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Pre-germinated Parboiled Brown Rice Drying Using Fluidization Technique

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***Abstract*—**Pre-germinated parboiled brown rice or Khao hang (in Thai) is paddy which undergoing the processes of soaking, steaming, drying and dehusking to obtain the edible form for consumption. The objectives of this research were to study the kinetic of pre-germinated parboiled brown rice drying using fluidization technique and to study the properties of pre-germinated parboiled brown rice after drying. The dryings were performed at the different temperatures of 110, 120 and 130 ^{o}C at the bed depth of 2 cm with the air velocity of 1.98 m/s. The results found that the higher drying temperature led to the faster moisture reduction. After drying until the moisture content of pre-germinated parboiled brown rice was lower than 14%wet basis, samples were taken to determine various qualities such as percentage of head rice and L* a* b* color values. The shade drying was used as a control. The results found that the higher drying temperature resulted in the decrease of head rice percentage. For the color assessment, the trend of L* and a* values was increased with the drying temperature, while the b* value was not significantly difference (p › 0.05) by drying temperatures. However, the b value of drying by fluidized bed dryer was higher than the control.

***Keywords*—**Brown rice; dehydration; fluidized bed; grain.

I. Introduction

BROWN rice is a wealth of nutrients that are contained in the bran layer. This lost health food is now being revived and taken back into the regular diet of consumers [1]. Brown rice can be processed in different form such as parboiled brown rice [2] and brown rice bread [3]. Pre-germinated parboiled brown rice or Khao hang (in Thai) is one of the attractive products which are benefit for health lovers. The process consists of the major steps of soaking, steaming, drying and dehusking to obtain edible form for consumption. Pre-germinated has potential functional food benefits such as γ-aminobutyric acid [4]. The antioxidants like orizanol and proanthocynin in pre-germinated and germinated brown rice can neutralize the damage of oxidation [1]. There are many ways to remove the water from the product. Sun drying is a conventional method with the lowest cost of operation. However, it is not convenience in rainy season. Drying is not applied only for removing water from the product; but hot air can also change some properties of rice as it is heat sensibility. In the past, the conventional sun drying was used to dry the product down to the moisture content about 14 % wet basis. This method causes many problems due to very slow drying rate and cannot be done in the rainy season. Alternatively, mechanical drying has been applied to overcome those problems. Hot air is commonly used as drying media since it is simple and low cost operation. According to the information from literatures, fluidized bed drying has been widely used for drying particulate materials such as paddy [5] and corn [6] Fluidized bed techniques, where solid particles and fluid media are in a good contact over the entire bed. The fluidized bed drying offers several advantages such as rapid drying, small dryer size, and uniform product quality.

However, the drying characteristics of pre-germinated parboiled brown rice and the effect of drying conditions on the product quality must be previously known. Therefore, it was of our interests to compare this technique under different drying temperature.

The objectives of this study were to study the drying characteristics of pre-germinated parboiled brown rice by hot air fluidization technique, as well as to quantify the change in color of the dried samples. This attempt was expected to obtain the most suitable drying conditions of pre-germinated parboiled brown rice.

II. Materials and Methods

A. Experimental Setup

A batch drying system was developed by the Faculty of Engineering, Mahasarakham University, Thailand. The system consists of a vertical cylinder shape drying chamber with a dimension of 15 cm in diameter and 60 cm in height, 18 kW electrical heater and a backward curve fan driven by 2 kW electrical motor as shown in Fig. 1 and 2. Drying-air temperature was controlled by a proportional integral derivative controller with an accuracy of $\pm 1^{o}$C. A frequency inverter regulated airflow rate.

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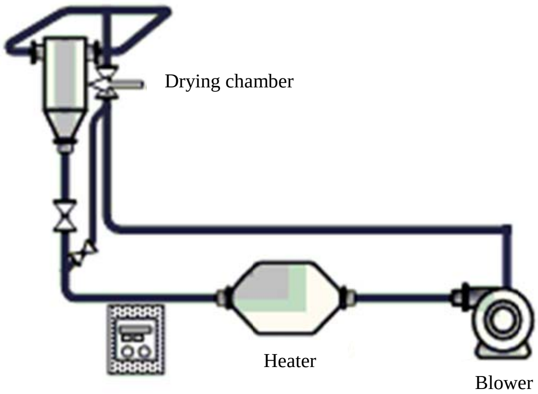

Fig. 1 A schematic diagram of the experimental dryer

Fig. 2 The fluidized bed dryer used this study

B. Materials

Paddy samples were newly harvested from a paddy field in Mahasarakham province, Thailand. The sample was soaked in water at room temperature for 24 hr, then steamed at the atmospheric pressure for 45 minutes, then left at ambient conditions for 2 hr and finally kept in an isolated sealed container before the experiment. The initial moisture content of paddy was about 35 %wet basis. Sample approximately 300 g was prepared for each drying experiment. The moisture content was determined by the oven method at temperature of 103^{o}C for 72 hr.

