant temperatures. The results obtained are:

C_1 = 943170, C_2 = 4792 (paddy variety; Standard #35)

EMC of Indica paddy is calculated by Henderson's equation.

$$1 - rh = exp(-k\, T_p\, M_{DE1}{}^n) \quad (10)$$

$k = 6.093 \times 10^{-6}$, n = 2.318. rh; relative humidity [decimal].

4. Results and discussion

(1) The result of the experiment involving the mixing of fresh paddy with dried rice husk in small vessels is shown in figures 1 and 2. The EMC of paddy mixed with rice hull

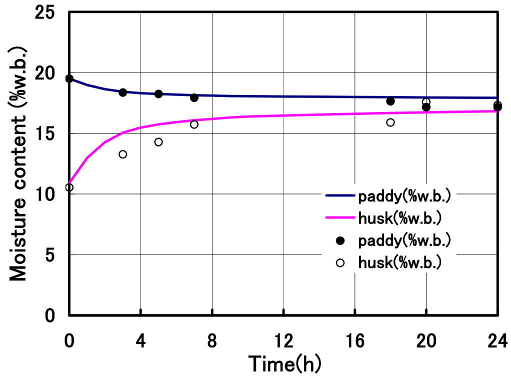

Figure 1 Changes in the MC of paddy and dried rice husk mixture; volumetric mixture ratio 1.2.

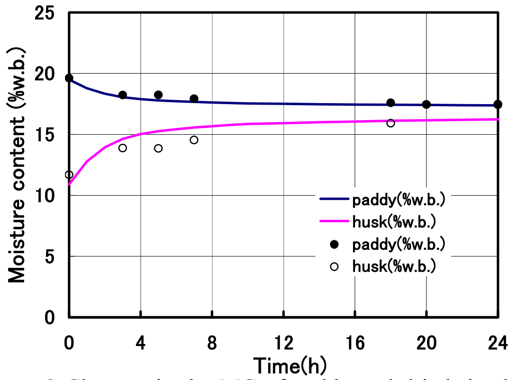

Figure 2 Changes in the MC of paddy and dried rice husk mixture; volumetric mixture ratio 1.8 (y-axis: calculated MC).

decreased as the mixture ratio of rice hull increased. The MC of paddy decreased exponentially and 50–60% of the MC decrease occurred within 5 h. The calculated value of MC using equation (8) provided a good approximation of the measured value. This shows that the EMC of the mixture can be calculated using the initial MC of the materials and the dry matter weight ratio (equations 7, 8). This method can also be adopted to calculate the change in the MC of the mixture, EMC, and the equilibrium humidity of atmospheric air, which is equivalent to the MC of the mixture.

Using equations (6) and (7), the EMC of paddy and absorbent (rice husk) can be calculated based on the initial MC of the mixture, mixing ratio, and storage temperature. Figure 3 shows the average EMC of paddy and rice husk and the equilibrium humidity calculated based on the volumetric mixing ratio of rice husk with an MC of 5%. Accordingly, the EMC of the mixture with an initial MC of paddy at 21% w.b. and rice husk at 5% w.b. is calculated to be 17.5% w.b., and