C. Experimental Procedure

The experimental conditions were set up as follows: initial moisture contents of 35 % wet basis, drying temperatures of 110, 120 and 130^{o}C at a fixed superficial velocity of 1.9 m/s. Each sample was approximately prepared for 300 g for each drying condition. Each temperature, sample was dried in a batch at different drying times of 2, 4, 6, 8, 10, 12, 14, and 16 minutes, then it was taken to determine the moisture content. For the quality assessment, it was dried until the final moisture content down to 14% wet basis.

After drying, Sample was slowly cooled down to ambient temperature and kept in a seal plastic bag for 2 weeks in a refrigerator at 2-5 ^{o}C before quality testing.

For the ambient drying, soaked paddy was shaded drying until the moisture content down to desirable level and kept in a seal plastic bags for further determination.

The dried paddy sample was dehusked by rubber roll to get the brown rice. Then, it was separated the head yield (the grain with the length higher than 80% of whole grain). The percentage in weight of head rice was obtained by calculation.

D. Drying Curve and Drying Rate

The drying curve was plotted between the moisture content in wet basis versus drying time at each drying temperature. The drying rate was calculated from change in moisture reduction with time.

E. Head Rice of Pre-germinated Parboiled Brown Rice

The dried paddy sample was dehusked by rubber roll to get the brown rice. Then, it was separated the head yield (the grain with the length higher than 80% of whole grain). The percentage in weight of head rice was obtained by calculation

F. Color of Pre-germinated Parboiled Brown Rice

The color of initial and dried pre-germinated parboiled brown rice samples was measured by a Hunter Lab Colorimeter (Mini Scan XE Plus, Hunter Associates Laboratory Inc., Reston – Virginia, USA). The Hunter L*, a*, b* scale gave measurement of colors in units of approximate visual uniformity throughout the solid. The L* value measures lightness and varies from 100 for a perfect white and 0 for black, a* and b* when positive measure redness and yellowness, respectively. All measurements were conducted in five replicates and the averages of the color values were presented as the mean and the standard deviation

G. Statistical Analysis

The effects of drying temperature on the head rice yield and color of pre-germinated parboiled brown rice were compared using analysis of variance. Duncan's multiple range test at the 5% significance level was applied to experimental results to indicate the significant difference among the means.

III. Results and Discussion

Fig. 3 shows the moisture content of pre-germinated parboiled brown rice at different drying temperature during drying by hot air. It was found that the moisture content decreased exponentially continuous with drying time. It can be assumed that there is no constant-rate period but the falling-rate period is presented. Moreover, the higher temperature drying results in the higher moisture removal. The effect of drying temperature on the drying rate is shown in Fig. 4. The drying rates are sharply decreased in the first 3 min of drying period and then it is gradually decreased with the drying time. This due to the large different between drying temperature and sample temperature in the first drying period leads to the high vapor diffusion of moisture from sample. Another reason is the sample with high moisture content contains free water inside the sample which is easily to remove from sample in the first period of drying. After that, the bound water will be removed from the sample which is more complicated and slowly remove from sample. We noted that the key factor influencing drying rate is drying temperature as shown in Fig. 4 that the higher drying temperature produced higher drying rate. This is due to an increase of the air heat supply rate to the product and the acceleration of water migration inside the sample [6][7].

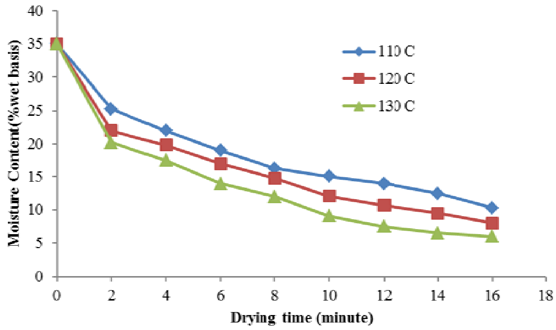

Fig. 3 Variations in moisture content of pre-germinated parboiled brown rice at different drying temperatures

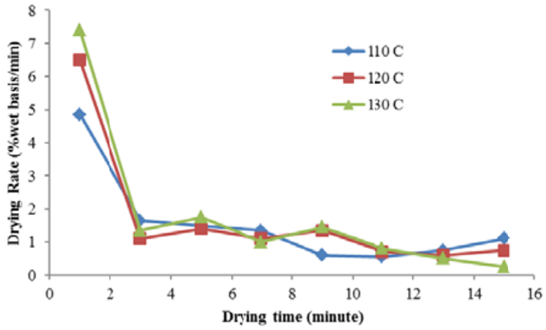

Fig. 4 Variations in drying rate of pre-germinated parboiled brown rice at different drying temperatures

The head rice yield of pre-germinated brown rice is presented in Table I. The results show that the drying by fluidized bed technique at any drying temperatures provides the higher head yield. This due to the high temperature causes the partial gelatinization within the rice kernel. The endosperm becomes plasticised material and any cracks in it are sealed. As a result, the rice kernel is more stress resistant, resulting in the less breakage. This result was agree with the previous reports [6] [8] [9] that the high temperature drying produced more head rice yield.

TABLE I
HEAD RICE UNDER DIFFERENT DRYING TEMPERATURES AND METHOD

Drying Method	Drying Temperature (°C)	Head Rice (%) mean	SD
Hot Air	110	95.91c	0.50
	120	95.04c	0.42
	130	94.40b	0.20
Ambient drying		89.14a	0.73

Means with the same letter within a column are not significantly different ($P < 0.05$) by DMRT

One of the most important criteria for acceptability of food is color. Undesirable changes in color of a food may lead to a decrease in its physical and sensory qualities as well as marketing value. The results for color parameters in term of L*, a* and b* obtained from the different drying processes are presented in Table II. L* value of sample dried by hot air is significantly different by drying temperature between 120 and 130 °C. The a* value increases with the increasing of drying temperature. This could be explained that non-enzymatic browning reaction occurred when higher temperatures were applied. The b* value is not significantly different by drying temperatures. This might be the pigment in brown rice has the color of redness than the yellowness. However, the b* value of brown rice drying by fluidized bed dryer was higher than the control.

IV. CONCLUSION

Based on the experimental results of the present work, the following conclusions could be drawn

- the higher drying temperature led to the faster moisture reduction.
- the higher drying temperature resulted in the decrease of head rice percentage.
- the color assessment, the trend of L* and b* values was increased with the drying temperature, while the b* value was decreased but not significantly difference.

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TABLE II
COLOR VALUE UNDER DIFFERENT DRYING TEMPERATURES AND METHOD

Drying Method	Drying Temperature (°C)	L* mean	L* SD	a* mean	a* SD	b* mean	b* SD
Hot Air	110	56.80a	0.36	4.67a	0.62	28.01a	0.13
	120	57.20b	2.44	5.33a	0.13	27.39a	1.36
	130	59.83b	0.94	5.41b	0.32	27.02a	0.89
Ambient drying		58.07ab	1.11	5.09ab	0.24	25.84b	0.15

Means with the same letter within a column are not significantly different ($P < 0.05$) by DMRT

REFERENCES

[1] P. Dinesh Babu, R.S. Subhasree, R. Bhakyaraj and R. Vidhyalakshmi, Brown rice-beyond the color reviving a lost health food - A review, American-Eurasian Journal of Agronomy, 2009, 2 (2): 67-72.
[2] S.Soponronnarit, A. Nathakaranakule, A. Jirajindalert and C. Taechapairoj, Parboiling brown rice using super heated steam fluidization technique, Journal of Food Engineering, 2006, 75 (3): 423-432.
[3] S. Renzetti and E.K. Arendt, Effect of protease treatment on the baking quality of brown rice bread: From textural and rheological properties to biochemistry and microstructure, Journal of Cereal Science, 2009, 50(1): 22-28
[4] D. Karladee and S. Suriyong, γ-Aminobutyric acid (GABA) content in different varieties of brown rice during germination, ScienceAsia, 2012, 38: 13-17
[5] W. Rordprapat, A. Nathakaranakule, W. Tia, and S. Soponronnarit, Comparative study of fluidized bed paddy drying using hot air and superheated steam, Journal of Food Engineering, 2005, 71 (1): 28-36.
[6] S. Soponronnarita, A. Pongtornkulpanichb and S. Prachayawarakornc. Drying characteristics of corn in fluidezd bed dryer, Drying Technology: An International Journal, 1997, 15 (5): 1603-1615.
[7] L. Wiset, G. Srzednick, R.H. Dricroll, J. Tumambing and N.Poomsa-ad, Modeling of Paddy Drying in Fluidised Bed Dryer." Proceedings of the 13th International Drying Symposium (IDS' 2002) Beijing, China, 27-30 August 2002, vol. A,362-370
[8] G. Elbert, M.P. Tolaba and C. Suarez, 2001. Effects of drying conditions on head rice yield and browning index of parboiled rice. Journal of food engineering, 2001,47(1): 37-41.
[9] C. Taechapairoj, I. Dhuchakallaya, S. Soponronnarit, S. Wetchacama and S. Prachayawarakorn, Superheated steam fluidised bed paddy drying. Journal of Food Engineering, 2003, 58(1): 67-73.